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Spatial Analysis of Urban Parks and COVID-19: City of Whittlesea, Victoria, Australia

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Parks are an important part of the urban fabric of cities. The Victorian Government has made it clear that everyone with a pre-existing medical condition, needs to play a part in controlling the spread of the novel COVID-19 virus. Self-isolation and social distancing from other people will reduce the spread of the virus but may also be impacting negatively on people's physical and mental health. The Government allows people to leave their homes to exercise. For this reason, parks remain open, providing that visitors observe the protocols of not being in groups larger than two (apart from households) and keeping a safe distance of two metres between each other. The purpose of this paper is to explore the mental health conditions across age groups within spatial relationships between park availability and age care facilities in the City of Whittlesea. The association between having a park within 800 m from an aged care facility and the likelihood of having zero, one, two or more aged care facilities nearby was examined.

25.1 Introduction

Urban parks have received attention in recent years as a possible natural factor that could encourage physical activity, prevent obesity, and reduce the incidence of chronic conditions [12]. Despite long hypothesized benefits of parks for mental health, few park studies incorporate mental health measures. COVID-19 related restrictions have accentuated the community's reliance on open space to maintain its physical fitness and stabilise its mental health. It has also been demonstrated that older people are among the most vulnerable to both the effects of policy-induced isolation and disease itself. The benefits gleaned from being able to access open spaces and associated walking trails were demonstrated in Australia [29] and proximity to a park was inextricably linked to an increased frequency of park use, regular exercise and improved mental health [28]. However, the government has encouraged older people to stay at home for their own protection during the pandemic and implemented physical distancing measures to slow the spread of the disease. Unfortunately, older people, especially those in aged care facilities, may not have access to open spaces large enough to enable them to adhere to physical distancing measures within their facilities whilst spending time outdoors. This results in a reduction in social interaction even with the people that they live with and effects their mental health. Those living in aged care homes face additional mobility and psychological challenges that they (and their carers) must overcome before they are able to obtain the benefits associated with spending time in nature. One barrier faced by people in aged care facilities is access to public open space. Population forecasting indicates that, by 2036, there will be an 87% increase in people aged 50+ years in the City of Whittlesea

[17]. The city has committed to investing in, maximising and delivering recreation infrastructure that improves connectivity between places and removes the barriers experienced by older people to promote physical activity, active travel and incidental exercise (profile.id, 2019). To future-proof its investments and deliver equitable wellbeing outcomes there is a need to identify where existing and potential open spaces are situated, and their proximity to aged care facilities.

Aims of the Study

To identify the proximity between urban parks and aged care facilities and whether there is a link between proximity and clusters of older adults (60 years and over) who consider themselves impacted by mobility, or from mental health or physical health issues. The suburbs and towers associated with the inception of a second wave of COVID-19 in Melbourne have demonstrated that the most vulnerable members of our communities are those living close to limited open space.

This paper aims to contribute to two different strands of relevant literature. The first relates to the effect of park and open space proximity to aged care facilities on health. A relatively common finding in this literature is that people living near park areas report being in better physical and mental health and experience lower levels of stress, this is largely attributed to the size of the open space available, cleaner natural environments and better-quality air found in parks [2]. Through facilities, outdoor settings, and services provided, smaller public parks enable people of all ages, socio-economic backgrounds, and ethnicities to obtain these same benefits. Several studies show that that council parks provide opportunities for people to increase their rigorous physical activity, thereby reducing obesity. The literature consistently reveals that those living in close proximity to parks and other recreation facilities have superior physical activity levels, physical and mental health [7, 10, 11, 13, 15, 21, 27].

A second strand of the literature to which the paper contributes investigates the drivers of the COVID-19 pandemic, including the role of crucial factors such as lockdowns, human and economic activity, climate and pollution. On the role of social distance, Greenstone and Nigam [8] find that the mortality benefits of social distancing are about $8 trillion for the US $60,000 per US household. Fang et al. [6] analysed the impact of restrictions on human mobility and calculated that without the Wuhan lockdown, contagion cases would have been 64.81% greater in the 347 Chinese cities outside Hubei province, and 52.64% higher in the 16 non- Wuhan cities inside Hubei. Several authors have examined the drivers of Italy's severe COVID-19 outbreak [9, 20, 22, 24] with Ciminelli and Garcia-Mandicó [4] demonstrating that the congestion of the health care system exacerbated the number of deaths in Italy.

These research findings contribute to both research strands by showing that park areas play an important positive role in health outcomes specifically under the context of a pandemic, and that environmental factors impact geographical spread of the disease. In the final part of the paper, we discuss methodological issues, directions for future research and policy implications of our results.

25.2 Urban Parks

Public and private urban parks are critical to the long-term health, liveability and resilience of communities. Access to nature helps individuals to stay physically healthy [16]. Physical activity in nature (e.g. walking, cycling, gardening and other outdoor activities) can lower anxiety [14] and reduce post-traumatic symptoms [19], which might prove to be important after the COVID-19 world-wide social distancing orders are liberalized [1]. Using data from Kansas City, Kaczynski et al. [12] documents having a park within 800 metres from home and the likelihood of having 0, 1, or 2 or more chronic health conditions (CHCs). Rosenfeld et al. [25] reveal that urban parks induce increased physical activities of nearby communities in Dublin, Ireland. Dharmarajan et al. [5] provides evidence of positive mental health outcome due to residing close to parks in Los Angeles. In a recent study, Rice and Pan [23] argue that during these extraordinary circumstances,

urban nature offers resilience for maintaining well-being in urban populations, while enabling social distancing.

In the Australian context, the benefits gleaned from being able to access open spaces and associated walking trails have been demonstrated in Temple Lang [29]. The results of this study strengthen the growing body of evidence that mental health is significantly related to residential distance from parks, with the aged care facility, residents within short walking distance from the park (400 m) and decreasing significantly as the distance increases. The number of visits and physical activity minutes are significantly and independently related to distance.

25.3 Study Area

The study area was the entire CoW municipality, which is one of Melbourne's largest urban municipalities, located about 20 kilometres north of the city and the fastest growing area in the north of Melbourne. The CoW has established urban areas in the south and urban growth areas (new communities) and rural areas in the north. It has been designated as one of six 'growth areas' along the fringes of Melbourne. Between 2016 and 2041, it is projected to grow by 175,000 people in 62,400 additional households. While the population is ageing, it will continue to mainly attract a diverse group of younger families moving to outer areas to establish a home. Some residents are less advantaged than those in other parts of Melbourne and the new suburbs, migration from a wide range of areas across Melbourne means some residents will have fewer community connections. This growth is said to provide significant benefits derived from the critical mass required to make businesses, services, clubs and infrastructure viable. Diversity may provide an interesting culture and the type of vibrancy in which tourism, education, and other activities thrive. However, growth and diversity also make Whittlesea vulnerable to some of the negative effects of emerging challenges such as:

- Increasing demand for infrastructure.
- Changing work patterns.
- Increasing transport issues.
- Climate change.
- Social disconnection.

Suburban development in Whittlesea began after World War 2 and has progressed north since (Figure 25.3). In 2002, an Urban Growth Boundary for Melbourne was put in place that divides Whittlesea's urban and rural areas. There was a lull in new housing development in the late 2000s, but in the last few years, several large subdivisions in previously rural areas, and infill development in the established suburbs, have rapidly increased the number of households.

Despite ageing, the population will continue to be dominated by family households. Whittlesea currently has a markedly younger population than the rest of Melbourne. By 2041, all population groups will grow, but the population will age, with an increased proportion of older people (aged over 55). There will also be an increase in the proportion of the population aged 5 to 19, while those aged 20-54 will decrease. The median age is projected to increase only slightly, from 34 in 2016 to 35 in 2041 (Figure 25.4).

25.4 Methodology

To identify the proximity between urban parks and aged care facilities in CoW and its impact on older adults (60 years and over) who consider themselves impacted by mobility, or from mental

FIGURE 25.1
CoW and Surrounding Area (Northern Melbourne comprises LGAs of Banyule, Darebin, Hume, Moreland, Nillumbik and Whittlesea). Source: SGS Economics and Planning 2018 Data: Victoria State Government 2017, Plan Melbourne

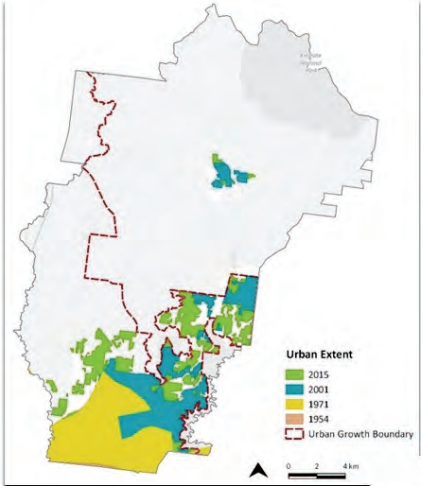


FIGURE 25.2
Figure 2. Extent of Urban Development 1954–2015. Source: SGS Economics and Planning 2018 Data: Victoria State Government 2017, Plan Melbourne

health or physical health issues in this study we conduct an individual survey and a GIS based proximity analysis. The results from both methods are presented in order.

25.4.1 Survey

Analyses of the City of Whittlesea 2019 Household Survey (1,083 respondent households and 3,083 individual respondents) were conducted looking specifically at the results for people who reported being 60 years of age or older [18]. 676 (62%) respondents identified as being over the age of 60 years, 674 respondents indicated their residential location, 2 did not. The distribution of these respondents is presented in Figure 25.4.

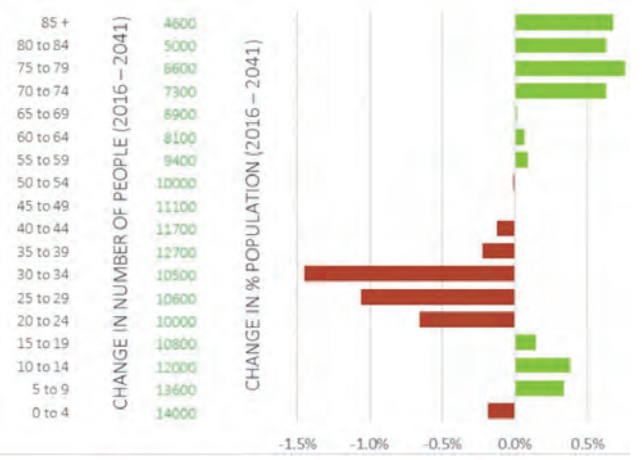


FIGURE 25.3
Whittlesea Population Change by Age Group. Source: SGS Economics and Planning 2018 Data: Victoria State Government 2017, Plan Melbourne

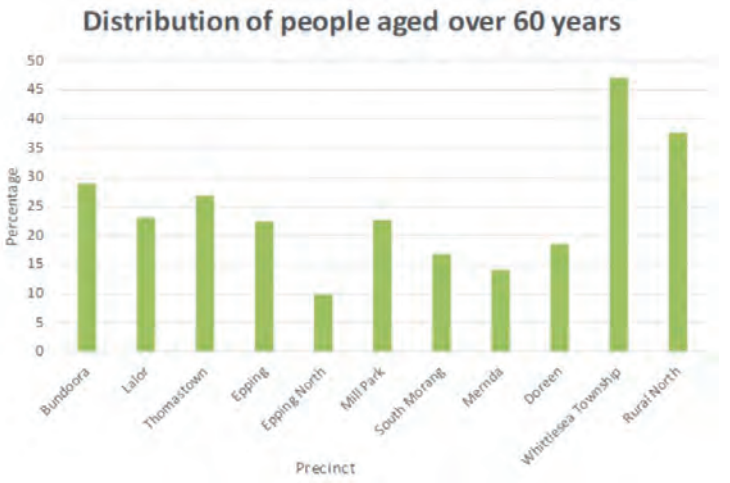


FIGURE 25.4
The top five concentrations of respondents aged older than 60 by precinct (in order of highest to lowest) were in the Whittlesea Township (47%), Rural North (37.3), Bundoora (29%), Thomastown (26.9) and Mill Park (22.6)

According to the survey undertaken in CoW, older adults and senior citizens (aged 60 years and over) – respondents were measurably more likely than average to have done less than five hours moderate to vigorous physical activity.

There was measurable and significant variation in the amount of moderate to vigorous physical activity undertaken 'in the last week' observed by respondent profile (age structure, gender, and language spoken at home). The following graph provides a summary of the results for respondents doing less than 5 hours last week and those doing five hours or more, as follows:

Of all respondents, 62% answered the questions pertaining to disabilities, within the 60 plus age group, 33.4% of respondents indicated that they had permanent or long-term disability. Ranked in order of highest to lowest, the top three precincts with the highest percentage of people reporting

a disability linked with mobility and/or mental health and/or a medical condition were Epping North, Bundoora and Lalor. On average, in this demographic;

- 2% of total respondents identified mobility as their disability.
- 1% identified mental health as their disability.
- 5% of respondents identified as having a permanent or long-term medical condition.

By precinct, the top three precincts where respondents identified 'Mobility' as their disability resided in Lalor (30%), Epping (24%), Mill Park (22%). The top three precincts where respondents identified 'Mental Health' as their disability were Mernda (31%), Thomastown (26%), South Morang (21%), followed by Bundoora and Lalor (both 19%). The top three precincts where respondents identified as having a 'Permanent or long-term medical condition' were Epping North (86%), Bundoora (69%) and Mill Park (65%).

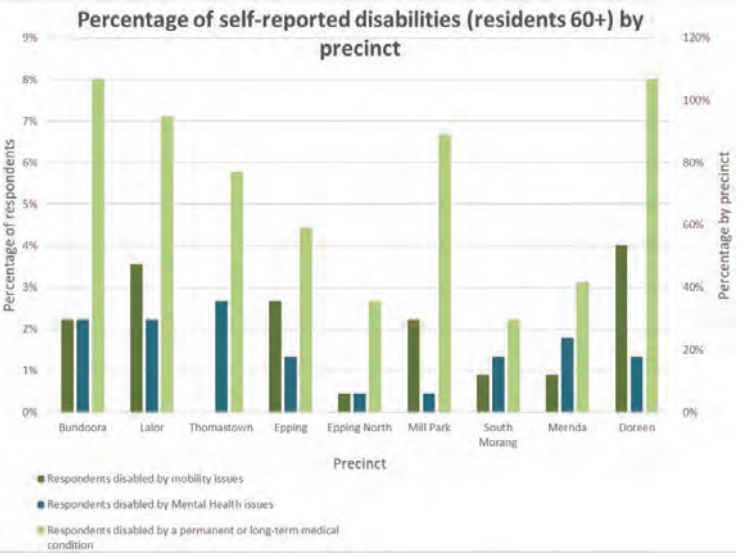


FIGURE 25.5
Percentage of Self-Reported Disabilities (residents 60+) by Prescient

Figure 25.5 offers distribution of residents self-reporting disabilities and the types of disabilities reported among precincts. For each disability reported, the following rates were the highest among respondents. Four percent (4%) of residents aged over 60 residing in Lalor reported being disabled by 'Mobility' issues, 3% of residents aged over 60 residing in Thomastown reported being disabled by 'Mental Health' issues and 8% of residents aged over 60 residing in Bundoora reported being disabled by a permanent or long-term medical condition.

Respondents aged over 60 were also asked to self-report whether they undertook vigorous physical activity in the week prior to the survey. The results indicated that those who resided in Mernda and Doreen performed vigorous activity for longer periods than respondents in any other precinct. Interestingly, most residents in Bundoora, Lalor, Thomastown, Epping, Epping North and Mill Park who performed vigorous activity, only did so for less than 2.5hrs over the week.

Figure 25.6 indicates that a high percentage (29%) of residents aged over 60 years reported a need for support (data not shown), and that those in Lalor were in highest need of support for daily tasks, to overcome the limitations of their mobility and to be able to participate in social events.

By precinct, in order of highest to lowest, the top 3 precincts with the highest levels of access

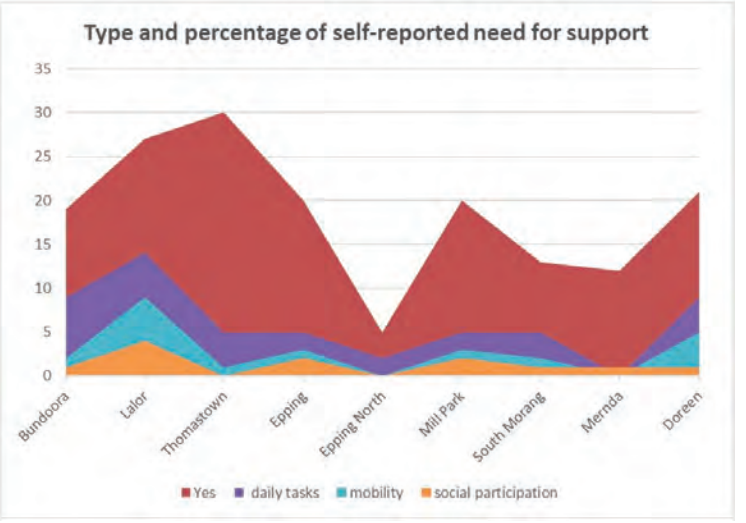


FIGURE 25.6
Type and Percentage of Self-Reported Need for Supports

to or used Aged care services were Lalor (12.6%), Doreen (6.7%) and Bundoora (5.7%). The top 3 precincts with the highest levels of access to or used Mental health services were Epping (9%), and Lalor (8.8%) and Doreen (8.6%). The top 3 precincts with the highest levels of access to, or used Other social services were Bundoora (4.6%), Thomastown (3.9%), and Lalor (3.0%). The data also indicates that between 87.4 and 99 percent of respondents indicated they did not have access to aged care, mental health or other social services, though only two individual respondents specifically identified that distance was a barrier to access.

25.4.2 GIS Based Proximity Analyses

GIS users bring a wealth of knowledge about physical space, particularly geographic space, into the process of interpreting GIS data. The proximity toolset in the analysis ESRI ARCGIS software toolbox can be used to discover proximity relationships. These tools output information with buffer features or tables. Buffers are usually used to delineate protected zones around features or to show areas of influence. For example, one can buffer an aged care facility by one mile and use the buffer to select all the parks that are more than one mile from the park in order to plan for the transportation of aged-care residents to and from their facility to that park. One could also use the multi-ring buffer tool to classify the areas around a feature into near, moderate distance, and long-distance classes for analysis. Buffers are sometimes used to clip data to a given study area, or to exclude features within a critical distance of something from further consideration in an analysis. Buffer and Multiple Ring Buffer create area features at a specified distance (or several specified distances) around the input features. In this research we conducted proximity analysis on multiple ring buffers to identify suitable parks for aged-care residents to visit and completed a gap analysis of aged care facilities and reserves, local parks and smaller urban spaces for the CoW.

Data were collected for parks and Aged care facilities and the distance from each point was calculated. This table can be used for statistical analyses, or it can be joined to one of the feature classes to show the distance to points in the other feature class. Use the Point Distance tool to look at proximity relationships between two sets of things. For example, you might compare the distances between one set of points representing several types of businesses (such as theatres, fast food restaurants, engineering firms, and hardware stores) and another set of points representing the locations of community problems (litter, broken windows, spray-paint graffiti), limiting the search to one mile to look for local relationships. You could join the resulting table to the business

and problem attribute tables and calculate summary statistics for the distances between types of business and problems. You might find a stronger correlation for some pairs than for others and use your results to target the placement of public trash cans, or police patrols [26]. Use Point Distance to find the distance and direction to all the water wells within a given distance of a test well where you identified a contaminant. Below is an example of point distance analysis. Each point in one feature class is given the ID, distance, and direction to the nearest point in another feature class. proximity findings are incorporated to make the framework more relevant to the users of Geographic Information Systems (GIS) concerning their spatial circumstances.

Urban parks, along with other natural elements like conservation reserves and waterways are a key mechanism that will enable the CoW to cope with future urban challenges linked to densification. They will also make the community more resilient to human health, wellbeing and environmental challenges such as heatwaves, flooding and soil contamination. A park hierarchy groups parks into distinct types and defines how each type of park is used, what it contains, and what service levels are associated with them. The hierarchy and naming conventions adopted by CoW, park types include:

Figure 25.7 present number of parks near aged care facilities identified at 100 metres apart. While only nine (9) aged care facilities were located within 100 metres of a nearby park, 125 aged care facilities were within 800 metres. For a person living in an aged-care facility, walking a distance of 800 meters could prove to be a demotivating factor; whether many of them would have enough energy to cover those distances unsupported is also unknown.

TABLE 25.1
Distance between Parks and Aged Care Facilities in CoW

Distance from aged care 100 m interval	**100 metres**	**200 metres**	**300 metres**	**400 metres**	**500 metres**	**600 metres**	**800 metres**	**Grand Total**
Civic & Commercial Facilities			5	4	3	3	4	19
Conservation Area	1	1		2	4	3	10	21
Landscape Site	2	8	14	17	19	33	43	136
Major Community Parks				1	1	1	1	4
Municipal Open Space		5	7	9	8	11	12	52
Neighbourhood & Local Open Space	6	18	29	30	40	40	55	218
Special Purpose Site					1			1
Grand Total	**9**	**32**	**55**	**63**	**76**	**91**	**125**	**451**

From Figure 25.8a we can easily understand that most of the aged care facilities (marked as a solid black circle) are located in the lower section of the map, while most of the larger conservation areas, open space and landscape sites are located in the top right section of the lower half, too far away to access. Even some of the neighbourhood and municipal open spaces, and major community parks are quite distant from aged care facilities.

In Figure 25.8b while the aged care facilities in this map are comparatively small, a lot of them are quite distant from conservation areas, landscape sites, and major community parks which are often the most equipped to service the needs of senior citizens and those who live in aged-care facilities.

Park and recreation professionals are seeking answers to key questions as they move into a response and prevention mode in the coming days and weeks, especially in communities that are starting to document confirmed cases of COVID-19 (Figure 25.9). As part of hazard identification and mitigation process, it is important to identify any parks near aged care facilities, to provide adequate communication to affected residents when closing or cleaning these facilities or providing advice on the nearest open space at which residents may find natural respite.

The numbers of confirmed coronavirus cases on 12 July are:

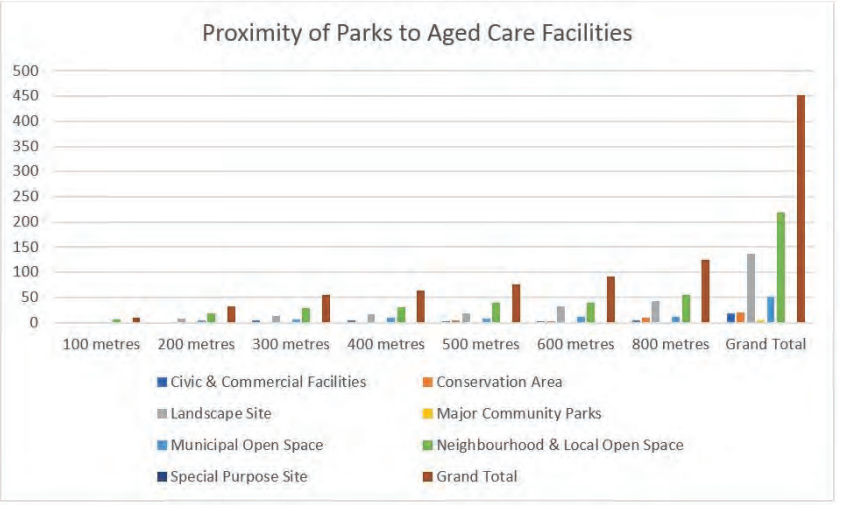
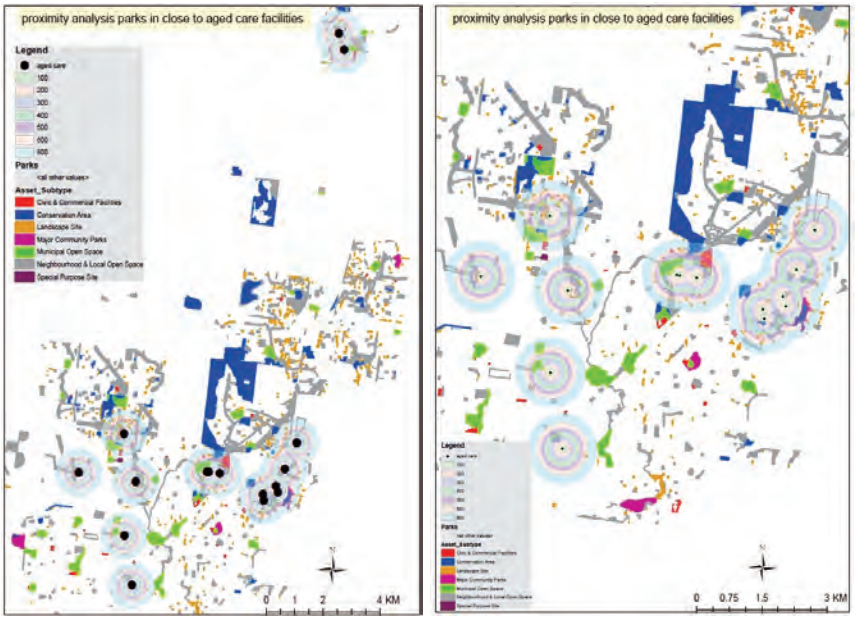


FIGURE 25.7
Proximity of Parks to Aged Care Facilities



(a) (b)

FIGURE 25.8
(a) Proximity of Parks to Aged Care Facilities (b) Proximity analysis parks in close to aged care facilities

- **In Australia:** 9797 cases – 7728 recovered (108 deaths)
- **In Victoria:** 3967 cases – 2329 recovered (24 death)
- **In Whittlesea:** 33 cases (including 2 active cases)

Community transmissions of second wave started to spread across Victorian aged care families.

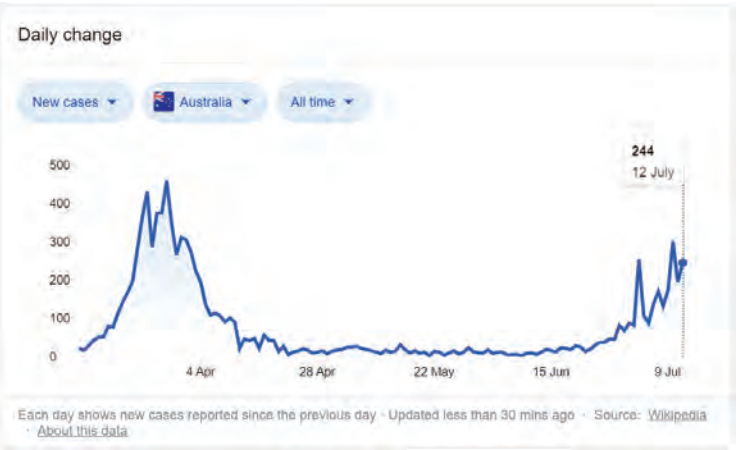


FIGURE 25.9
Daily change coronavirus cases from April to July

As of July 14, 2020, a total of 14 residents and 17 staff at the Menarock Life Essendon aged care facility in Essendon have tested positive to coronavirus, the largest cluster in the state. In this backdrop while planning for location choice for aged care facilities or parks two major criteria should be proximity of recreational facilities to aged care facilities as well as the design of these facilities to ensure social distancing while people are using these facilities.

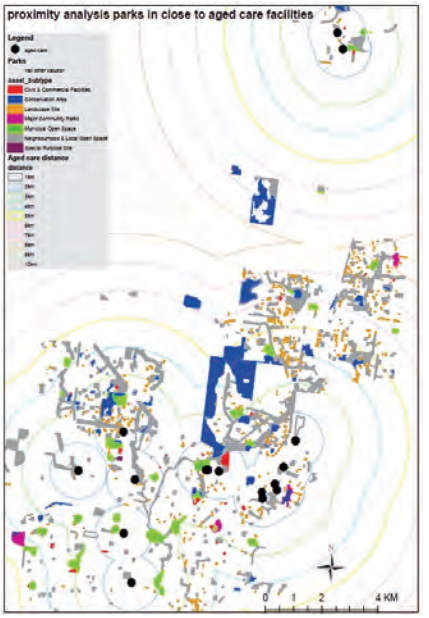


FIGURE 25.10
Age care distance from 1 km to 10 km

25.5 Results Discussion and Limitations

The proximity analysis indicates that aged care facilities are clustered in the south west and west of the municipality and that these centres are in closer proximity to parks. It also reveals that in the northeast (newly developed areas) aged care facilities have not been collocated with parks. The model also reveals that the distribution of Aged care facilities is less dense in the newly developed areas in comparison to older suburbs like Epping, South Morang. Whittlesea, and Lalor. The demographic analysis shows that in order of highest to lowest, the top three precincts consisting of residents who reported they were living with a disability were Epping North, Bundoora and Lalor.

By analysing the impact of multiple demographic factors such as the methodology used herein, information can be gleaned to determine the spatial location of those in most need. Our data analysis shows that residents over the age of 60 who resided in Lalor needed the most support. Lalor had the highest number of people reporting they experienced limitations due to mobility and needed the most support with daily tasks and to overcome limitations they faced when trying to socially participate. Interestingly, the precinct of Lalor also recorded the most respondents to use and have access to aged care facilities and the lowest rate (87.4%) of respondents who indicated they needed the services but could not access them. These results do not directly correlate with the proximity analysis because there were no aged care facilities located in Lalor.

A nearby urban park has been associated with the same mental health benefits as decreasing local unemployment rates by 2 percentage points, suggesting at least the potential for environmental interventions to improve mental health [28]. There are limitations to the application of the proximity analysis we have conducted. It is cross-sectional, making it impossible to control for important confounders, including residential selection, and assumes that the park needs to be in proximity of an Aged-care facility to be utilised by its occupants. The analysis does not provide an evaluation of the impact of the quality, location or suitability of park infrastructure such as seats, barbeques, walking or cycling paths for older people. Another limitation of the study is that it has not evaluated the impact of the modes of transport that would be utilised by residents of Aged-care centres or their carers to facilitate park visitation. Similarly, other than to locate them within a spatial precinct, the survey data does not identify the spatial location of the resident who filled in the survey. This is critical because the likelihood of a person in an aged care facility completing the household survey would be very low; it is complex and requires a certain level of cognitive ability to complete. It could be argued that the survey results reflect more about the composition of households and that specific surveys of residents living in aged care facilities focusing on their interaction with nearby open space within these precincts is required to understand the effect of the proximity to open space on the mental health of residents therein.

Implications for planning and open space policy makers

Mental health policy has traditionally focused on interventions required to cure an illness at an individual scale, such as providing clinical support or improving access to services for sufferers in need of support. It is our contention that mental health policy should shift its focus from curing the individual to prevention by maximising the benefits of environmental determinants such that both the most vulnerable and the broader population may benefit substantially from such measures.

25.6 Conclusions

The paper set out to explore the importance of several parks and the spatial relationship between park availability and COVID-19 across age groups in the CoW. Park-based physical activity is a promising means to satisfy current physical activity requirements for COVID-19 time. However, there is little research concerning what park environmental and policy characteristics might enhance

physical activity levels. This paper analysis and proposes a spatial model to guide thinking and suggest hypotheses. This paper also describes the relationships between park benefits, park use, and physical activity, and the antecedents/correlates of park use.

This paper suggests that in councils policies regarding spatial design, the provision of park space close to residential areas aged care facility and should be considered so that individuals can engage in activities such as walking and exercise [3]. As indicated through our analyses as well as some earlier studies, having a well-designed landscape planning with proximity between aged care and recreational facilities help develop an agile and resilient community ready to physically and mentally cope up with unprecedented events like COVID-19 pandemic. In future research will discuss classification scheme, the discussion focuses on park environmental characteristics that could be related to physical activity, including park features, condition, access, aesthetics, safety, and least cost path analysis and policies. Data for these categories should be collected within specific geographic areas in or around the park, including activity areas, supporting areas, the overall park, and the surrounding neighbourhood. Future research also focuses on how to operationalize specific measures and methodologies for collecting data, as well as measuring associations between individual physical activity levels and specific park characteristics. Collaboration among many disciplines is needed.

Acknowledgments

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26

The Economic Impact of COVID-19 in Pacific Island Countries and Territories

Phil Bright and David Abbott

This chapter describes the impact of COVID-19 on the socio-economic situation of the Pacific Island Countries and Territories (PICTs) during the first nine-months of 2020. Fortunately, only six of the PICTs have had cases of COVID-19 to date, but the far-reaching social and economic effects on such a vulnerable region are significant. This chapter highlights the economic impacts currently being felt, and those which are being forecast for the near future. The chapter is primarily focused on the tourism sector, which is one of the principal industries for the region providing livelihoods for people in both the formal and informal sectors. Spatial analysis of the Pacific situation is limited, but a few examples are presented.

26.1 Introduction

When people think of the Pacific Islands, they often imagine the postcard photo of coconut trees, white sand and turquoise water. This is certainly the case for parts of the Pacific, but in reality the region is very varied with low-lying atoll countries interspersed with high, mountainous and sometimes volcanic islands. The region is made up of thousands of islands spread out across a vast ocean ranging in size from the atoll country of Tokelau with a population of a little over 1,500, to the rugged, and mountainous country of Papua New Guinea with a population of almost 9 million.

The region is also very cultural and ethnically diverse. This is manifest in the more than 800 individual languages in Papua New Guinea (PNG) and the regionally recognised Melanesian, Micronesian and Polynesian sub-regions. Each with its own distinct, yet varied cultures and customs.

In total the Pacific region currently comprises a little over 12.3 million inhabitants and is characterized by relative fast population growth in many countries, notably in Melanesia, and rapid urbanisation (as nationally defined) in countries across the region. The population is expected to increase by more than fifty percent and to pass 20 million in the next 30 years[1].

The region is also among the most vulnerable to natural disasters and climate change. Excluding PNG, 90% of Pacific Islanders live within 5km of the coast [1] making them highly susceptible to sea level rise and extreme weather events, including storm surges, cyclonic damage and coastal flooding. There have also been incidents of earthquake-related tsunamis causing serious loss of life and infrastructure damage in Samoa, Solomon Islands and PNG; and volcanoes have caused similar damage in Vanuatu. Having geospatial data that accurately maps these areas of vulnerability will be essential as the consequences of climate change affect the fragile island environments.

[1] Pacific Data Hub.stat. Population Projections. https://stats.pacificdata.org/

26.2 Socio-economic Context

Although PICTs being small islands in a vast ocean, are often regarded as isolated from the rest of the world and the vagaries of the global economy, in reality they are as fully integrated as any other nation. The economies of the Pacific are very open with merchandise trade, the aggregate value of both imports and exports often exceeding the value of their national Gross Domestic Product (GDP). And most of the smaller, resource-poor, small island states experience persistent balance of trade deficits that amount in some cases to over 70 percent of GDP. In recent years increases in fishing licence fees, revenues from sovereign wealth and trust funds have helped to cover these deficits.

PICTs are also highly dependent on foreign development assistance (increasingly so in the current pandemic environment), worker and family remittances, and receipts from tourism, all of which are directly and closely linked to the state of the global economy. This means they are highly susceptible to the impact of external events or shocks, including the consequential effects of the pandemic even when the health aspects have been largely avoided.

The region is therefore very dependent on the "outside" with remittances being equivalent to around 40% of Tonga's GDP[2], and tourism is estimated to account for between 20-30% of economic activity in many countries including Samoa, Tonga and Vanuatu [2]. There is also a significant dependency on Overseas Development Assistance (ODA) with half of the PICTs falling in the top 15 countries in the world in terms of net ODA received per capita (US$)[3].

Lack of economic opportunities in the small island economies of the Pacific have led to high rates of youth unemployment and significant rural-to-urban-to-overseas migration. This has led to rural depopulation in a number of countries, increasing rural dependency ratios and a reduction in the contribution of rural agriculture to national GDPs. Gender inequality, increasing levels of hardship and basic-needs poverty and the incidence of domestic violence also present significant challenges in the region. Poor health outcomes, largely the result of the prevalence of non-communicable diseases (NCDs) which represent a very high, 75%, of mortality, putting the region above the global average, are also a major challenge [3]. The high prevalence of NCDs also makes Pacific people potentially highly susceptible to the COVID-19 virus and its complications; a major reason for the strict border controls and international movement instituted by most of the island governments.

26.3 Coming of COVID-19 and How It Is Reported in the Pacific Region

26.3.1 The Spread of Covid-19 in the Region

The first case of COVID-19 appeared in French Polynesia on 10 March 2020. Over the next 3 weeks, Guam, New Caledonia, Fiji, PNG and the Commonwealth of the Northern Marianas detected their first cases.

As has been the case globally, PICTs adopted strict measures to close their borders and restrict domestic movement. The timeliness of these measures have resulted in many PICTs recording no cases of COVID-19, and others being able to effectively limit, at least initially, the numbers of cases entering the country. New Caledonia for example, significantly reduced international travel starting on the 18th of March when the first case of COVID was diagnosed. The authorities then enforced a nation-wide four weeks of confinement from the 24th of March, closing schools and non-essential services, and prohibiting leisure activities apart from limited exercise within 1 km of place of

[2]World Bank Data. Personal Remittances, received (% of GDP) https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS?most_recent_value_desc=true

[3]World Bank Data. Net ODA received per capita (current US$) https://data.worldbank.org/indicator/DT.ODA.ODAT.PC.ZS?most_recent_value_desc=true

residence. Shopping was allowed, though any movement outside the place of residence required an "*attestation de déplacement dérogatoire*" which meant everyone moving outside of their immediate residential area needed to carry a statement indicating why the person had left the house. Such an attestation needed to be carried by every household member[4].

As of 15 September there were 3,656 COVID-19 cases (Figure 26.1) and 38 reported deaths in the Pacific, with significant increases reported in the previous four weeks, notably in Guam, French Polynesia and PNG (Figure 26.2)[5]. In New Caledonia where border restrictions were still some of the tightest globally, there were only 26 cases, with none of them being from community transmission.

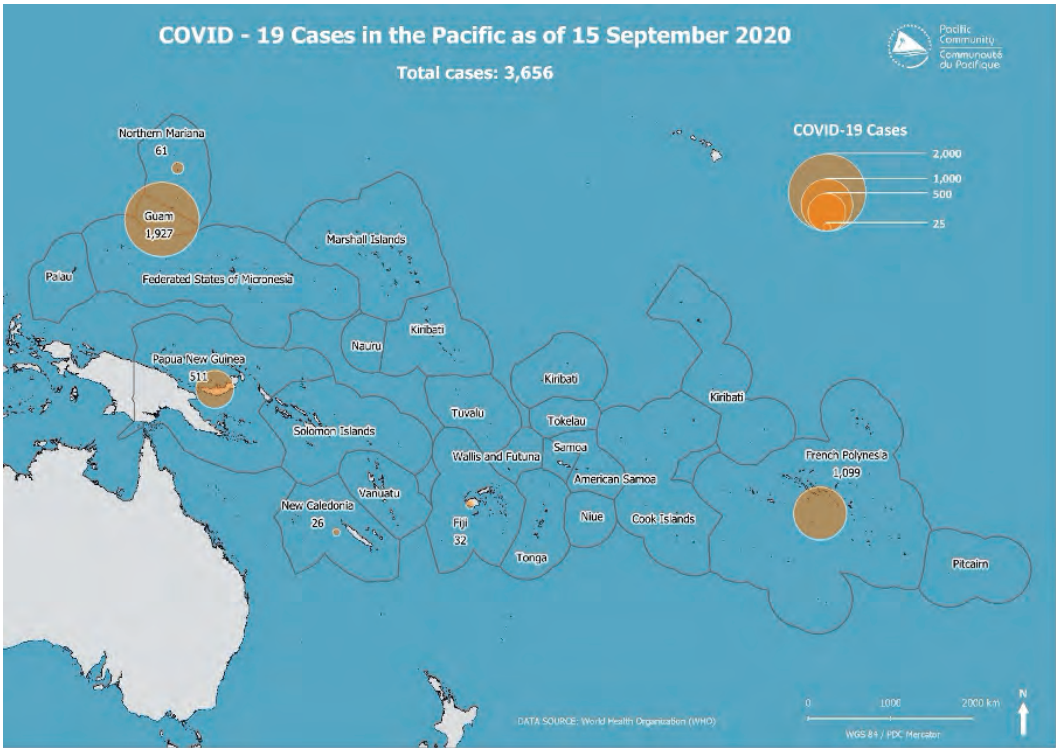

FIGURE 26.1
COVID-19 Cases in the Pacific as of 15 September 2020 (Source: See footnote 5)

26.4 Mapping COVID-19 in the Pacific

Robust spatial data infrastructures in the Pacific's twenty-two countries and territories would be ideal to prepare for and manage a pandemic like COVID-19; "A virus-resilient economy requires knowing exactly where infected people are, living conditions, and access to medical services – all of which hinges on geospatial information" [4].

Although there has been increased adoption of GPS-locational data, satellite and drone imagery, and improvements in the mapping of services and infrastructure, what is generally lacking across

[4]Gouvernement de la Nouvelle Calédonie. Info coronavirus Covid-19. https://gouv.nc/coronavirus
[5]Pacific Community. COVID-19: Pacific Community Updates. https://www.spc.int/updates/blog/2020/09/covid-19-pacific-community-updates

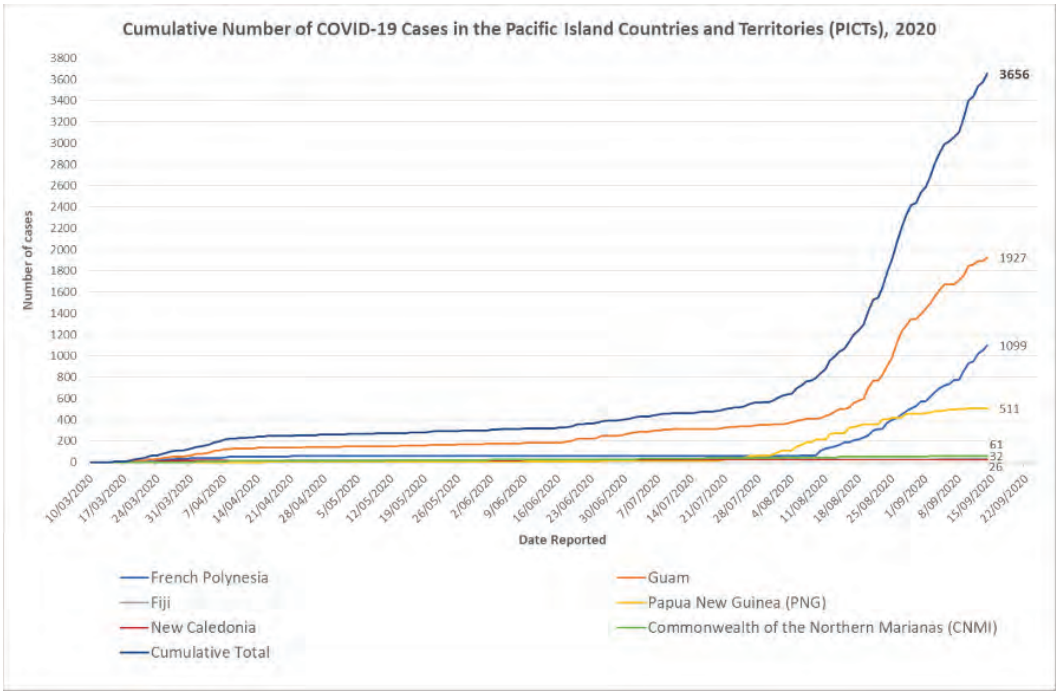

FIGURE 26.2
Cumulative COVID-19 Cases in the Pacific as of 15 September 2020 (Source: See footnote 5)

the region is a way to easily access, utilise and link these disparate data sources. Mobile phone data is also being more frequently utilised and some crowdsourcing of data in disaster situations.

Population grids such as the one shown in Figure 26.3, developed by the Statistics for Development Division (SDD) at the Pacific Community (SPC)[6], are an example of where value-added spatial analysis has been undertaken and can be used in applications such as disaster preparedness and also disaster relief.

To date the use of geospatial tools to analyse the COVID-19 situation at a sub-national level in the region has not been widespread. This is to a large degree because of the limited availability of detailed COVID incidence data, the required local-level socio-economic data, and the resources to perform the analysis. The most detailed mapping the authors are aware of, is that which has been done by the World Health Organisation (WHO) which shows data at a provincial level for most of the PICTs affected by COVID-19.

There is also the Pacific COVID-19 Response Map created by the Australian National University (ANU) CartoGIS, the Australia Pacific Security College (PSC), and the ANU Department of Pacific Affairs to monitor the ongoing responses of Pacific Island Countries and Territories[7]. The map is updated weekly.

26.4.1 Communicating the Pandemic

Communicating nationally important health messages across the countries of the region is frequently very difficult. Internet, TV and mobile phone penetration is very low in many of the poorer and widely dispersed mountainous countries of Melanesia, and amongst the small atoll and island states with widely scattered, small and often isolated communities. Not only is communication difficult but also the collection of the "real-time" data required to monitor and

[6]Pacific Community, Statistics for Development Division. Covid-19. https://sdd.spc.int/disasters-data/covid-19

[7]Policy Forum. Pacific COVID-19 Map. https://www.policyforum.net/pacific-covid-19-map/

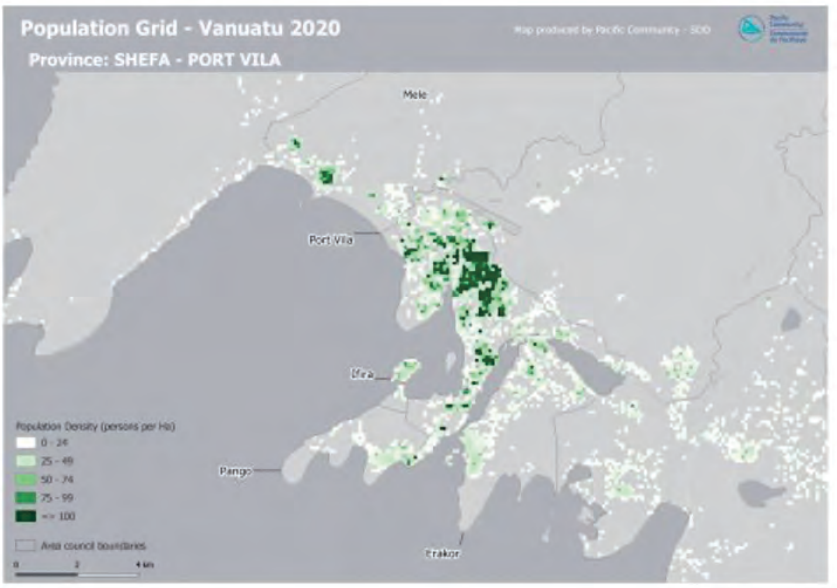

FIGURE 26.3
Population Grid of Port Vila, Efate, Vanuatu with each cell representing $100m^2$ (Source: See footnote 6)

address disaster-related events, such as the COVID-19 pandemic and the tropical cyclones that are a regular occurrence for many.

26.4.2 Awareness and Coping Strategies

In an attempt to overcome this information and communication constraint, the World Bank conducted the first round of High Frequency Phone Monitoring (HFPM) Surveys at the end of June 2020, interviewing more than 3,000 respondents in PNG [5] and over 2,600 in Solomon Islands [6]. The surveys showed that fortunately there was a high degree of COVID awareness, with over 95% of PNG respondents and 91.8% of respondents in Solomon Islands reporting that they were aware of the pandemic; awareness in the Solomon Islands urban centres at 97.4% was however a little higher than in the rural areas (90.9%).

The most important sources of information were reported as the radio 53.2% and 28.4% in Solomon Islands and PNG respectively, followed by family & friends (7.1% & 14.7%), community leaders (9.0% & 13.0%) and newspapers (2.1% & 15.2%). In Solomon Islands the internet and social media (7.4%) and health clinics (6.2%) were also important. These results were reflected across all levels of respondent suggesting that radio is a cost effective and equitable means of providing information to the public at large [6]. See Figures 26.4 and 26.5 below for the PNG results.

The PNG HFPM survey also looked at the coping strategies of those who had lost their jobs or seen their income reduced as a result of the pandemic. Coping strategies for these families included both selling some of their own local produce or livestock to raise needed cash (over one-third of respondents in PNG and just over seventeen percent in Solomon Islands), and/or reducing food or non-food consumption expenditure, an average of 28% in PNG and just over 52% in Solomon Islands. Around one quarter of households in PNG and almost half of households in Solomon Islands reported receiving cash or borrowing from family or friends and in PNG a quarter also reported receiving other forms of assistance from this source. In Solomon Islands almost 45% found ways to earn extra money, 27% used credit or delayed payments and 18.8% received assistance from their church, in PNG only 10.9% reported receiving assistance from this last source.

Of particular concern however was the report from PNG that just over 50% of households had

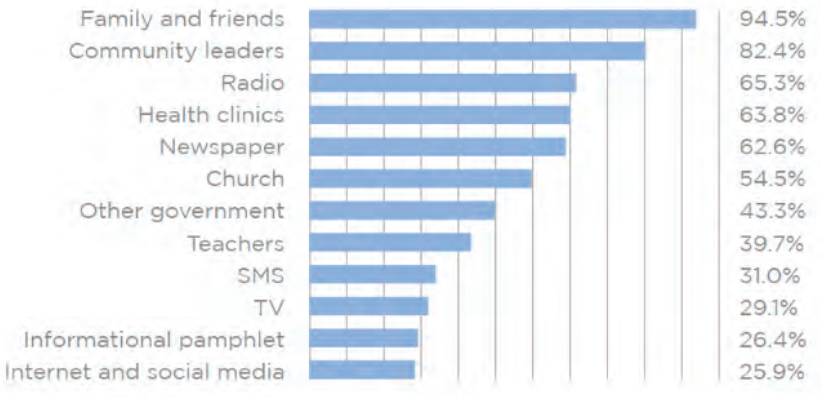

FIGURE 26.4
Sources of Information on COVID-19. World Bank High Frequency Phone Survey, PNG Round 1 June 2020 [6]

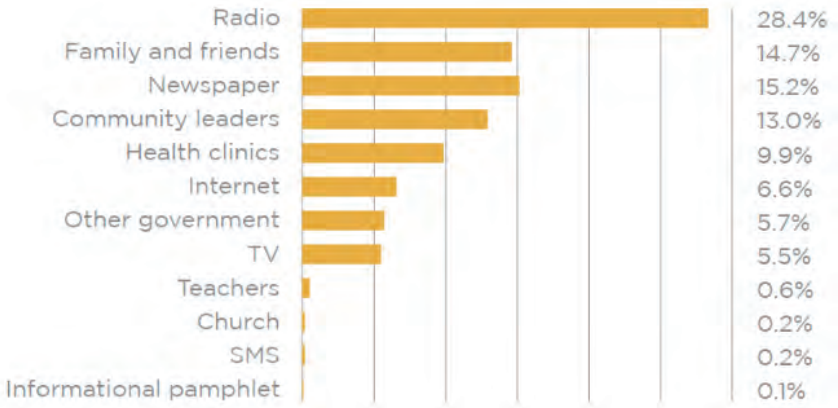

FIGURE 26.5
Main Source of Information on COVID-19. World Bank High Frequency Phone Survey, PNG Round 1 June 2020 [6]

removed children from school. The HFPM did not provide sufficient information to definitively identify the underlying reason for this and it could have been a combination of many factors including financial cost, concern at school-level COVID-19 transmission and the need for additional help in domestic food cultivation. Subsequent rounds of the surveys are expected to delve more deeply into the effects on inequality, gender and children.

26.5 What Is Being done to Monitor the Impact of COVID-19 via Economic Statistics?

The pandemic is adversely affecting almost all activities in the economic and social spheres of the Pacific region. Economic activity in the Pacific Islands has slowed at an unprecedented rate and

scale, triggering major crises in the tourism, trade, financial, construction, personal services and government sectors.

It is also having a serious impact on the informal parts of Pacific economies. For example, many women are involved in selling food and other items in local markets or handicrafts in hotels and tourism sites. With many of these now closed or devoid of tourists the livelihoods of a large number of these informal vendors will have been destroyed. Job losses, restrictions on small businesses and declining remittance flows are therefore likely to be having a major impact on the levels of hardship and poverty being experienced by households and families across the region.

More than three-quarters of the respondents in both HFPM Surveys said they were worried about their household finances in the next month. In PNG there was a bias towards those in the bottom 40% (poorer population) where more than 85% of households were worried (Figure 26.6).

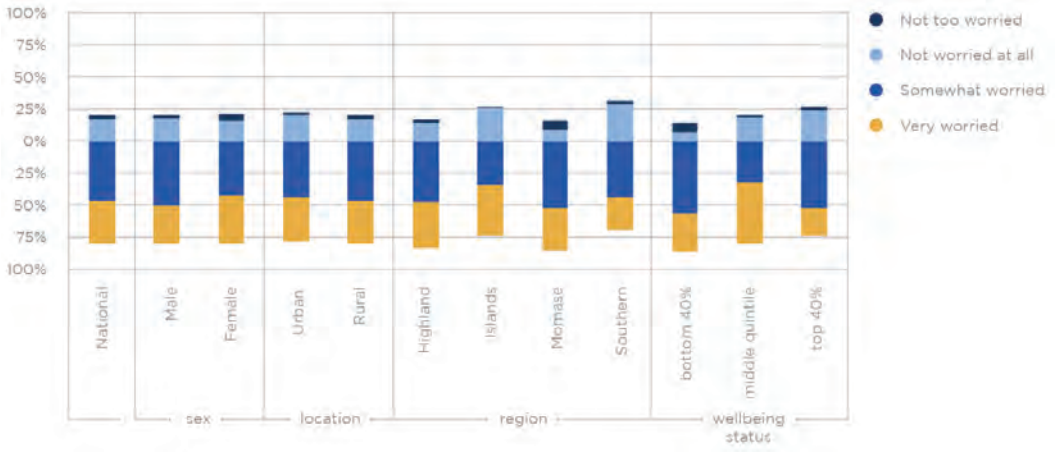

FIGURE 26.6
Financial Anxiety (by sex, location, and well-being status). World Bank High Frequency Phone Survey, PNG Round 1 June 2020 [6]

26.5.1 Economic Impacts and Fiscal Responses

All Pacific countries announced immediate fiscal responses to COVID in March or April [7]. Many have expanded on these as the pandemic has continued to disrupt economic activity, for example the US$37.5 million the Solomon Islands Government is injecting into key sectors. These measures include tax breaks for tourism operators; subsidies for copra and cocoa exporters; concessional loans for large private companies and equity injections for public/private companies. There is also a ramping up of donor-funded infrastructure projects with a focus on local employment [8].

Notwithstanding these early fiscal responses, the extent of the initial and underlying economic impacts are now being seen in available quarterly GDP data and budget forecasts from countries across the region. For example, in the first half of 2020 GDP in Samoa was an estimated 7.7% (in constant 2013 prices) below the level of the first half of 2019. The tourism-related sectors in the Samoa economy were the worst affected with the value-added contribution to GDP of the accommodation and restaurant industries falling by 53.3% and manufacturing, including of food and beverages, falling by a quarter over the same period[8].

The state of the tourism sector in Fiji and elsewhere tells a similar story. In the second quarter of 2020 there were effectively zero tourist arrivals to Fiji, Samoa and Solomon Islands. Employment in the accommodation industry in Samoa was down by 26.6% in the second quarter of 2020 compared to the same period of 2019; decreases in employment in construction (-6.0%), restaurants (-3.0%) and personal services (-4.3%) were also recorded.

[8]Samoa Bureau of Statistics; Gross Domestic product June 2020, September 2020

With tourism being so important to the Pacific, the impact will be felt in areas including government finances, supply chains and transport. The tourism industry in Fiji accounts for roughly 35% of GDP which is why the impact of COVID-19 is estimated to be creating such a large contraction in the Fijian economy.

The impact on the Fiji economy was clearly outlined by the Fiji Finance Minister in his 2020-21 budget address. The Minister reported that by July 115,000 workers, approximately one-third of Fiji's total workforce, had either had their hours reduced or had lost their jobs entirely as a result of the collapse in tourism [9]. As a consequence, the 2020-21 budget projected a 21.7% contraction in GDP in 2020 leading to a forecast budget deficit of 20.2% of GDP in the 2020-21 fiscal year[9].

Somewhat unusually it is those in formal employment that are experiencing the worst of the economic impacts. Most natural disasters deprive rural populations of their livelihoods through destroyed crops and damaged rural infrastructure. This time the pandemic is causing job and income losses principally amongst those previously in formal employment, especially in the tourism and services sector. The border closures and lockdowns have left rural populations relatively unscathed and with continued access to their crops, livestock and fishing grounds. There is, however, anecdotal evidence to suggest that many urban families are returning to their traditional villages and that such return migration, is having adverse impacts through the over-exploitation of coastal fisheries and traditional plantations.

A reduction in sources of income and disturbed supply chains are also impacting Pacific food systems. Governments across the region are implementing various initiatives to enhance the production of healthy local produce. These include distribution of fruit and vegetable seedlings to farmers and families; fast-tracking of existing agriculture initiatives; and distribution of Tilapia fingerlings and feed to stock backyard ponds. Government authorities in some countries have also been buying produce from farmers and delivering to vendors during lockdown periods, where trade in local produce declined due to domestic travel restrictions [10].

The coming fiscal year is likely to be very tough for all Pacific countries. Reduced public revenues coupled with increasing demands for higher public expenditure to support struggling businesses, to provide social protection for the most vulnerable and those being made unemployed by the closed borders, are undermining fiscal stability for many Pacific countries. Demands for external budget support from bilateral donors, international finance institutions and borrowing are increasing [11].

26.5.2 Social Protection

Prior to the arrival of the pandemic and its serious consequences for employment and incomes, it was estimated that across the region as a whole, around one-in-four families were living at or below their respective national basic-needs poverty lines [12]. This suggests that over 3 million Pacific Islanders were struggling to meet a minimum standard of living in their own countries. Estimates by the Australian National University (ANU) Development Policy Centre [13] and the Statistics for Development Division of the Pacific Community (SPC). indicate that if household consumption expenditure declines by an average of between 30%-50% an additional one million people will likely fall below the basic-needs poverty lines during the pandemic[10].

Throughout the Pacific region national governments play a significant role in almost all Pacific economies. However social protection has not generally been a high priority in public expenditure. Traditional Pacific systems of caring and sharing amongst families, kinship groups, communities and church congregations have been left to carry much of the burden. However, these traditional systems have come under pressure as Pacific economies have monetized, migration has increased and the structural nature of societies has changed. Only in a few Pacific countries have social protection systems kept pace with the changing social environment.

Although spending on social protection has increased in recent years (from the equivalent of 4.1% of GDP in 2009 to 6.0% in 2015) [14, p 74] the distribution of benefits tends to favour those in the formal sectors of the economy, primarily through the social insurance provided by national

[9]Pacific Community, Statistics for Development Division. Covid-19. https://sdd.spc.int/disasters-data/covid-19

[10]Pacific Community, Statistics for Development Division. Covid-19. https://sdd.spc.int/disasters-data/covid-19

provident funds and social security administrations. Frequently those engaged in the informal or semi-subsistence sectors have been excluded.

Social assistance is usually universally available to those who meet the criteria for each particular benefit but is nevertheless estimated to only reach around 20% of intended beneficiaries across the region. Social assistance benefits generally provide limited payments for vulnerable people, including the elderly, people living with a disability and for child welfare. Although benefits are comparable, on average, to those seen in Asia, social protection spending in the Pacific reportedly favours the nonpoor over the poor, and men over women [14, p 63]. In 2015 the ADB estimated that, in total, social protection covered only 31.2% of intended beneficiaries in the region [14, p 21]. The extent of the social and economic damage caused by the pandemic has caught most countries off-guard, and social protection responses to COVID are therefore building on a limited base.

With fiscal constraints and limited institutional structures to establish and manage large scale social protection schemes, to date only a few countries have introduced new or increased levels of social protection benefits; these include Cook Islands, Fiji, Samoa and Tuvalu. Only Fiji has a broad poverty-targeted social welfare programme, and thus has institutional arrangements in place to introduce new social protection measures.

But like most other Pacific countries the social protection system in Fiji does not provide comprehensive support for those experiencing such sudden and widespread loss of employment and income. In its 2020-21 budget Fiji allocated around US$50 million (approximately 1% of GDP) in funding for unemployment assistance in 2020-21. If the pandemic-induced economic recession lasts well into 2021 that allocation will not go very far to alleviate the increasing hardship being experienced. The newly unemployed in Fiji and elsewhere across the region will need to find coping strategies to meet their final commitments and basic needs. The newly unemployed in Fiji and elsewhere are largely on their own.

Many governments including Fiji, have allowed those being made unemployed to access a proportion of their own savings in national provident funds. This is generally a nil-cost measure for governments, and one that favours the minority who have provident fund savings. It certainly assists in alleviating the most urgent needs but comes at the expense of depleting savings for retirement. Moreover, it does little for those in the informal sectors. Indeed, some countries, including Fiji, have a condition that access to central government assistance is only available to those who have completely exhausted their own provident fund and other savings, and even then, will receive only FJD220 per fortnight.

26.6 What We Can Learn from COVID-19 for Future Pandemics or Other Disasters?

The social and economic impact of COVID-19 in the Pacific, as with the rest of the world, will likely long outlast the discovery and application of the first vaccines and the reopening of economies. Many small businesses have already closed with their cash flows having already dried up and with no access to additional capital or lines of credit. The confidence of these small entrepreneurs and family businesses, and that of other investors will likely take years to fully recover, indeed if ever [15].

The Pacific is a vulnerable region, whether it be from impacts related to cyclones, earthquakes or other natural disasters, or from pandemics such as COVID-19. Indeed, it might be argued by many in the health sectors of the PICTs that there is an ever-present epidemic situation involving NCDs. These might not have the same macroeconomic consequences as the current COVID pandemic, but at the household and family levels the impact can be just as devastating as the complications often associated with NCDs that remove individuals from the labour force, either as sufferers or as carers.

Travel restrictions and lockdowns have created a perfect storm of social and economic disruption to the small, fragile economies which are highly dependent on external drivers and resources. With

small domestic economies and few economies of scale it is hard to offset the magnitude of the economic losses caused by the closing of borders and disruptions to trade.

"Fiscal space" to enable more resources to be channelled towards public health, providing economic stimulus and improving social "safety nets" [16] can be created through avoiding wasteful spending and improving cost-effectiveness in situations where raising additional revenues might be difficult. Likewise, encouraging household production of fresh produce for home consumption or sale in local markets can reduce dependency on purchased goods, particularly imports of food.

Although the pandemic has raised the profile of social protection as a major policy concern, much remains to be done. For example, would it be desirable or affordable to introduce a national minimum income or social protection floor and better targeting of those in need, especially people with disabilities, the poorest and most vulnerable. The social impact of COVID-19 further highlights the need for improved public sector performance in the delivery of essential public sector service provision including health, education and welfare. The inter-related issues of affordability, social preferences and performance might be better served by engaging more cooperatively and effectively with civil society and the private sector.

26.7 Building Preparedness Through Better Data

Administrative systems and data collection processes lack the efficiencies which generally exist in more developed countries. This can result in data being hard to access and collate, and in some countries with limited statistical capacity the data might not be collected at all. This makes it difficult to effectively prepare for a pandemic or such a similar event, or to monitor the impacts should such an event occur. In addition, sub-national disaggregation is either non-existent or data is only disseminated in a highly aggregated form, making detailed spatial analysis difficult. This is an area which needs to be improved, not only to assist with the management of pandemics, but to assist in infrastructure planning and building climate change resilience.

The collection of locational data has improved with the utilisation of Global Positioning Systems (GPS) and Computer Aided Personal Interviews (CAPI) during census and survey fieldwork which has facilitated the development of population grids for many PICTs. If pandemic case data were also recorded and disseminated at a highly disaggregated level then more complex analysis would be possible.

More could be done to prepare for future events including natural disasters and pandemics through better data compilation and monitoring of emerging trends and issues. In particular, sharing of administrative data between government ministries, agencies and state-owned enterprises and the national statistics offices could enable data to become available more quickly and more comprehensively.

As connectivity across the Pacific region also improves, the use of "big data" and the wider use of geo-spatial and satellite data from global platforms will allow much greater understanding of how and where Pacific people are living, and how their local environments and livelihoods are being affected by climate change, migration and other shocks and disasters.

The long-term sustainability of the Pacific islands, especially the low-lying atolls and islands depends on the regular monitoring and assessment of these factors and events on the people and their social-economic environments.

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27

Promoting Resilience While Mitigating Disease Transmission: An Australian COVID-19 Study

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In this Chapter, we present evidence to inform evolving COVID-19 response planning by analysing how Australians were thinking, feeling and behaving in response to the so-called "first wave" of the COVID-19 epidemic and the associated public health measures. These topics were explored through an online survey of Australian adults (n=999) between 3–6 April 2020, less than one week after "stay-at-home" restrictions were enacted nationally to mitigate the spread of COVID-19. To explore if and how people's thoughts, feelings, and behaviours may have changed over time, we fielded the same survey between 28 April and 6 May 2020 (n=1020), with 732 respondents completing both surveys. Overall, our study found high levels of community acceptance and adherence to physical distancing measures. While physical distancing measures have proven highly effective at mitigating disease transmission worldwide, they have substantial social and economic costs. Our results highlight the negative social and emotional impacts of physical distancing and the importance of complementary policies that enable social connection and self- and collective efficacy to minimise these impacts and promote community resilience.

27.1 Introduction

Australians watched with concern when the novel coronavirus SARS-CoV-2 was first reported in Wuhan, China in December 2019 [1]. Concern turned to alarm as, by March 2020, the virus had spread to all global regions, and COVID-19 (the disease caused by SARS-CoV-2) was threatening to overwhelm some of the world's economies and strongest health systems [2, 3]. In the absence of an effective treatment or vaccine for COVID-19, physical distancing measures soon formed the cornerstone of the global response — at a scale that was not typically contemplated by existing pandemic plans [4–8].

There is so much that is new about this pandemic that "unprecedented" soon became the most used word in formal and informal discussions about how to deliver a proportionate public health response. Indeed, in free text responses to our first survey (described later), respondents referred to it by emotive names such as "rotten", "disgusting", and "invisible". Some worried that scientists did not understand its basic biological processes.

This chapter presents evidence to inform continued, evolving response planning in Australia, and where relevant, in other countries around the world. It includes findings from two nationwide surveys [9, 10] asking the overall question: How were Australians thinking, feeling and behaving in response to the "first wave" of the COVID-19 epidemic and the associated public health measures?

By doing so, we aim to guide decision-making on how best to manage disease transmission and promote community resilience.

Specifically, we provide insight into levels of transmission-reducing behaviours, how these changed over time, and how these behaviours related to people's concerns and perceptions. We explore how these trends differed between lower- and higher-impacted Australian states and territories.

Next, the chapter reports on the social and emotional impact of COVID-19 on Australians. Internationally, it is agreed that five elements are essential to support people and communities confronted with large scale-disaster and loss in the immediate and mid-term [11]. These elements, which also underpin Psychological First Aid [12, 13], are the promotion of: a sense of safety; calm; a sense of self- and community efficacy; connectedness; and hope. We conclude with insights into how these elements interacted with people's mental health and wellbeing during pandemic restrictions.

27.2 Early Phase of the Australian Epidemic and the Public Health Response

Australia has a federated political system featuring overlapping responsibilities between a federal government, eight state and territory governments and local governments. The political geography of Australia, as an island continent, has informed the shape of the responses. Over two decades, one of the most strident political positions for successive federal governments has been to use its authority to control the national borders to reduce the number of refugees arriving by boat to seek asylum in Australia. By contrast, the eight states and territories, with different climates, industry, population structures and geography, have their own powers to close borders to other jurisdictions. In response to COVID-19, a National Cabinet was quickly formed to improve communication, co-ordination across states and territories, and joint decision making.

The first case of COVID-19 was detected in Australia on 22 January 2020 [14]. On 1 February, when China was the only country reporting uncontained transmission, Australia closed its borders to mainland China [15]. Australia only reported 12 cases of COVID-19 through February. By contrast, globally the number of confirmed cases and geographic extent of transmission continued to increase drastically [16]. By early March, Australia faced the threat of importation from all global regions, and governments and health authorities were concerned when daily case counts rose sharply through the first half of March. Although more than two thirds of cases were connected to returned travellers who acquired their infections overseas, pockets of local transmission were reported in the cities of Sydney and Melbourne [17].

As a result, from 16 March 2020 the eight state and territory governments of Australia used their own authority to progressively implement physical distancing measures to prevent and reduce community transmission of SARS-CoV-2 [18]. By 29 March 2020, all Australians were strongly advised to leave their homes only for limited essential activities and public gatherings were limited to two people (known as "stay-at-home" restrictions). These measures were in addition to self-isolation advice for (mild) confirmed cases and their contacts, as well as for returned overseas travellers.

By late March, daily counts of new cases were declining, and the effective reproduction number was estimated to be below 1 [19], indicating that the collective actions of the Australian public and government authorities had successfully mitigated a first epidemic wave. Of the 7,075 confirmed cases of COVID-19 in Australia up to 17 May 2020, 70% were acquired overseas [20].

27.3 Understanding the Response of Australians to COVID-19

To develop a timely understanding of how people in Australia were thinking, feeling, and behaving in relation to the COVID-19 pandemic and the associated response measures, we conducted two nationwide surveys.

The first survey was conducted online from 3 to 6 April, shortly after the activation of "stay-at-home" restrictions in response to the initial wave of imported infections, and the other three weeks later (29 April to 6 May) when restrictions remained in most state and territories (Figure 27.1). Western Australia commenced easing of restrictions on 27 April [21], followed by the Northern Territory and New South Wales on 1 May [22, 23]. Note that all data were collected during the first epidemic wave, prior to the establishment of a second wave in the state of Victoria in late June 2020 [24].

FIGURE 27.1
Plot of national daily new case notifications in Australia [25], timings of key national response policies and Surveys 1 (teal) and 2 (blue). Note: we include both overseas and locally acquired cases in the daily case counts. Of all cases in Australia notified up to 17 May 2020 with a known place of acquisition (95%), 70% were acquired overseas [20]

27.4 Overview of Data Collection and Analysis

The sample size of Survey 1 was 999 Australian residents aged 18 years and over. The sample size of Survey 2 was 1020 individuals, of which 732 (71.8%) had previously completed Survey 1. Results were weighted and are representative of the adult population in Australia (as described below).

The two surveys were based on research developed and conducted by Imperial College in the UK in mid-March 2020 [26]. Some questions in the Australian survey were modified slightly to reflect local response measures and terminology. Additional questions were added to the Australian survey to measure social and emotional impacts. Data collection in both the UK and Australia was conducted by the online market research agency YouGov.

We used a structured questionnaire addressing the following three domains:

- perceptions of risk and consequences of COVID-19 infection;
- measures taken by individuals to protect themselves and others from COVID-19 infection; and
- social and emotional impact.

Finally, we included an open-ended question to allow people to express their main concern regarding the COVID-19 pandemic. The question requiring a free text response was: "What is your biggest concern at the moment?" All respondents answered the question as it was mandatory. We conducted thematic coding, informed by Framework analysis [27] which was designed to code qualitative data in order to inform policy and practice. The data reported here are primarily a sub-section of the total coding frame, designed to illustrate key points in the quantitative analysis.

The questionnaire was administered online to members of the YouGov Australia panel of individuals who have agreed to take part in surveys of public opinion (over 120,000 Australian adults). Panellists, selected at random from the base sample, received an email inviting them to take part in a survey, which included a survey link. Once a panel member clicked on the link and logged in, they were directed to the survey most relevant to them available on the platform at the time, according to the sample definition and quotas based on census data. A plain language statement appeared on screen and respondents were required to electronically consent prior to the survey questions appearing. Proportional quota sampling was used to ensure that respondents were demographically representative of the Australian adult population, with quotas based on age, gender, income and location (state and metropolitan or regional).

The study was by approved by the University of Melbourne Human Research Ethics Committee (2056694).

27.5 Geographic Variation in COVID-19 Epidemiology and Public Health Response in Australia

Our analyses differentiated between lower-impacted and higher-impacted jurisdictions because of the geographical variation in COVID-19 epidemiology and the associated physical distancing policies. Australia's two most populous states, New South Wales (more than 8.1 million people) and Victoria (more than 6.1 million people), also the most exposed to international travellers, experienced considerably higher total numbers of confirmed cases and peak daily incidence than other jurisdictions [14]. Consequently, people living in New South Wales and Victoria also experienced longer periods of restriction on their movement and social gatherings. New South Wales and Victoria are therefore defined as higher-impacted jurisdictions and all other jurisdictions as lower-impacted jurisdictions (Figure 27.2).

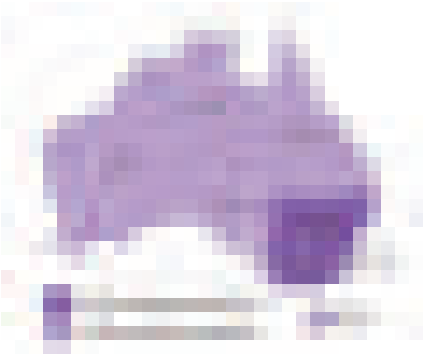

FIGURE 27.2
Map of the higher and lower impacted jurisdictions in Australia.

27.6 Findings

27.6.1 How did people perceive the risk and consequences of SARS-CoV-2 infection?

Respondents perceived that their risk of SARS-CoV-2 infection decreased between the two survey periods, which coincided with a reduction in disease prevalence across Australia. Fewer respondents believed that it was likely they would be infected with SARS-CoV-2 at some point in the future at Survey 2 (29.6%) compared to Survey 1 (38.2%). This change was similar across lower- and higher-impacted jurisdictions.

There was little difference in perceived severity of SARS-CoV-2 infection between surveys. In both surveys, older adults were more likely than younger adults to believe that, if infected themselves, SARS-CoV-2 would be life-threatening or very severe (requiring hospitalisation). Respondents with a self-reported health status of "poor" or "fair" were also more likely to believe that, if infected, their infection would be very severe or life-threatening compared to those who reported being in "good", "very good", or "excellent" health. These self-assessments are consistent with risk profiles for COVID-19 where increasing age and comorbidities are associated with more severe outcomes [28]. Despite having different risk profiles, responses between males and females were very similar.

27.6.2 How did people change their behaviours to prevent the spread of COVID-19?

Overall, very high levels of physical distancing behaviour were reported at both Surveys 1 and 2 (Figure 27.3).

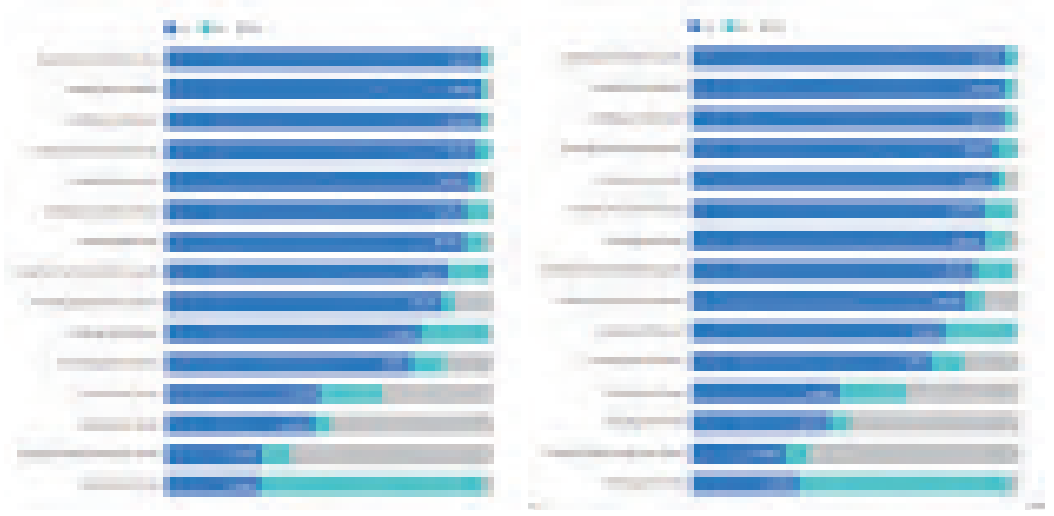

FIGURE 27.3
Percentage of respondents taking measures to protect themselves and others from SARS-CoV-2 infection at Surveys 1 (left) and 2 (right). Applying social distancing rules = "staying 1.5m apart, not shaking hands etc". Keeping children home from school = "keeping children home from school when schools are open". N/A = not applicable to me.

SARS-CoV-2 spreads via close contact between infectious and susceptible individuals. The rate of spread depends on a number of factors, including 1) the number of social contacts made

by an infectious individual and 2) the nature of those encounters (how long they were, whether there was physical contact, whether they occurred indoors/outdoors). Both of these factors are impacted by changes in physical distancing behaviour. Accordingly, we used two types of physical distancing behaviour in our analyses. Firstly, behaviour that reduces the number of daily contacts made by an individual (excluding members of their household), such as working from home or avoiding social gatherings ("macro-distancing" behaviour). Secondly, behaviour that reduces the per contact probability of transmission such as handwashing, avoiding physical contact, and staying 1.5m apart from others ("micro-distancing" behaviour). Distinguishing between these two types of behaviour and directly measuring them through population surveys has been critical to monitoring the transmission potential of SARS-CoV-2 [29].

In the longitudinal subsample, there was no meaningful difference in the percentage of respondents applying micro-distancing measures (keeping 1.5 metres away from others, not shaking hands, etc.) between Survey 1 (97.0% [96% CI: 95.9, 98.2]) and Survey 2 (96.5% [95% CI: 95.4, 97.9]). There was no meaningful change in the overall percentage of respondents washing their hands more frequently at Survey 2 (92.1% [95% CI: 90.3, 94.0]) compared to Survey 1 (94.6% [95% CI: 93.1, 96.2]).

Our results indicate that Australians reached high levels of self-reported adherence to micro-distancing measures recommended in March 2020 and maintained these behaviours into early May.

On the other hand, our results provide evidence of a reduction in macro-distancing behaviour between early April and May. In the longitudinal subsample, there was an increase in the number of people reporting 2–3 non-household contacts and a decrease in the number of people reporting 0 daily non-household contacts between Survey 1 and 2 (Figure 27.4). The easing of restrictions in both lower- and higher-impacted jurisdictions overlapped with the timing of Survey 2.

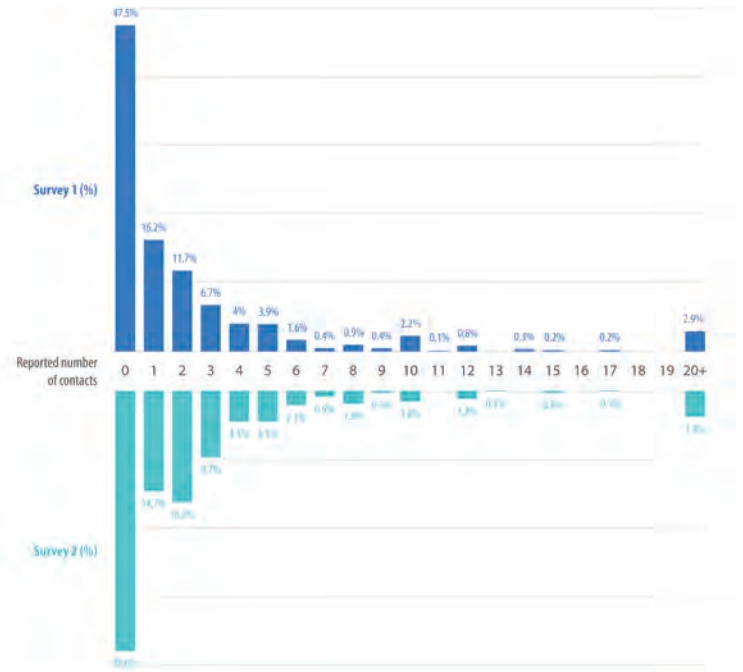

FIGURE 27.4
Reported number of non-household contacts at each Survey. A contact was "considered either a face to face conversation of a least three words or any form of physical contact, such as a handshake". Note that the bar charts are truncated at a maximum of 20 contacts, to better visualise spread values > 20, which comprised only 3% of respondents.

In both surveys, younger adults were more likely than older adults to report having a high number of contacts. However, the number of contacts was also linked to profession, with respondents working in health and medical services, air travel, restaurant services and retail more likely to report a high number of contacts outside of their household unit.

27.6.3 How were people's concerns and perceptions related to their adherence to prevention measures?

We examined how the change in reported perception of infection risk was associated with changes in the number of daily non-household contacts made and adherence to certain preventative measures. We report only associations between variables and make no attempt to infer causative relationships. For repeat respondents, the mean change in reported non-household contacts in the previous 24 hours showed an increase of 0.7 (95% CI: -1.6, 3.0) additional contacts at Survey 2 compared to Survey 1. This varied by change in perceived risk of infection. At Survey 2, those who believed they were less likely to be infected had a mean reduction in non-household contacts (1.83 fewer contacts on average than Survey 1). This varied between lower-impacted (0.75 fewer contacts) and higher-impacted (2.54 fewer contacts) jurisdictions. Those who showed no change or an increase in perceived risk of infection at Survey 2, showed a slight increase in non-household contacts (0.15 additional contacts on average).

A univariate multinomial regression showed that those who said they were at lower risk of SARS-CoV-2 infection at Survey 2 had a 1.1-fold [95% CI: 0.65, 1.86] increase in odds of reporting fewer non-household contacts at Survey 2 than those who reported no change in perceived risk of infection. Note that the wide confidence interval spanning 1 does not preclude the possibility of no effect or an effect in the opposite direction.

Analysis of the free text responses from Survey 2 showed a new (relative to Survey 1) and dominant theme linking community complacency, distancing, and a second wave of infections. Respondents were not so much blaming people, but suggesting that as time goes by there is a natural tendency to become complacent, contributing to a second wave, for example:

> *"Australians will become complacent, and the second wave of outbreaks will not be able to be controlled effectively."*

Together with the quantitative findings of high levels of physical distancing behaviour, this suggests that some respondents were indeed maintaining distancing measures irrespective of the risk of personal infection: perhaps explained by their concern about the population (rather than personal) level implications of a second wave.

27.6.4 What was the social and emotional impact of COVID-19?

At both Surveys 1 and 2, a significant minority of respondents reported symptoms indicating high levels of anxiety (24.2% and 19.9%, respectively) and high levels of depressive symptoms (17.5%, and 17%, respectively).

Conversely, 60.8% (Survey 1) and 65.1% (Survey 2) of respondents were either somewhat or very optimistic about their future. People experiencing higher feelings of hope for their future were more likely to report lower levels of depression and anxiety.

In our longitudinal subsample, there was a statistically significant decrease in mean anxiety scores [1] between Survey 1 (6.9) and Survey 2 (6.4). This result suggested that most survey respondents experienced a slight decrease in anxiety symptoms but remained in the normal range. However, the percentage of respondents who reported high levels of anxiety and may require professional mental health support increased between Survey 1 (15.4%) and Survey 2 (19.4%).

Free text responses revealed fewer expressions of worry about the pandemic between Surveys 1 and 2. At Survey 1, the dominant themes in concerns named by respondents were people, virus and

[1] As measured with the Hospital Anxiety and Depression Scale, out of a maximum of 21 points, scores between 0 and 7 are considered in the normal range, while cases with scores of 11 or above may require professional mental health support.

health. "People" referred both to fears for the health of family and close friends, and concerns that not everyone was adopting distancing measures. Respondents used many different words expressing concern about economy, income and family and social factors. At Survey 2, people remained the dominant concern while the statements raising concerns about virus and health decreased in number. There was a large increase in the word "restriction", and more mentions of economy. At Survey 2, the words used to describe the virus were very different. There were fewer emotive statements about the scary or unknown characteristics of the virus. Although there were similar comments about spread in the virus compared with Survey 1, new concerns emerged about lack of herd immunity, winter coming in Australia, and a fear of a new spike or second wave. Some thought the health system would not be able to cope. Others had very serious personal concerns such as being about to give birth to their first child or the health of vulnerable family members.

27.6.5 How did COVID-19 affect people's connection to others and people's connection to others influence their experience of COVID-19?

At both surveys, higher levels of community connectedness were significantly associated with lower levels of depression and anxiety (see Table 27.3). Regarding social support, 68.7% (Survey 1) and 67.2% (Survey 2) of respondents said that they could rely on two people or more for assistance or support during the pandemic if they needed it. Meanwhile, 9.9% (Survey 1) and 10.0% (Survey 2) reported that they had no one to rely on. These individuals may be at increased risk of negative mental health effects as higher levels of anxiety and depression were significantly associated with having fewer people to rely upon for assistance or support during the pandemic.

Additionally, 68.4% (Survey 1) and 68.0% (Survey 2) of respondents said that two or more people relied on them for assistance or support during they pandemic. Those with more people who relied on them for assistance or support showed lower levels of anxiety and depression.

Free text responses in both surveys revealed evidence of altruism expressed in concerns for other groups of people, society in general and social justice. Respondents were concerned about "the loss of jobs of many vulnerable groups in the society, leading to unemployment and homelessness:" "temporary residents" and "survival of the less privileged in the society." Some said that while they were "financially OK," they were "concerned for the world in general and the impact on those who have lost more" leading to "an even larger gap between the rich and the poor." A small number of respondents were concerned for their employers:

> *"If I had to self-isolate, would have a dramatic impact on my employer; I would find that hard to deal with."*

There were more responses about altruism and social justice in Survey 2 than in Survey 1, for example:

> *"I am fine. My biggest concern is for those who are not or will not be. That I will catch it without knowing and pass it on to the more vulnerable."*

Some also spoke of concerns about domestic violence, aggressive behaviour and crime.

27.6.6 Level of worry about the COVID-19 outbreak in Australia

Respondents were asked to report their level of worry about the COVID-19 situation in Australia. Considering only those who responded to both surveys, the percentage of respondents who reported being worried about the COVID-19 outbreak in Australia decreased from 84.0% at Survey 1 to 69.2% at Survey 2. This trend was consistent across lower- and higher-impacted jurisdictions.

Respondents who were less worried about the COVID-19 outbreak in Australia at Survey 2 (compared to Survey 1) had a mean increase in non-household contacts (1.37 more contacts), however respondents residing in higher-impacted jurisdictions had a smaller mean increase (0.56) compared to lower-impacted jurisdictions (2.35).

Respondents who were more worried about the COVID-19 outbreak in Australia had an

overall mean decrease in contacts at Survey 2 (1.11 fewer contacts), however respondents residing in higher-impacted jurisdictions had a mean 2.44 fewer contacts and those in lower-impacted jurisdictions had a mean 1.75 more contacts.

We propose that individuals who were less worried once relative control of the epidemic was achieved (by the time of Survey 2), may have had lower levels of adherence to macro-distancing measures. Individuals who were more worried at Survey 2, appeared to be more cautious about making contacts. In both groups, individuals residing in higher-impacted jurisdictions made less contacts than those in lower-impacted jurisdictions, potentially reflecting different levels of restrictions. However, the easing of restrictions in both lower- and higher-impacted jurisdictions overlapped with the timing of Survey 2. It should be noted that our study does not distinguish between types of contacts (e.g., social versus workplace) and how "essential" these contacts might be deemed under different levels of restrictions: for example, the limited choices available to front line workers to reduce their contacts.

TABLE 27.1
Daily number of non-household contacts.

	More worried at Survey 2	Less worried at Survey 2
Higher-impacted jurisdictions	2.44 fewer	0.35 more
Lower-impacted jurisdictions	1.75 more	2.35 more
Overall	1.11 fewer	1.37 more

27.6.7 Perceptions of the future for Australia and the world

At the time of data collection for Survey 2, the majority (95.4%) of respondents were confident they could manage until the restrictions due to COVID-19 were over, however only 52.8% were confident that Australia could manage until the restrictions were over.

Feelings of confidence were also reflected in some of the answers to the survey's open question, for example: "I am feeling very confident that Australia has beaten this virus so am just looking forward to going out again."

High numbers of respondents in both Surveys provided free text responses criticising the behaviour of other people, suggesting some sort of moral, character or behavioural flaw. In Survey 1 there were more concerns about such behaviour: very many spoke of *"Not adhering to rules"* and a number about *"Hoarding and panic buying"*. Concerns about behaviour were linked to the invisibility of the virus and young people's actions.

At Survey 2, 60.4% of respondents were either somewhat or very optimistic about the future of Australia, and 47% felt the same way about the future of the world.

The answers to the survey's open question on people's biggest concern were not, however, all bleak. Some spoke of qualified hope or optimism, for example:

"I don't want to imagine anything negative right now, hope for the best."

"That we all stay positive"

Higher feelings of hope for the future of Australia and the world were significantly associated with lower levels of depression and anxiety. These results were consistent with Survey 1.

27.6.8 Five elements to support people and communities confronted with disaster

In this section, we summarise patterns of responses to the five elements to support people and communities confronted with large scale-disaster and loss in the immediate and mid-term [6]. We also explored how these five elements interact with people's mental health and wellbeing during pandemic restrictions.

Overall, we found that higher feelings of hope, connectedness, self and community efficacy, calm and safety were significantly associated with lower levels of anxiety and depression (Table 27.3).

TABLE 27.2
Summarises patterns of responses to the five elements to support people and communities confronted with large scale-disaster and loss in the immediate and mid-term.

Element	Findings
Calm	During both surveys, most poll respondents said that they could sit at ease and feel relaxed (66.1% at Survey 1 and 70.6% at Survey 2).
Sense of safety	The proportion of respondents who believed it was very likely or somewhat likely that they would become infected with COVID-19 was 38.2% at Survey 1 and 29.7% at Survey 2. In our longitudinal subsample, respondents' perceived likelihood of becoming infected decreased between Surveys 1 and 2.
Efficacy	**Self-efficacy**: during both surveys, most respondents felt they could manage until restrictions due to COVID-19 were over (89.9% at Survey 1 and 68.1% at Survey 2). Although the percentage of people who felt confident decreased between Survey 1 and 2, respondents' mean scores in self-efficacy tended to increase. **Collective efficacy**: the percentage of respondents who felt Australia could manage until restrictions due to COVID-19 were over was lower at Survey 2 (77.4% at Survey 1 and 52.8% at Survey 2).
Community connectedness	In Survey 1, out of a total score of 30 points, the mean score for community connectedness * was 22.36 (standard deviation = 4.59). Meanwhile, in Survey 2, the mean score was 22.68 (standard deviation = 4.54).
Hope	**About one's future**: in Survey 1, 60.8% of respondents were either somewhat or very optimistic about their future, and 65.1% felt this way at Survey 2. **About the future of Australia**: in Survey 1, 56.5% of respondents were either somewhat or very optimistic about the future of Australia, and 60.4% felt this way at Survey 2. **About the future of the world**: in Survey 1, 46% of respondents were either somewhat or very optimistic about the future of the world, and 47% felt this way at Survey 2.

* Measured with the Social Solidarity Index [30]

TABLE 27.3
Bivariate correlations (2-tailed) between the five elements of mid to long-term recovery[11] and levels of depression and anxiety measured with the Hospital Anxiety and Depression Scale (HADS)

	Correlation [95% CI]			
	Anxiety		Depression	
	Survey 1	Survey 2	Survey 1	Survey 2
Calm	-0.208 [-0.269, -0.147]	-0.202 [-0.264, -0.140]	-0.099 [-0.162, -0.037]	-0.126 [-0.189, -0.063]
Sense of safety	-0.248 [-0.318, -0.179]	-0.225 [-0.292, -0.158]	-0.041 [-0.114, -0.032]	-0.132 [-0.201, -0.063]
Self-efficacy	-0.204 [-0.265, -0.143]	0.046 [-0.015, 0.108]	-0.261 [-0.321, -0.201]	0.060 [-0.002, 0.121]
Collective efficacy	-0.032 [-0.094, -0.030]	-0.039 [-0.101, 0.022]	-0.099 [-0.161, -0.037]	-0.002 [-0.064, 0.059]
Community connectedness	-0.163 [-0.232, -0.095]	-0.168 [-0.239, -0.098]	-0.196 [-0.264, -0.129]	-0.254 [-0.322, -0.187]
Hope for one's future	-0.251 [-0.313, -0.190]	-0.292 [-0.352, 0.232]	-0.348 [-0.407, -0.288]	-0.381 [-0.439, -0.323]
Hope for the future of Australia	-0.123 [-0.186, -0.060]	-0.170 [-0.232, -0.108]	-0.224 [-0.286, -0.162]	-0.249 [-0.310, -0.189]
Hope for the future of the world	-0.059 [-0.123, 0.005]	-0.127 [-0.189, -0.064]	-0.158 [-0.221, -0.095]	-0.183 [-0.244, -0.121]

27.7 Discussion and conclusions

In this chapter we have presented evidence to inform evolving COVID-19 response planning by analysing how Australians were thinking, feeling and behaving in response to the first wave of the COVID-19 epidemic and the associated public health measures. We explored these topics through an online survey of Australian adults (N=999) between 3–6 April, less than one week after "stay-at-home" restrictions were enacted nationally. To explore if and how people's thoughts, feelings, and behaviours may have changed over time, we fielded the same survey between 28 April and 6 May (N=1020), with 732 respondents completing both surveys.

High levels of adherence to physical distancing measures were reported in early April and high levels of micro-distancing behaviour (e.g., hand washing, staying 1.5m from others) were maintained into May. There was some evidence of a decrease in macro-distancing behaviour (i.e., number of non-household contacts), which differed by jurisdiction and level of worry (see Table 27.1 for detail). Free text responses revealed fears that lockdown would be eased too early leading to a second wave. Added to concerns that people would become complacent, this suggests strong support for distancing measures.

While the level of worry about the pandemic in Australia decreased between early April and May 2020 overall, the group of individuals who reported increased levels of worry, reported lower rates of non-household contacts. This suggests that people's level of concern about the outbreak may impact their adoption of physical distancing behaviours. The trend was most marked for individuals residing in higher-impacted jurisdictions (New South Wales and Victoria). It should be noted that our study does not distinguish between types of contacts (e.g., social versus workplace) and how "essential" these contacts might be deemed under different levels of restrictions: for example, the limited choices available to front line workers.

Our findings are consistent with a number of other studies assessing people's response to COVID-19 public health measures. Recent studies conducted in China [31], Hong Kong [32], Japan [33], Korea [34], the Philippines [35], the United Kingdom [26], the United States [36], Germany, Italy and the Netherlands [37] report high levels of adoption of and broad support for physical distancing measures, during the period under study. Other studies conducted during/after the epidemics of severe acute respiratory syndrome (SARS) in 2003 [38], influenza A(H1N1)pdm09 in 2009 [39], and more recently, during the COVID-19 pandemic [40], have reported that higher levels of worry and/or perceived risk of infection were associated with the adoption of infection-prevention behaviours. However, it is important to also consider the influence of sense of self-efficacy on behaviours because previous evidence [41] shows that "when the threat was high as compared to low, people changed their behaviour in the advised direction only when efficacy was high, and not when efficacy was low". In fact, when efficacy was low, the behaviour change showed, if anything, an effect in the unhealthy direction" [42]. Further analyses are required to examine the relationship between the perception of risk, self- and community efficacy, and behaviour change [43]. At the time of writing, we did not identify any published longitudinal studies assessing how perceptions and behaviours may have changed during the course of the COVID-19 pandemic and response.

Since the success of physical distancing measures relies on people changing their behaviour, a challenge that lies ahead for policymakers is the potential for community fatigue. Individuals may not respond as quickly or assiduously if/when physical distancing measures are re-established in response to future outbreaks. Overall, our study found high levels of community acceptance of physical distancing measures. There was also evidence that distancing behaviours decreased between April and May; however, it is unclear whether this was due to reduced compliance or the easing of restrictions.

While physical distancing measures have proven highly effective at suppressing transmission of COVID-19 [44], they place a significant emotional and psychological burden on individuals, as highlighted by our study and others [45–47] — not to mention the economic consequences and potential longer-term health impacts. Governments around the world are currently grappling to balance the risks associated with an uncontrolled outbreak of COVID-19 against those associated with intensive and/or prolonged physical distancing measures. Studies such as ours can help to

understand and guide the management of mental health risks associated with physical distancing measures.

Our findings about the association between mental health and sense of safety, calm, self and community efficacy, social connectedness and hope suggest ways forward in informing the public about support as communities emerge from pandemic restrictions. Previous evidence about use of fear to promote health behaviours [42] shows there is a risk in conveying the seriousness of the health risk unless it is accompanied by messages that promote sense of self- and community efficacy. Our qualitative data also suggested levels of hope, altruism, and trust in science counterbalance difficult decisions and bad news. At the same time, previous studies have shown that individual and community empowerment must go beyond promoting feelings of competence — they require having access to and control over the resources in one's environment [48, 49]. In line with this, we argue that policies and services that support people experiencing economic adversity (such as Australia's income support payments "JobSeeker" and "JobKeeper" [50]), and those associated with childcare, mental health and family violence can be a crucial source of individual and community resilience during the response and recovery phases of the pandemic.

Other studies conducted during COVID-19 have found that access to reliable health information and precautionary measures like hand hygiene and wearing a mask was associated with lower levels of emotional distress [45, 51]. In our study, having a larger number of people to rely on for assistance or support or being the source of assistance or support for other people was associated with lower levels of anxiety and depression, highlighting the importance of social connections for supporting mental health and wellbeing. Our findings are consistent with previous evidence about the human impacts of disasters, including the COVID-19 pandemic, and show how important it is to find ways to maintain social connections while following the physical distancing guidelines. Since pandemics have the potential to perpetuate and exacerbate existing social disparities [52], the social structures of populations most at risk of negative outcomes from the disease and/or transmission-mitigating policies, should be closely considered if the goal is an equitable response strategy.

Our study was necessarily rapidly conceived and implemented in response to the evolving epidemiological and policy situation in Australia. While useful for gaining rapid insights into people's feelings and behaviours, our results need to be interpreted in the context of the limitations of the research design. The sampling strategy did not allow for surveying individuals without internet access, low literacy or limited English language skills, or communication or cognitive difficulties. Additionally, people who register to complete YouGov surveys may also be different from the general population in ways that we cannot identify. Subgroup analyses may be limited by smaller participant numbers; and qualitative data was from one free text response, limiting potential analyses.

In conclusion, studies such as this are necessarily conducted with short lead times and rely on the skills and capacity of public health researchers to work quickly within resource constraints. We therefore offer reflections and recommendations for research design in this and other pandemics. A formal and collegial review of studies to date would also be prudent, so we can learn and make methodological suggestions for future rapid onset research.

Studies such as ours provide broad, population-level insights, and near-real-time data for estimating transmission potential and forecasting epidemic activity [29]. COVID-19 epidemiology and response policy will continue to change rapidly over the coming months and years. In order to capture/monitor associated shifts in people's feelings and behaviours, public health researchers should plan flexible studies where data collection (repeated cross-sectional or longitudinal) is timed to occur in response to key changes in epidemiology and public health policy. Data collection and participant recruitment methods should ensure the representation of higher-transmission groups, in terms of their demography and geography.

Ultimately, more in-depth studies of the social, emotional and behavioural dimensions of physical distancing should be conducted to supplement findings from structured online surveys. These studies may include less structured interviews and/or surveys with more opportunities for individuals to respond in their own words. Follow-up studies should also target population groups most impacted by COVID-19 — in terms of disease outcomes and restrictions — in order to understand what different groups may need to help them to follow public health guidelines and to support the development of tailored and targeted public health policy. For example, this

may include exploring the potential barriers to cooperating with physical distancing, isolation, and quarantine regulations experienced by individuals with insecure employment or higher-density housing conditions.

27.8 COVID-19 Developments and Further Research

In late June 2020, the state of Victoria experienced a significant resurgence of COVID-19 epidemic activity. By late July, daily case counts reached nearly 20 times those seen in March and stay-at-home restrictions had been reinstated across Victoria [53].

The epidemiology of Victoria's second COVID-19 incursion has been distinct from the first. While caseloads in March and April were dominated by overseas acquired infections, the June outbreak has seen the establishment of community transmission, and heightened transmission within groups that are less able to practice physical distancing (e.g., healthcare workers, public housing residents including communities from migrant and refugee backgrounds and residents of aged care facilities). At the time of writing, a third survey of Victorian residents, including interviewer-assisted surveys of individuals from migrant and refugee backgrounds, was in progress to help inform the State's response.

Insights from this study have been considered by various policy and strategy structures and this chapter, along with further analyses, can help to inform public health planning for the management of COVID-19 and other diseases of epidemic potential.

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28

Impacts of COVID-19 Lockdown Restrictions on Housing and Public Space Use and Adaptation: Urban Proximity, Public Health, and Vulnerability in Three Latin American Cities

Raul Marino, Elkin Vargas and Mariana Flores

This chapter presents the results of an investigation about the lack of access to public space and social interactions in three Latin-American cities by using literature review, location data and online survey (quantitative and qualitative information) from household members on how these restrictions affected their daily life and their relationship with community and public space use. Focused on Bogota, Quito, and Mexico DF (n = 650), geospatial tools are used to correlate the survey's respondents' answers with official COVID-19 reports from government. The results show the correlation between the number of contagions by zones and users' behavioral shifts in terms of housing and public space use and adaptation. This could support the efforts of communities and decision makers to improve public health standards, reduce vulnerability to COVID-19, improve their resilience and enhance urban proximity to essential services and public spaces.

28.1 Introduction

In order to mitigate and manage the incidences of the pandemic, the World Health Organization [1] suggests the management of reliable information, as well as the isolation associated with social distancing, hand washing and treatment in case of contagion. The risks of a pandemic increase when community health and wellbeing weakens, however, there is a high incidence of contagions in land use, life expectancy, displacement, climatic disability and poor air quality. Confinement has undoubtedly transformed everyday life [2].

For the present study, a descriptive and causality analysis was carried out to explore the impacts of the COVID-19 pandemic on housing and public space use and adaptation, based on a survey that was applied online in different countries, but focusing in three cities of interest: Bogota (Colombia), Quito (Ecuador) and Mexico City (Mexico). An innovative methodology was proposed using official data, our survey results and geospatial analysis. Geospatial analysis allows integrating themes in disease mapping such as spatio-temporal analysis, health and geography, environmental variables, data mining and web mapping, and understanding the spatial conditions of propagation for the design of mitigation strategies, in decision-making, planning and community action. The importance of geospatial analysis methodologies lies in the possibility of strategically identifying vulnerable

sectors, either due to their location, services or nearby infrastructure, geographical conditions, or particularities in the case of informal settlements [3].

28.1.1 Proximity and density

The urban factors identified in the spread of the pandemic in Wuhan were the intensive urban growth, hospitals, shopping centres, mixed uses, the population ageing index and roads, among others, which evidenced the need for planning strategies focused on understanding the transmission of infectious diseases in urban settings [4, 5]. Physical distancing as a health measure does not imply social distancing, which is why it suggests the proximity argument based on the dichotomy of "being in the place" and "being connected" [6]. The urban density allows numerous complex social and economic interactions, which are associated with prosperity by being close to work centres and services. Communities exhibit demographic and socioeconomic differences associated with vulnerability [7]. Urban density as a key metric of sustainability, can be defined as the proportion of the total number of inhabitants living within a delimited urban footprint of a city. Research indicates that inhabitants of a compact city with a higher urban density will be closer to others, which will make moving from one place to another more efficient and sustainable. Some indicators to measure urban density are the urban footprint, the total population, residential occupancy, parcel coverage, the height of the buildings, the efficiency of the plants, the occupancy level, and people per dwelling unit. Studies have revealed a number of benefits of compactness: more productivity; lower cost public services; greater social and economic mobility, as well as diversity; increased use of public transport; lower energy use and emissions; and improved health and wellbeing [8, 9].

The current pandemic suggests investigating how connectivity influences spread more than density, since large metropolitan areas are closely linked through economic, social and transport relationships, so dense areas may have better access to care facilities and further implementation of distancing policies and practices [10]. The most marginalized populations are seen to be more likely to get sick and die from being exposed to unequal conditions [11]. In terms of community, density is not related to infection rates and is inversely related to mortality rates [12].

28.1.2 Vulnerability and public health

COVID-19 has exposed urban structural weaknesses and inequalities, where health is the best element of cohesion to insert proposals for development and progress in contaminated communities. Due to their inability to access adequate medical care, transportation, and nutrition, socially vulnerable populations are at increased risk of health problems during disasters [13]. The greater degree of vulnerability is accompanied by demographic change, infrastructure, and governance, which is why the virus occurs mostly in more developed areas. In this case, migration, urban population growth, and high population density are important factors influencing the spread of disease. Associated with science and technological responses to COVID-19, it is necessary to integrate more critical and reflective analysis in addition to theoretical knowledge. According to Polko et al. [14], public space is an open and impartially accessible geographic dimension for all, which includes social interactions, subject to restrictions such as physical distancing, and is a key characteristic of a resilient city due to its ability to transform itself for health purposes of emergency, and the flexibility to adapt to new needs [14]. Urban designers seek to create places where people feel welcome, comfortable, and safe. In this way, urban residents experience nature most of the time at "the cognitive level of urban space", that is, at the level where "the people on the street" live in the city. The questions from architecture and urban planning in the face of the crisis are focused on how it will affect our relationship with public space [15–19].

28.1.3 Accessibility, adaptation and resilience

The adaptation processes include aspects of housing and the city such as morphology, spatial distribution, connectivity and resilience, where green areas represent important cores that are added to concepts such as proximity, access and quality [20]. Resilience provides an adaptive

approach to environmental problems, natural hazards, and public health emergencies. At the urban context, resilience is understood as the ability of cities to absorb and respond to disasters through five dimensions: scale, structure, form, function and urban spatial network [21]. According to Urban Resilience Hub of United Nations, it is the "measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming towards sustainability" [22]. Resilience allows a system to adapt to changes, regarding environment/ecology, infrastructure and governance/institutions. Meanwhile, accessibility considers access to urban and public services, health, food, financial resources, places, etc., for the entire population and vulnerable sectors [23].

28.2 Case Studies Context Summary

28.2.1 México city, Bogota, and Quito: common urban realities

For our study, we focused on three of the main Latin American capitals that have special conditions of interest for our research: Mexico City in Mexico, Bogotá in Colombia, Quito in Ecuador (see Figure 28.1). These cities share among each other similar economic, social, and cultural characteristics; moreover, some other particularities in common such as geographical and climatic condition as well as similar environmental challenges. We consider that a comparative approach between these cities would allow us to evaluate more in detail certain hypotheses related to relationship between the spreading and impact of the COVID-19 pandemic with geographic, environmental, social, and climatic variables. The data collected, apart from those by official sources, were obtained through an online global survey with emphasis on Latin American region, where the three study cities represent almost the 50% of the total surveys gathered (n = 1538). Another reason for doing a comparative analysis is the possibility to identify the successes or failures of policies and regulations implemented by local governments in relation to pandemic and its behaviour, by setting up possible linkages between these data and the results with variables such as urban density, centrality and proximity.

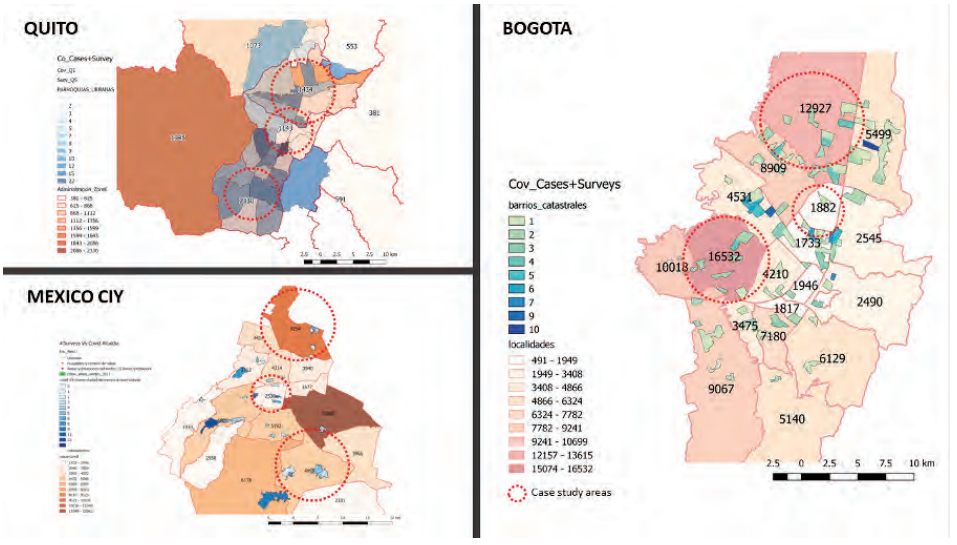

FIGURE 28.1
Case study cities: Quito, Mexico DF (left), and Bogota (right) – COVID-19 cases, survey participants and study area locations

Other common characteristics among the three study cases are related to high altitude (Mexico City: 2200 mamsl while Bogotá and Quito are located at 2800 mamsl) and geographical and climatic conditions. These cities have been built up on wetlands surrounded by mountains, and in the case of Mexico City and Quito nearby to volcanos. Their urban humidity levels are quite similar as well as the climate, especially in Quito and Bogotá along the year because there are no seasons as in Mexico City. In terms of population and density (as indicated in Table 28.1), Mexico City is the largest with 8,928,653 inhabitants and a density indicator of 5,966 p / km^2; Bogotá is the second in population with 7,181,469 inhabitants and the third in density with 4,907.45 p / km^2; Quito has 2,011,678 inhabitants and the second highest density rate among the three cities with 5,401.29 p / km^2 after Mexico City (see Table 28.1).

TABLE 28.1
Comparative city data [24–26]

For the spatial analysis, two scales of analysis were selected: a Metropolitan scale and a municipality scale as it allows us to have a similar observation patterns in each of the three cities (see Figure 28.1). In this sense, Mexico City is divided into 17 sectors or "Delegaciones". In the case of Quito, the homologous territorial administrative division is called "Administración Zonal" with eight such subdivisions. Finally, in the case of Bogotá, the political-administrative unit is called "Localidad", with a total of 19 localities.

28.2.2 Informality and public health

One of the main common patterns in our three case study cities is urban informality. This concept is understood not exclusively from the economic perspective; informality is also related to spatial features. It is considered as a pattern of land occupancy that characterizes the Latin American city and the global south in general and shapes most of the marginal peripheries where a large percentage of low-income population lives [27]. From public space view, the street vendors add an activity buzz become a vital part of the urban, cultural and social landscape of many cities and towns in the Global South [28, 29]. Millions of households depend on informal economy, which mostly take place on public space [30]. Only in Mexico City, the informality rate is 49.7%, that is, almost 5 out of 10 workers in the capital have an informal job [31]; a very similar indicator is shared by Bogotá [32] and Quito [26].

The impact of informality in public space becomes more complex during the current quarantine restrictions, as many street vendors are forced to keep crowding the streets as these are their only source of income. This risk increases in the case of Bogotá and Quito where large numbers (450,000 in Bogota alone) of migrant refugee population from Venezuela, is engaged in informal economic activities, as public vendors, increasing their vulnerability and contagions rates [33]. The policies of physical distancing and staying at home are not only difficult, they are often impossible to meet for large percentage of the population in developing countries [34].

Related to the current public health crisis, according to information available by 31 July 2020 (our baseline date), the impact of COVID-19 in terms of number of infections responds as follows: in Mexico City[1], 76,169 cases and 8,731 deaths (mortality rate: 11.5%); in Quito[2], 13,438 cases and

[1] https://datos.cdmx.gob.mx/pages/covid19/

[2] https://coe-pichincha.senescyt.gob.ec/wp-content/uploads/2020/08/Infografi%CC%81a-Cantonal-01_08_2020.pdf

640 deaths (mortality rate = 4.8%); in Bogotá[3], 101,955 cases and 4,900 deaths (mortality rate = 4.8%). Additionally, on the basis of COVID-19 test taken per 100,000 inhabitants in each city, the city with the highest impact of virus spreading is Bogotá with 14,196 infections per million inhabitants, as indicated in Table 28.1.

In this sense, it is likely that the pandemic will push street vendors and other informal workers to a long-term economic recession without precedent in modern times. In fact, the recession will not be exclusively in terms of informal activities, the most of formal economic sectors are currently affected. However, informality, increases the state of emergency in Latin American countries where this sector represents around 40% of the labour force [35]. This condition in the global south and our case study cities makes even more important the capacity of reorganization and resilience of governments and communities in the face of current regulatory absence and political legitimacy crisis of governments, especially in Latin America.

28.3 Research Methodology

The analysis of the impacts of the COVID-19 pandemic were undertaken using a mixed methods approach, based on firsthand data collected by the authors through an online survey covering the three selected case study cities: Bogota, Quito and Mexico, and the results of a proximity analysis on Points of Interest (POI): public space, health facilities and public transport access (see Figure 28.2). So far, the analysis of the discussion of the impacts of the COVID-19 pandemic has been mostly focussed on secondary data or observations of public space use by researchers [36], with few published papers showing firsthand results. Also, most research on COVID-19 and the built environment has focused on either housing [10] or public space [37]. Only a small percentage of previous research addressed the integrated study of housing and public space.

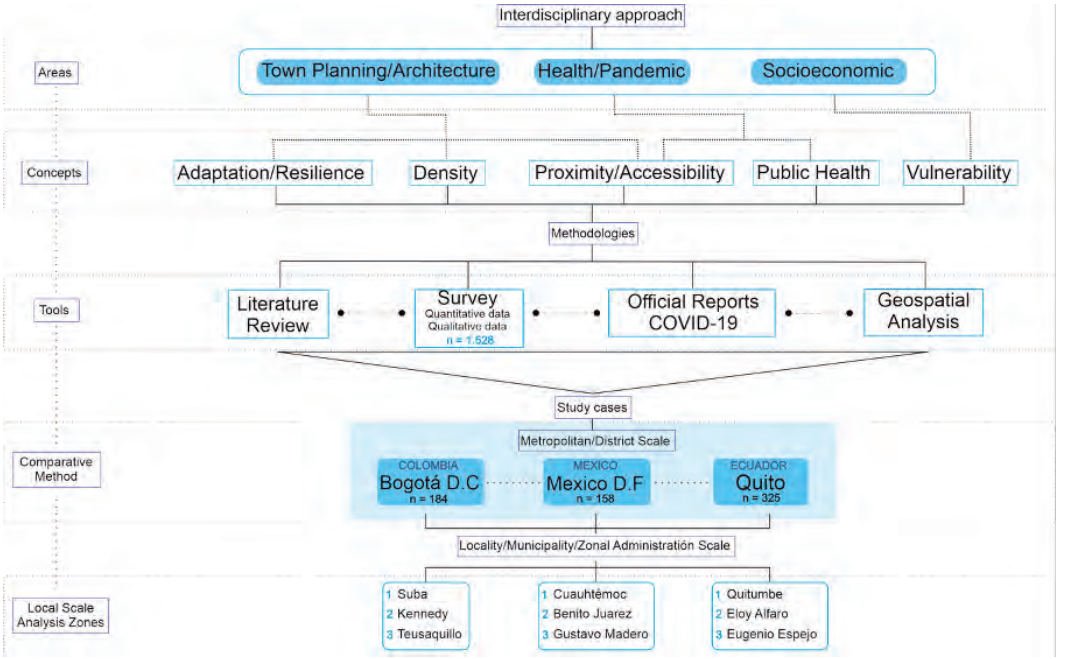

FIGURE 28.2
Research Methodology Scheme 1

[3] http://saludata.saludcapital.gov.co/osb/index.php/datos-de-salud/enfermedades-trasmisibles/covid19/

Geospatial analysis has been used widely to understand the factors driving the contagion of cases in urban areas, from the first cholera cluster maps in the London Epidemic in 1854 done by Snow, to the use of advanced tools using artificial intelligence and advance algorithms calculations [38]. The challenges of public health management in the last decades had led medicine research to support itself with geographical analysis, especially GIS systems, to understand the development and trends of infectious diseases in urban and rural contexts [39]. Important discoveries related to patterns of incidence and spread of the some of the main diseases affecting human population such as cancer, diabetes and lung and heart problems, and their correlation with the urban form and structures of cities, their density and their access to public transport [40, 41].

Surveys have been used as a method to collect information on sociodemographic characteristics of urban population and their housing and mobility behaviour [42, 43]. Its focus change according to the information needs, from surveys covering all the population in a given city or urban area (census), to surveys focused on specific segments of the population (by age, income, housing type, etc) and also focused on specific areas of the city where a certain phenomenon or trends needs to be investigated [44]. Based on these experiences, this paper follows a mixed method of collection of the required data for our analysis (see Figure 28.2), integrating two analytic tools: the analysis of the results of the survey conducted by our team on impacts of quarantine in housing and public space use; and the geospatial analysis of the case study cities selected in this paper: Bogota, Quito and Mexico DF.

28.3.1 Data collection

The collection of data was performed using two approaches, an Online Survey and collection of COVID-19 contagions reports from our case study cities.

- **Online survey**: The online survey collected information about the impact of quarantine's restrictions on housing and public space and adaptation. The survey was open for any person or household currently (from 25 April to 31 July 2020) experiencing restrictions on their daily activities due to governments emergency regulations to COVID-19, such as curfews, lockdowns, mobility restrictions, and other. The survey was divided into 7 categories (socioeconomic profile, housing, community, public space, mobility, working/education, and public health), with a total of 42 questions and a running time of 14 mins. The questions were divided into multiple selection and questions with open-ended responses, to collect a wider variety of observations from the participants. The delivery system used was through academic and professional online networks from the main authors in several countries in Latin America, Europe, and Oceania, focusing on Colombia, Ecuador, and Mexico as main case study areas for this research. To access the online survey site please see: `https://www.surveymonkey.com/r/urbanmappingagency-English`

- **Collection of COVID-19 data and geospatial data from the case study countries:** The data and figures related to the number of COVID-19 cases per city and analysis zones were collected from the government's official portals (see Bibliography for references on COVID-19 Portals) and reports to the closing date of the study: 31 July 2020. It is important to mention that being this pandemic such a dynamic and changing phenomenon, from which we are still trying to learn its nature and behaviour, the reported COVID-19 cases reports from each country and city can differ from the real number on COVID-19 contagions [1].

28.3.2 Data analysis

The collected data was analysed following a mixed methods approach:

- **Online survey:** (a) Qualitative information: The collected answers were analysed using content analysis and sentiment analysis tools [45], looking to understand the opinions and experiences of the participants in front of the quarantine's restrictions. (b) Quantitative information: The quantitative data were tabulated and analysed using statistical analysis tools (SPSS and Minitab), however the results of this analysis will be presented in a separate follow-up report.

- **Geospatial analysis**: This paper focused on the relationship of spatial variables such as density, accessibility and proximity to the points of interest: public space, health facilities and public transport hubs, and their relationship with the location of COVID-19 contagions clusters in our case study cities. The geospatial analysis tools used were selected to map and measure accessibility and proximity levels in a combined mapping of the local zones selected in each city. To achieve this, the Cost Distance tool [46] was selected to evaluate the accessibility and proximity to parks, health facilities and public transport hubs. To create the Cost Distance Maps, we converted the street network to raster format used Euclidean Distance tools to get the cost raster as an input parameter in cost distance tools.

- **Limitations and assumptions**: The study's limitations relate to availability of data for the case study cities, and possible small errors in the spatial files used to run the geospatial analysis. Also, the reports of the COVID-19 might have also misreporting information on the number and location of cases. The authors gave their best effort to minimize these errors.

28.4 Results

28.4.1 Survey results (housing, public space, mobility, community)

This section presents the results of the online survey and geospatial analyses described in Section 28.3, Methodology. The information is presented in the form of comparative figures, matrix of proximity mappings per case study city (see Figures 28.4, 28.5 and 28.6) and comparative table integrating all results (Table 28.2).

The online survey had a final number of 1,568 of complete answers by the cut-off date of 31 July 2020. The survey was opened to all persons or households experiencing quarantine restrictions in any city in the world, and the survey collected information from 38 countries and 121 cities (see COVID-19 preliminary Survey Report, 2020). From this complete sample (n=1,568), the 45.6% corresponded to our three case study cities, with a sample of 189 complete answers in Bogota, 320 in Quito and 155 in Mexico DF. The survey collected information on the impact of the restrictions of the COVID-19 pandemic in housing and public space use and adaptation, including information about impacts on mobility, community, working and education. In this chapter, we focus on the results related to public space use, mobility, and community responses to the crisis. More information about the survey's results on housing use and adaptation can be found in the preliminary report cited above.

Changes in house use and restrictions to access public space have an impact as well in the change of use of public space, driving shifts in behaviour and mobility [47]. Most of the participants in the three case study cities (65.18%) expressed that they make some changes in the use of the houses, in response to the restrictions imposed by the quarantine. Studies in Mexico and Bogota also arrived at similar conclusions [48, 49]. This number indicates that the restrictions are having a profound impact on the life of people and families, which should be further investigated to provide a better quality of life in the face of new conditions arising from COVID-19 pandemic.

Housing flexibility is one of the main factors that enable rapid adaptation to new living and working conditions. When asked about their houses' flexibility to adapt to new uses such as working and education, 46.3% of the participants indicated that their houses did not have flexibility to cope with the change of lifestyles and permanent cohabitation with the other members of their family groups or households. Therefore, it is essential that governments and institutions provide guidelines for housing adaptation to new uses such as working, education, gym and others, and also promote the development of new housing typologies that could adapt faster to the needs of their inhabitants and be more resilient to the impacts of the pandemic.

One of the main impacts of the COVID-19 pandemic has been the lack of face-to-face interaction with other community members. This increased the cases of psychological stress and depression on populations under severe quarantine restrictions. Question 32 of the survey asked participants

which activity in public space they missed the most, and 35.7% of the participants expressed that it was the lack of social interaction with other people in public space, followed by walking (19.9%) and working out in public space/parks (14.3%). The survey also asked about the impact of the lack of social interaction on the participants' mental health and 81% indicated have some alteration to their mental health, mainly anxiety, irritability, and depression. These findings are similar to the ones presented by some surveys and studies on the same topic, which described the lack of social interaction as one of the main impacts on people's health during the COVID-19 pandemic [37, 50].

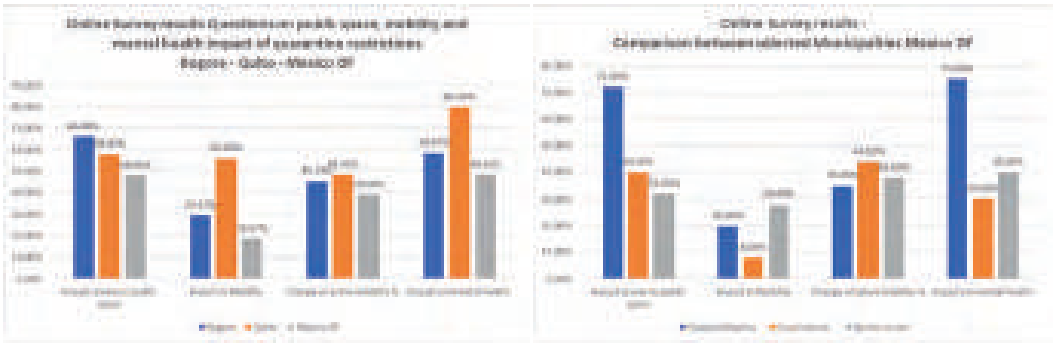

FIGURE 28.3
Online survey results comparison – Case Study cities analysis areas average (left) and results for Mexico City (right)

Access to public space and green areas is vital for the social and community life of cities [51]. According to survey results, 74.5% of the participants have a park or green area close to their homes (500 m), and the 52.4% expressed being affected by the restrictions in access and use of public spaces such as parks, recreation areas, public gyms and playgrounds (see Figure 28.3). This indicates that the strategies to manage the impacts of the COVID-19 pandemic in cities should consider more actively how to keep open these vital infrastructure, instead of just closing all parks and green areas as many cities in the world did (including our case study cities). The lack of access to public sport facilities and gyms had also created rising problems in public health, accelerated by the sedentarism of homeworking and home-schooling [36].

28.4.2 Geospatial analysis results (proximity, accessibility, density, etc.)

This section presents the results of the geospatial analysis of the selected variables (proximity, accessibility, density) in our three case study areas. The results are presented in a matrix of maps per case study to facilitate the comparison amongst the three selected local areas. As described above, our three-case study Metropolitan Areas (Bogota, Quito, Mexico), were analysed at municipality level, to enable a finer grain analysis of the urban conditions of each zone. These three subdivisions for each Metropolitan area are: Bogota (Kennedy, Suba, Teusaquillo), Quito (Espejo Alfaro, Eugenio Espejo and Quitumbe) and Mexico DF (Gustavo Madero, Cuauhtemoc and Benito Juarez). The results are described briefly in this section and will be analysed in more detail and compared with the survey information in the next section, Discussion.

In general, the three areas selected show a degree of lack of proximity to public space (parks), health facilities, and public transport. Proximity to Public Transport was more evenly distributed in Quito and Mexico, with large areas of Bogota's analysis zones showing a lack of accessibility to the BRT Transmilenio system (specially in Kennedy and Suba localities). The following part presents the results of these analyses per city in a comparison matrix. To see more details in each of the maps, please see: https://burodap.co/project-details/habitar-bajo-condiciones-de-cuarentena

In the case of the three analysis zones in Bogota, the analysis show that there are large contrasts amongst them, with localities such as Suba containing large areas that are not covered by public transport system, health facilities and have no parks (see Figure 28.4). One of the reasons for these

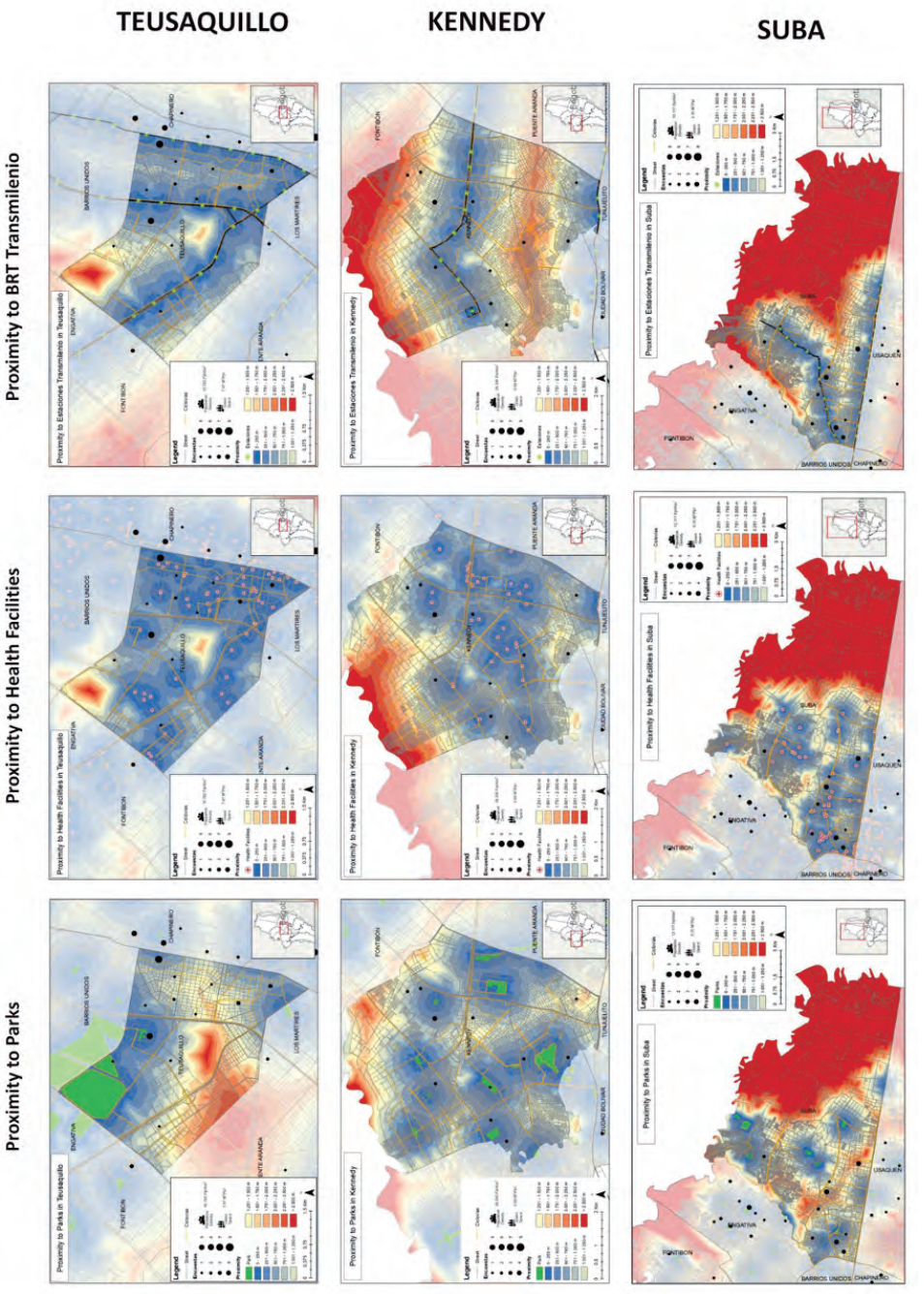

FIGURE 28.4
Geospatial proximity analysis Bogota (Kennedy, Suba, Teusaquillo)

results can be that a large part of the north part of Suba locality is a protected reservation zone which contains some small industries, and very low population density.

The selected zones In Quito also showed differences in proximity to parks, health facilities and public transport (see Figure 28.5). However, these differences were smaller than our other

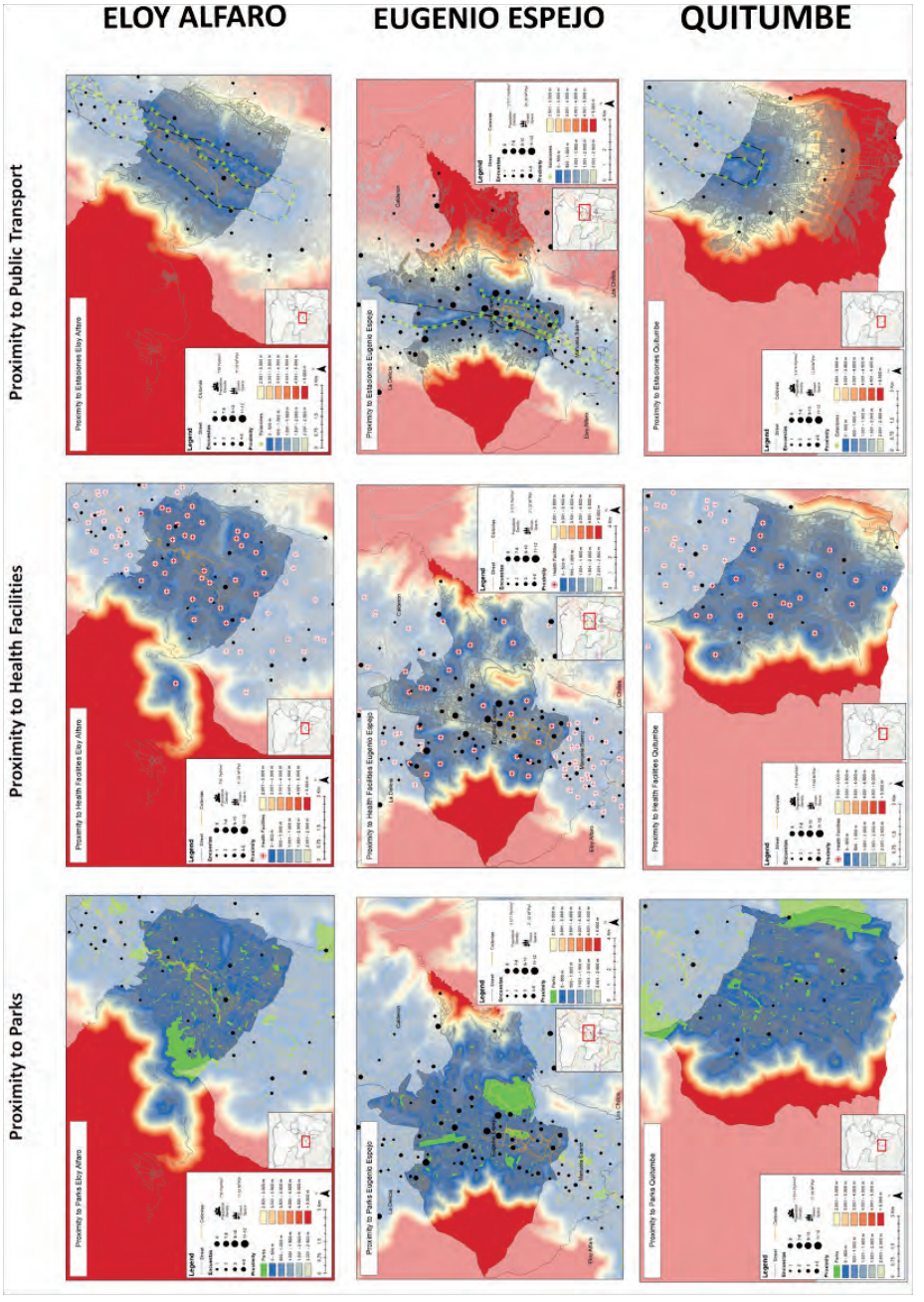

FIGURE 28.5
Geospatial proximity analysis Quito (Eloy Alfaro, Eugenio Espejo, Quitumbe)

case study cities, which can be related to the smaller population size in Quito, together with a denser distribution of population driven by the geographical features of the mountains conforming the metropolitan area of Quito. In some of the selected administrative zones, the analysis show a higher lack of accessibility to these infrastructure, which can also be related to the land use classification in these areas, which are more of an urban-rural character located at the periphery of the city.

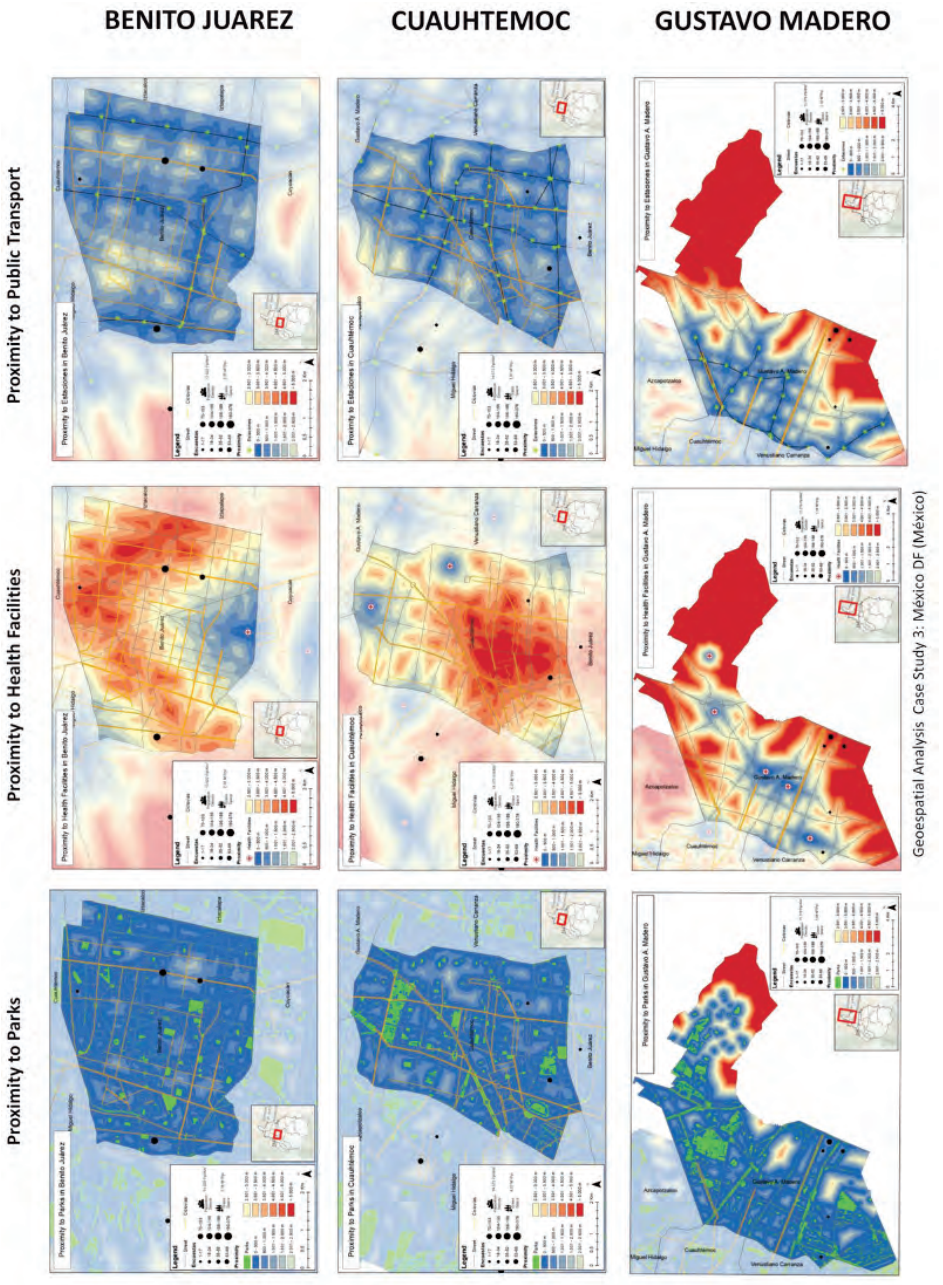

FIGURE 28.6
Geospatial proximity analysis Mexico City (Benito Juarez, Cuauhtemoc, Gustavo Madero)

For Mexico, the three municipalities selected showed a larger lack of accessibility to health facilities, but also have a better distribution of green areas and parks than our other case study cities (see Figure 28.6). One of the municipalities analysed, Gustavo Madero, displayed a lower coverage of public transport network, especially in the north part, which is located at a peripheral area of the city and mostly consisting of low-income households.

28.4.3 Integration of survey and geospatial results

The areas of analysis in each city were selected considering their number of COVID-19 cases, and also the urban characteristics of the areas, with areas located close the city centre and other located at the peripheries, with the aim to cover a larger variety of urban configurations. Also, the selected areas were considered related to the number of survey participants located in these areas, to be able to compare our survey results about the experience of users in public space and mobility during the restrictions of the COVID-19 quarantine. The maps of the geospatial analysis shown in Figures 28.4, 28.5, 28.6 above display the survey's participant number in a black circle magnitude scale (the larger the circle more surveys according to scale in the legend) (see Figures 28.4, 28.5, 28.6 from one result to nine or more results. These results were geolocated using the survey's information on location of the participant (neighbourhood), collected in Question 13. The following section will discuss first the results of this survey in each city related to the use and changes in public space and mobility, and secondly, it will discuss the results compared with the result of the geospatial analysis of proximity to parks, health facilities and public transport for each selected zone in the case study cities.

TABLE 28.2
Integration of Survey and proximity analysis results per case study cities and localities

Area of analysis per city	Density/Public space		Geospatial Analysis results			Online Survey Results				Covid19 Reports
	Pop. Density (pop/km2)	M^2 parks per person	% Proximity Parks (1500 m)	% Proximity Health (1500 mt)	% Proximity Public Transport (1500 m)	Impact access to public space	Impact in Mobility	Change of active mobility	Impact on mental health	Covid Cases 31 july/2019
Bogota			71.74%	76.92%	62.59%	66.00%	29.67%	45.33%	58.67%	107826*
Kennedy	28206	0.69	93.34%	83.35%	58.16%	70.00%	39.00%	52.00%	62.00%	16532
Suba	12117	0.35	41.30%	50.29%	34.08%	65.00%	35.00%	43.00%	67.00%	12927
Teusaquillo	10782	7.67	80.57%	97.11%	95.52%	63.00%	15.00%	41.00%	47.00%	1733
Quito			39.71%	21.99%	25.60%	58.00%	56.00%	48.33%	80.00%	9450
Eloy Alfaro	13100	11.02	7.60%	6.90%	5.03%	60.00%	42.00%	50.00%	90.00%	1945
Eugenio Espejo	3571	21.32	70.29%	57.47%	34.89%	63.00%	46.00%	40.00%	70.00%	1434
Quitumbe	3614	17.09	41.23%	1.60%	36.89%	60.00%	80.00%	55.00%	80.00%	2330
Mexico DF			93.59%	19.67%	69.03%	48.00%	18.67%	39.00%	48.33%	76169
Gustavo Madero	11779	7.58	81.03%	9.07%	28.09%	72.00%	20.00%	35.00%	75.00%	9254
Cuauhtemoc	14572	4.07	99.88%	42.24%	89.36%	40.00%	8.00%	44.00%	30.00%	4314
Benito Juarez	13992	2.38	99.87%	7.71%	89.64%	32.00%	28.00%	38.00%	40.00%	2536

Table 28.2 shows the integration of the results of the proximity analysis to our POI (parks, public transport, and health facilities). The values represented in each cell in the geospatial analysis section represent the percentage of the municipality area that have access to the interest point within 1,500 m. This range was selected as a class measure based on different urban planning studies supporting the development of 15-minute city in Paris [52] the 20-minute city in Melbourne [53], and the 20-minute neighbourhood in UK [54]. These plans promote the idea of a closer integration of activity hubs in the city subcentres, advocating for a better land use and reducing sprawl, increasing active transport (walking, bicycle) and reducing the need for long commuting to work, education, shops and recreational activities. The second part of the table shows the results of the survey's questions related to: impact of lack of access to public space, impact of mobility restrictions, shift towards active transport and impact on mental health. The values presented in these cells represent the percentage of the respondents in each city that indicate being affected by the restrictions of the quarantine in these activities. The last column presents the COVID-19 confirmed cases per city, as presented by official reports (see references in Section 28.2).

28.4.4 Statistical analysis: Multiple Linear Regression analysis results

The results of the proximity analysis were analysed using multiple linear regression analysis approach, with a backward stepwise tool to run several iterations of the data to find the best fit. The regression had our variables of interest (proximity, density, accessibility) as predictors (expressed as Proximity to Parks, Proximity to Health Facilities, Proximity to Public Transport and population density), and the amount of COVID-19 cases reported in our baseline data (31 July 2020), as dependent variable. The first round of the stepwise analysis showed that the variables Proximity to Health Facilities and population density did not have a significant impact on the dependent variable, so they were removed from the regression. The results of the final regression are shown in Table 28.3:

TABLE 28.3
Multiple Linear Regression analysis results

Coefficient Table Iteration 3 (adjusted R-squared = 0.737)								
	Coeff	SE	t-stat	lower $t_{0.045(5)}$	upper $t_{0.955(5)}$	Stand Coeff	p-value	VIF
b	3.819534	0.120283	31.754476	3.567200	4.071869	0.00000	5.81668e-7	
Log(X2) M2 Public Space	-0.562034	0.123662	-4.544935	-0.821455	-0.302612	-0.857770	0.00614089	1.081498
Log(X3) Prox.Parks	1.216468	0.509843	2.385967	0.146901	2.286035	1.061661	0.0326999	3.011498
Log(X5) Prox. Public Transport	-1.112501	0.456156	-2.438859	-2.069442	-0.155560	-1.098922	0.0487361	2.164527

As the results in Table 28.3 show, the selected research variables have a reasonably good fit for the model with an adjusted R^2 of 0.737. Public space per person (p=0.006), Proximity to Public Transport (p=0.058) and Proximity to Parks (p=0.0062) are significant predictor variables.

28.5 Discussion

28.5.1 Main findings of analysis

The three case study cities showed some similarities related to the patterns of contagions concentration, with peripheral areas of Bogota, Quito and Mexico DF registering the largest number of COVID-19 contagions. Also, when viewed separately, the patterns of proximity to the POIs (parks, health facilities and public transport) showed that these peripheral areas also have the lowest levels of proximity to the POI, especially in public transport accessibility and health facilities, indicating that there is a correlation between the access to these POI and the clustering of contagions in the local level areas analysed in each city.

Working and study activities have been also affected by the restrictions of the quarantine, shifting towards an online working, and learning model. 78% of the surveyed households have one member working remotely, 38% two members and 11.97% three members. This indicates the large amount of people that needed to adapt their houses to be able to work from home, with households having more than one member working at the same space, which creates problems related to privacy, concentration, noise and others. Regarding online education, the 63% of participants have one or more people learning online, and the 38.7% expressed having similar problems to be able to perform these activities in their homes.

The unit of spatial analysis in the three case study cities was based on certain criteria such as socio-economic and infrastructure characteristics of neighbourhoods and its densities. In this way, we classified the study sectors according to their urban proximity to our POI in low, medium, or

high level. In the case of Bogotá, the sector or locality with the best indicators of proximity is Teusaquillo, based on proximity to health service infrastructure, public spaces, and connectivity with the rest of the city (see Table 28.2). It is followed by the Suba sector and in third place we see the Kennedy sector, which coincides with the highest contagion rate and population density despite of having a good proximity average to public spaces, health facilities and transport services. In this regard, it seems that high population density plus a weak socioeconomic condition are the aspects that might be more directly correlated with the high number of infections in these sectors.

It is worth noting that when comparing the three areas across the case study cities, with the highest urban deficits in the three cities, we find out that it coincides with the highest COVID-19 contagion rates, but also in terms of proximity as they are the most disconnected and distant from the public transportation system; especially in Quitumbe (Quito) and Gustavo Madero (Mexico). Although this last sector is not the most public transport deficient in Mexico City, it matches with Quitumbe in Quito regarding the impact of mobility and proximity to health infrastructures. On the other hand, the sectors of Teusaquillo (Bogotá), Eugenio Espejo (Quito) and Benito Juarez (CDMX), register the least contagion rate and the best indicators of proximity to POI and socioeconomic conditions. They are also the ones with the lowest population density. However, when comparing these proximity results with the results of the survey, these same three sectors, being the most favoured in this research, reflect the greatest impacts and limitations on access to public space and mobility. Several reasons could be offered for this contrast, mainly related to the strict quarantine restrictions enforced in the case study cities which restricted access to most public parks, playgrounds, and other communal facilities.

In the case of middle-income sectors, such as Suba (Bogotá), Eloy Alfaro (Quito) and Cuauhtemoc (Mexico), the greatest impact due to restrictions is connected with the lack of access to public space, according to qualitative data from online survey, despite the fact that the indicator of proximity to parks remains high in the study sectors of Quito and Mexico. On the other hand, one of the most revealing indicators among these sectors is observed in the percentage of people who answered affirmatively to the question about the impact of quarantine on their mental health. In this field, it is evident that the most affected population corresponds to residents of the sectors with higher population densities and those who have less access to parks or green infrastructure. Taking this into consideration, the sectors with closer proximity relationships to public space, transportation and health facilities show a lower impact on the mental health of their residents.

Density of population is another factor that has been investigated in relation with COVID-19 contagions rates [10]. Some research show that there is no or little correlation between density and the number of cases [55]. However, some factors associated to urban density, such as pedestrian congestion and crowding in public space and public transport could increase the contagion cases. In our survey, 52.35% of participants think that density is an important risk factor, while 32.34% expressed that density was an important factor, but there were other more important such as urban hygiene, crowding avoidance, access to health facilities and social behaviour to follow the norms stablished in each city to manage the pandemic. In comparison Table 28.2, the municipalities with largest density had higher register of COVID-19 cases in each city. Also, when comparing the results of the proximity to parks and public transport we noticed that with less proximity to these areas, the rate of COVID-19 contagions tends to increase. However, this was not true for all cases in our case study cities, as some municipalities such as Gustavo Madero in Mexico City had a high proximity value but also higher COVID-19 cases in the city.

Regarding the concept of urban proximity investigated in this research, one of the important findings has to do with the relationship among community, neighbourhood or districts with public space access, and the amount of public space area per person (parks and squares). These kinds of urban infrastructures have an influence in quality of life and public health when there is a close proximity relation between them and residential areas in the case study cities. In this sense, we notice a close correlation of a high contagious rate with the lack of proximity between urban health facilities to housing or residential zones. Additionally, there is also a difference between the case study cities of this type of health infrastructure in terms of service coverage and concentration with the health system in each of the three countries. For instance, the health system in Colombian cities is financed by public resources but outsourced by private operators. On the other side, in Mexico and Ecuador the public sector is still the main operator of health services, therefore most

of the health facilities are centralized and managed by the public sector, consequently the coverage of health infrastructure is less dispersed along the city and more concentrated in large hospital complexes and multipurpose medical buildings.

Urban mobility has been also greatly disturbed by the restrictions of quarantine. 36% of the survey's participants in the case study cities expressed being affected in their mobility, and 74% report changing their transport modes towards more active transport such as walking and bicycling. On the other hand, 23% of the participants said that they would prefer to use private car to avoid any risk of contagion in public space. This shift towards active transport is an important trend that could support a change in urban transport planning, favouring bicycle networks and walkable pathways into the city's mobility infrastructure. Regarding these networks, 54% of the participants said that their cities did not have a bicycle network system, and 11% reported that such systems were currently under constructions in their cities.

Cities have adopted different strategies to manage the spread of the COVID-19 pandemic, mainly based on restrictions of mobility and agglomerations in public transport and public space. In this sense, our survey asked the participants about what strategy could be more effective to manage the reduction of contagions, and 25% expressed that the option: "Establish body temperature check point, hand washing stations and disinfectant gel in public space" was the best option, followed by the option: "Promote active transport and the expansion of bicycle networks and walkable paths", with 19%, and finally the option: "Redesign public space, urban furniture and green areas to reduce human contact" (16%). These results indicate that most in the urban communities wish to participate in the decision making process regarding the management of this pandemic, and is keen to support the development of active transport options and the redesign of public spaces to offer a safer environment for themselves, their families and the community. Participatory GIS options to collect community feedback on public space use and behaviour could be a valuable tool to support achieving this goal and offer better guidance to city planners in their quest to reduce the spread of the COVID-19 virus while reducing vulnerability in urban communities [56].

28.5.2 Main findings and links to similar COVID-19 studies or reports

Similar studies using online surveys to collect information about the impact of the COVID-19 pandemic restrictions on the life and behaviour of people and household have been published recently [37, 49]. The report presented by Gehl et al analysed the changes in the patterns of use and behaviour in public spaces in four Danish cities (Copenhagen, Helsingør, Horsends and Svenborg) and found that these cities are being used more for recreation, play and exercise, and the use of public space has remained constant, while A to B movements have decreased significantly. Similar results were found in our study regarding reduction of daily travels, however, the use of public space diminished during the pandemic in our case study cities, especially in Bogota. Another interesting observation of this study is that more children and older people are using the city's space than before. However, it is important to point out that the patterns of use and restrictions on the access and use of public space between Europe and Latin America are different, as most Latin-American cities have enforced strict restrictions to access parks, playgrounds, public gyms and other community areas. This is also supported by the results of the Google Community Reports on public space use [57] where it shows an increase of use in European cities (+85%) and a large decrease of public space use in our case study countries (-45%). This change can be driven by different factors, from the restrictions itself to access these spaces, to the change of attitude of people and community towards public space, considering it is now a risk area where there may be a higher probability of COVID-19 contagion [36].

28.5.3 Impact of findings on COVID-19 strategies and planning

As the results of the survey showed, and supported by similar reports [37, 58] in other cities, there is a significant shift towards active mobility (walking, bicycle) in cities in many countries, which could in turn increase the need for new strategies directed to increase and/or extend existing infrastructure to support this change of mobility patterns. On the other hand, there is also the risk that the low demand for public transport (already reported by several cities such as NY, Bogota

and Quito), could create economic challenges in the provision and operation of public transport networks, increasing as well the use of private cars as main transportation mode in cities [47]. Urban pollution had decreased as well as collateral effect of the restrictions in mobility, and large percentage of the population currently working and learning from home in the case study areas (65%), according to the data collected in our survey. The tendency towards these kinds of remote working and education has already being growing before the COVID-19 pandemic, and now has accelerated. This trend will likely continue, changing the way our cities and houses function.

Another possible scenario on the future growth of cities could be the increase of urban sprawl driven by the desire of larger housing spaces in low density neighbourhoods. In our survey, 24% of the participants expressed their preference for larger houses located far from the city centre. It is important that this tendency does not become a new wave of unsustainable expansion of cities towards their fringe areas, reversing the efforts of many cities towards better land use, with medium density mix-use areas located in strategic areas or activity clusters in cities, which had proven to be beneficial to reduce impacts of sprawl, pollution, energy use and promote an active community life [59, 60].

Communities have shown a great capacity to support groups vulnerable to the pandemic (migrants, street dwellers, the elderly, children), and a variety of responses have been received that show the potential that communities have to be an important part of management of the pandemic. However, citizen participation in decision-making about the management of this pandemic has been very low or non-existent in the study cities, as well as in many cities in the world.

28.5.4 Recommendations for decision-makers and community-based initiatives

Community participation in the decision making process about strategies to manage COVID-19 and other pandemics could be a vital factor to enhance urban resilience [61]. Most cities, including our case study cities, have not fully included communities in the decision making process in the current crisis. Communities and the civil sector felt ignored and forced to surrender temporarily their liberty to move-around and access public spaces in cities [62]. The social capital and community wisdom how their local neighbourhoods function and adapt are an important source of information that could enrich the decision making process together with local government authorities to better cope with the quarantine restrictions and reduce the adverse effects of forced lockdown measures during COVID-19.

In the proximity analysis, there are large areas in the case study cities with very low proximity and accessibility to green areas and public spaces. The analysis also shows that in the densest areas and with fewer area of public space per inhabitant, the level of contagion to COVID-19 is higher. Therefore, public policies oriented towards the provision of more and better public space should be on the agenda for cities in developing countries, with special emphasis on the informal areas most vulnerable to COVID-19.

The vulnerability to develop serious heath complications from COVID-19 is correlated with diseases such as diabetes, heart problems and high blood pressure and lung problems [1]. The rate of occurrence of these diseases is related to urban areas with low accessibility to green areas and active transport (walking, cycling), which promotes car dependency and sedentary lifestyle. Our research showed that large areas of the case study cities, affected by the highest levels of contagions, have public transport disadvantage and low proximity to parks. It is important to understand this relationship between the characteristics of the virus and urban planning, which should more efficiently promote active transportation and exercise in parks and recreational public spaces.

Another important recommendation to local administrations is to collect higher resolution data and made publicly available, to facilitate the efforts of academy and other institutions to provide better insights on the dynamics of pandemic spread or control. Finally, it is also important for cities to provide small scale disaggregated data on COVID-19, in order to understand the possible impacts of urban form and urban features such as the ones explored in this chapter (public space, mobility, density) on the spread and behaviour of the COVID-19 pandemic at neighbourhood or precinct levels.

28.6 Conclusions and Future Work

28.6.1 Summary of main findings

The impact of quarantine on the use of homes has been high, although its adaptation has been restricted due to lack of flexibility of housing. The development of new housing that can more easily adapt to new conditions and mix or types of uses to respond to the needs of its inhabitants is needed.

The use of public space has decreased considerably in the three study cities, mostly motivated by access restrictions and lack of confidence in the hygienic safety of public space and facilities. This could have a significant impact on public health, and potentially lead to an increase in the rate of diseases related to sedentary lifestyle and social isolation is expected [1]. Therefore, it is essential to avoid total restrictions (all or nothing approaches) in accessing public space and green areas, and instead promote strategies of capacity control, use of real-time data of public space agglomerations, continuous disinfection of urban and sports furniture and signage for social distancing.

The change of paradigm from face-to-face work and education to virtual work/education will be one of the main factors that will guide urban development in the coming years. This trend was already starting to occur in some cities that have decentralized their areas of employment from the city centre to nodes and secondary activity centres in the city. Steps in this direction have been already taken by some cities such as Melbourne and Paris, aiming to apply the 20-minutes city concept to their current and future urban development plans. But this trend has accelerated during COVID-19.

Proximity to public spaces and green areas has a correlation with the level of contagion in the case study cities, however it is important to take into account the impact of the socioeconomic profile and population density, since these could have more influence on the level of contagions by location according to the results of this research. There are several trade-offs between the advantages of density and the risk of contagion in areas with high traffic and urban density, which should be explored in more detail in order to improve resilience to COVID-19 and future pandemics.

Access to green areas and public recreational spaces is vital to better cope with the restrictions and lifestyle changes caused by the pandemic. The shift towards teleworking and online education has led to an increase in lack of physical activity and face-to-face interaction. Therefore, it does not make sense that in times of pandemic, decisions are made to close urban parks, playgrounds and public spaces, which further confines the population and leaves them without options for socialization, exercising and enjoyment of nature. These are considered essential for good mental and community health. Access to parks and public recreational space must be merely regulated, not prohibited. Authorities need to take advantage of the potential of new technology (such as crowd monitoring and public transport real-time data on commuters) to prevent crowding and increase the continuous disinfection of urban/public spaces and furniture.

28.6.2 Contributions to research and practice

Geospatial analysis can contribute to a better management of the COVID-19 pandemic by identifying the most important urban spaces for the community and understanding how the characteristics of each context influence public health and quality of life. After the first wave of the pandemic, COVID-19 control strategies in many cities have been aimed at identifying contagion clusters and selective quarantine of specific areas of the city, which is why it is essential to understand the relationships between the prevalence of contagion of COVID-19 and the urban characteristics at multiple scales of analysis (i.e., zonal, neighbourhood, municipality).

The development of urban centralities or activity hubs that reduce the need for the population for long commute to their jobs, studies, health and recreation areas is one of the strategies that can help reduce the spread of COVID-19, especially in cities with high urban density. The urban sub-centres (centralities) where there is a combination of activities (housing, employment, recreation, health), have the possibility of being more resilient to the impacts of strict quarantine,

by being able to organize the development of these activities more efficiently and adapted to their special needs. Generic quarantine and general curfew measures applied to cities may result in a worsening of the population's quality of life and economy, while more targeted and customized solutions and measures for neighbourhoods and communities may have a better chance of success.

28.6.3 Future steps

The relationship between density and COVID-19 involve several variables that should be further investigated to understand the possible trade-offs between the advantages of density and the management of public transport systems and crowded public spaces, especially in cities with a large percent of its population depending on informal trading in public spaces to secure a living, such as the three cities in our case studies. Also, with better data, we can undertake finer grain analysis and explore urban form variables at block or neighbourhood level. Many cities have been publishing their COVID-19 pandemic data through several portals and dashboards, which help to track the spread of the virus and prepare for second wave and other future pandemics.

The COVID-19 pandemic has highlighted the high vulnerability of cities and communities to manage new forms of risks to public health. Therefore, it is vital to learn from the lessons from the best (and also worst) management strategies that different countries and cities have applied to cope with the pandemic, and be able to adapt quickly to new conditions and be more resilient to future pandemic and other threats. The development of healthier cities, with more robust health infrastructure and multi-mode active transport networks and generous green zones should be included in the planning agenda of cities to reduce the social and economic impacts of current and future quarantine restrictions in cities.

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29

Use of Geospatial Information and Technologies in Understanding the COVID-19 Pandemic in Canada: Examples and Critical Discussion

David J. Coleman and Prashant Shukle

Despite the very uneven distribution and intensity of the spread of COVID-19 in different regions – and considering highly decentralised responsibilities for health care, and shared federal and provincial leadership for national emergency response coordination – Canada has been able to ensure a reasonably effective and well-coordinated response. All Canadian provinces and territories now have data driven dashboards or geospatial tools that highlight the incidence of COVID-19 in their respective jurisdictions. After a number of early independent development initiatives sponsored by different provinces, a nationally-endorsed, geospatially-enabled exposure notification app for cellphones was publicly released at the end of July. While supportive of the overall efforts under difficult circumstances, the authors suggest that specific responses could be improved if proactive work is done to share technology and data within the framework of national pandemic or disaster plans. As well, it would be valuable to ensure that the geospatial tools employed and data collected continue to be used as the public-sector focus shifts from pandemic response to economic recovery. Strong leadership and high levels of both national and international cooperation will be required to address these improvements.

29.1 Introduction

As of early September 2020, the spread of COVID-19 still varies significantly across Canada. Some provinces such as British Columbia, Alberta, Ontario and especially Quebec experienced significantly higher impacts whereas other provinces and territories such as Manitoba, New Brunswick and Newfoundland & Labrador experienced much lower levels of social and economic disruption. Despite this highly asymmetrical national spread of a global pandemic, highly decentralised responsibilities for health care, and shared federal and provincial leadership for national emergency response coordination – Canada has been able to ensure a reasonably effective and well-coordinated response. Governance and a long history of cross-jurisdictional collaboration have been critical success factors for Canada and reliance on data and technology were key enablers.

This chapter provides a very brief introduction to how they were deployed in Canada's COVID-19 pandemic. After providing selected examples of technology-level responses that were employed, the authors highlight early "hits and misses" which can be observed at this stage of the pandemic in Canada. The authors conclude with a look to the future in terms of opportunities for further development and cooperation.

29.2 Context

29.2.1 History and extent of the COVID-19 Outbreak in Canada

Figure 29.1 is a political map showing Canada's provinces and territories. Detailed timelines of events surrounding the COVID-19 outbreak in Canada may be found at Public Health Canada [1] and the Canadian Press [2]. Very early in 2020, as information became available, Canadian efforts moved from a pragmatic "wait and see" approach to one of increased proactivity. By January 25, Canada's first case of COVID-19 was declared. Canada's Public Health Agency activated its Health Operations Centre and triggered Canada's Federal/ Provincial/ Territorial Public Health Response Plan for Biological Events [3]. Thousands of families were affected in the months to come: Prime Minister Trudeau announced on March 12 that he himself was self-isolating as his wife had tested positive for COVID 19. By September 6, 2020, almost 133,000 cases of the virus and 9145 deaths had been confirmed nationally (Public Health Canada, 2020b). Relative numbers of cases varied widely across the country, with three provinces in particular (Québec, Alberta and Ontario) accounting for a disproportionately high rate of those cases (Figure 29.2).

FIGURE 29.1
Map of Canada's Provinces and Territories [4]

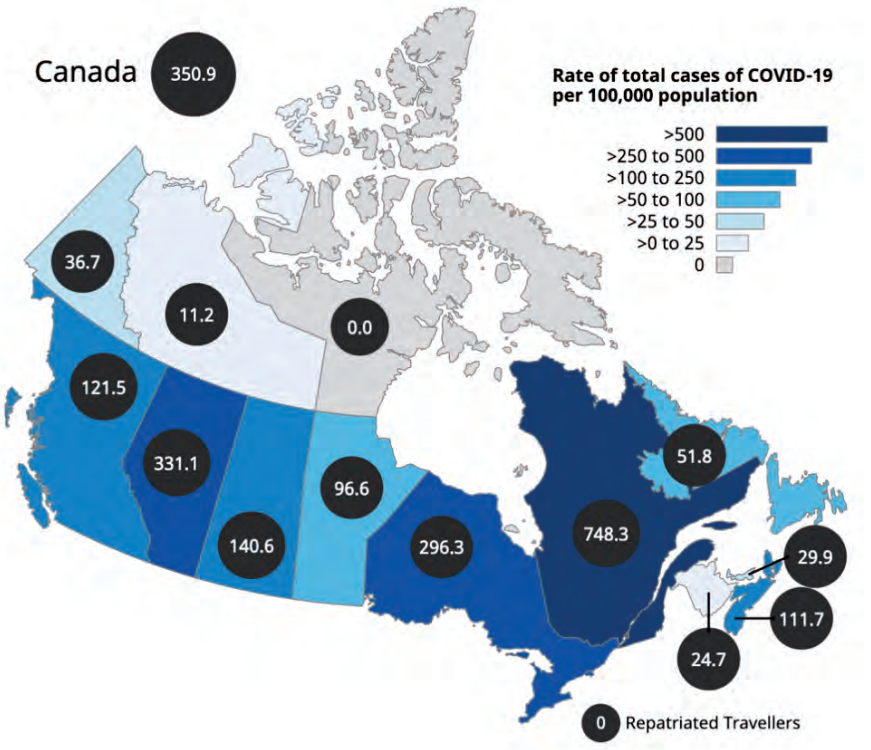

FIGURE 29.2
Rate of Confirmed Cases of COVID-19 per 100,000 population by Province as of September 6, 2020 [5]

No single factor accounts for the differences in the relative rate of cases in different provinces. Clearly the effects were greatest in large metropolitan centres, but that is only part of the picture. The high number of outbreaks in (especially) Nursing Homes and Seniors Care residences accounted for many of the cases found even in more sparsely populated provinces like Nova Scotia. Similarly, cities with busy international airports typically had higher incidence rates than those found elsewhere.

29.2.2 Federal/Provincial Issues and Reactions

Constitutionally, while Canada's federal government provides nation-wide leadership and coordination across all 14 jurisdictions in a national emergency (such as a global pandemic), each provincial government is responsible for adapting and implementing its own regional or local specific emergency management plan. Federal authorities are also required to provide 2-way communication with all provinces and territories when coordinating the influx of returning citizens and international travellers who are exiting or entering the country at the more than 140 land border crossings, 14 international airports, and over 550 port facilities that play a strategic role in Canada's goods and services supply chain.

Approximately 80% of Canadians live within 160 kilometres miles of the Canada – United States border. The other 20% of the population resides in the remaining land mass that stretches a further 5300 kilometres north. If there was ever a crisis requiring an understanding of location and its relation to human health – this was it.

29.3 Institutional and Technical Responses

Interestingly, the first capabilities to which Canadians turned were not geospatial in nature. Rather, governments at all levels relied upon institutional responsiveness and the reach of television, radio, social media, and newspapers. Depending on real-time events coupled with legacy economic and social influences in each province, each provincial government responded to their specific regional and local realities.

Communication strategies leveraged the power of a captive audience and the fact that 93% of Canadian adults are reached by television each week. To an impressive and unusual extent, federal, provincial and even (in major cities) municipal governments aligned to provide messaging that was overwhelmingly consistent, uniform, and readily available. Data initially focussed on the numbers of cases, the spread of the disease and the ongoing provision of expert advice and opinion. From March through May 2020, each provincial premier hosted daily news conferences that were televised on national and local media, usually following the Prime Minister of Canada who conducted his daily briefing for all Canadians. In the same sessions, expert senior public health authorities provided extensive information concerning the impacts, spread, and efforts at addressing COVID-19 in every federal, provincial and territorial jurisdiction.

Through different media channels, Canadians were urged strongly and consistently to: follow specific distancing and masking protocols, adopt telework arrangements, stay quarantined, and minimise exposure to each other by staying at home unless required. Given a tendency towards deference to authority and trust in governments, Canadians overwhelmingly adopted stringent health protocols.

29.3.1 "Dashboard" Services

To minimise speculation and conspiracy theorizing, all major political leaders in Canada threw their support behind expert management of the crisis. All governments established COVID-19 specific websites with extensive information and data about the impacts and preventative measures. For example, the Government of Canada released "Get Updates on COVID-19" a web-based email service that provides subscribers with critical information related to the pandemic. Developed by Health Canada, the Canadian Digital Service and Service Canada, the service ensured that those Canadians who subscribed would get authoritative and institutionally valid content through the Government of Canada website. Another application "ArriveCan", developed by the Canadian Border Services Agency and the Public Health Agency of Canada, allowed digitization of returning traveller information to help manage 14-day isolation information periods, including identification of whether the travellers have quarantine accommodations.

Baranovskiy et al. [6] offer an excellent early discussion of the difficulties in accessing, and organizing Canadian public datasets in order to create easy to understand thematic maps and charts that track the spread of COVID across the country. With "Made-in-Canada" geospatial solutions being initially slow off the mark, global substitutes were employed by national and local media outlets. For example, the John Hopkins Coronavirus Resource Center[1] provided a very effective dashboard highlighting global cases, detailed U.S. caseloads, and other visualisations such as timelines and critical trends such as mortality rates. Another exceptional visualisation tool used by Canadian sources came from the Financial Times[2], whose coronavirus data was used to illustrate not just the vectors and incidence of COVID-19 but also the economic impacts and shocks of the pandemic on global and national economies. Finally, the "COVID-19 Case Data Explorer" developed and maintained by Esri Canada [7] offers a very detailed up-to-date statistics at national, provincial and, in some cases, local health district levels.

It was not until May 2020 when the Government of Canada unveiled its first geospatially enabled dashboard which resulted from a shared collaboration between the Public Health Agency of Canada,

[1] See https://coronavirus.jhu.edu/map.html
[2] See https://on.ft.com/3d32Y1Z

Statistics Canada, and Natural Resources Canada[3]. The dashboard, like that provided by Johns Hopkins, was powered by ESRI GIS capabilities and drew upon Government of Canada data and technology. Added visualisations included COVID in the world, a situational awareness dashboard visualising provincial and territorial data and other economic and demographic indicators[4]. All Canadian provinces and territories now have data driven dashboards or geospatial tools that highlight the incidence of COVID-19 in their respective jurisdictions.

29.3.2 Geospatial Monitoring and Analysis – Contact Tracing

Contact tracing is "... the process of identifying, assessing, and managing people who have been exposed to a disease to prevent onward transmission" [8]. Public health agencies have long employed the tracing the contacts of infected individuals (and then their contacts in turn) in order to inform policies and practices which reduce infections in the population. Digital contact tracing today relies on positioning and tracking capabilities of (primarily) mobile personal devices in order to determine contact between a given infected patient and the device user.

Different countries have adopted different technical approaches and sometimes conflicting guiding philosophies to digital contact tracing. There is considerable debate on the user population-base requirements necessary to ensure effective contact tracing as well as the attendant privacy and security implications to individual citizens using contact tracing apps [9, 10].

Exposure notification applications rely on the same basic technology but purports to offer greater privacy protection to individual users [11]. Exposure notification apps notify you if you have been near someone who later tested positive for COVID-19. By comparison, contact tracing apps let people log their location and then share it (voluntarily or involuntarily) with public health authorities.

Through April-May 2020, Canada saw multiple efforts carried out by independent provincial governments in Alberta, Newfoundland & Labrador, Ontario, Manitoba, Saskatchewan and New Brunswick to either procure or develop in-house their own apps to support "exposure notification" [12].

Most of these initiatives intended to incorporate Bluetooth technology provided by Apple and Google. However, to avoid duplication and confusion, those companies made it clear they preferred supporting one nationally-endorsed app rather than many different regional ones [13]. The federally-funded COVID Alert app development project was led by the Canadian Digital Service and being undertaken in cooperation with partners from the Ontario Provincial Government and with help from volunteers from the commercial technology firm Shopify [14]. While originally expected to be rolled out by July 1, 2020, unexpected issues in refinement and testing delayed the national app's introduction until July 31, 2020 – and even then its reception was mixed [15].

From an institutional perspective, widespread public and commercial interest in COVID-19 related contact tracing apps quickly sparked concerns from government Privacy Commissioners and citizen interest groups alike across Canada. Two institutional responses provided early and very useful contributions to this debate. In April 2020, the Office of the Privacy Commissioner of Canada issued an assessment framework [16] intended to "... assist government institutions faced with responding to the COVID-19 crisis, and help organizations subject to federal privacy laws understand their privacy-related obligations during the pandemic". This framework was followed the next month with a more extensive Joint Statement by Federal, Provincial and Territorial Privacy Commissioners articulating their shared position on privacy principles for contact tracing and exposure notification [17].

Given the engagement of the Privacy Commissioner of Canada and other key geospatial departments such as Natural Resources Canada – concerns for individual privacy and protection directed the final application design to utilise Bluetooth to exchange random codes with nearby phones that also have the app involved. If someone within the proximate areas scanned by the phones later tests positive for COVID-19 they are to entire a key or code into the app. If any individual has spent more than 15 minutes and less than the mandated 2 metres apart from the

[3] See https://health-infobase.canada.ca/covid-19/

[4] https://health-infobase.canada.ca/covid-19/visual-data-gallery/

infected individual they will be notified. It should be noted that this app will not provide location, names, addresses, places, the time of contact or any health information to anonymise and protect the health information of Canadians.

29.4 Discussion

The "purpose-built" development of the new Canadian Government geospatial dashboard devoted specifically to COVID-19 tracking is notable for two reasons. First, it took well over 3 months for the relevant data and tools on the new dashboard to be configured and launched publicly. At the same time, the Government of Canada already had its own Federal Geospatial Platform [18] as an enterprise wide geospatial capability – one that had been highly touted as one of the Government of Canada's most successful data and technology initiatives. In the authors' opinion, this lack of responsiveness and subsequent duplication requires further study. Second, the time lag in preparing Canadian data dashboards suggests a gap in the institutionally driven pandemic Response Plan. Although this Plan had clearly undergone significant consultations and trial runs beforehand, it suggests the need for greater advance planning to reduce this time lag for data loading in the future.

As well, the authors look forward to seeing reports on the use of geospatially-enabled dashboards and exposure notification *for operational modelling purposes in Canada* through different stages of the pandemic. A significant amount of relevant health data on the spread and incidence of the disease may already be available to public authorities in geospatial and analysis-ready formats, but its veracity is still unclear. While we appreciate there are real and significant difficulties in planning and conducting such analyses effectively [19, 20], critical assessments of examples and lessons learned in this regard will be extremely valuable to the international community. Similarly, there has been no documentation yet on the impact and use of that geospatial data for economic and health recovery in Canada. Geospatially-enabled analysis of supply chains, detailed economic analyses at local levels, and sentiment analyses of citizens in hardest hit areas are all within the grasp of the technology of today. The authors look forward to seeing – hopefully soon – work undertaken in this regard as well.

29.5 Towards the Future

Geography – in particular, the very small number of densely-populated large metropolitan areas in relation to its vast area – has played a key role in Canada's relative success in containing the COVD-19 pandemic. Still, if the number of confirmed cases and mortality statistics are any indication, Canadian responses to the COVID-19 pandemic have been relatively well managed and of the "middle of the pack" variety. While new apps have been developed, websites built, and a variety of data disseminated to citizens, the first priority was clearly to use mass media to communicate information and expert advice in order to ensure that citizens were protected from the effects of COVID-19 and that the general population benefitted from the mitigation of any spread.

That said, the issues highlighted earlier do present significant institutional and technology-development opportunities in Canada.

First, most jurisdictions could respond more quickly if proactive work is done to share technology and data within the framework of national pandemic or disaster plans. Critical questions highlighting which data are essential to report and how should form a critical element of a clear data strategy in each plan.

Second, these pandemic plans should also focus on the recovery – it will be essential to understand how the health recovery is progressing alongside an economic recovery, and key social,

environmental and health indicators from national to local perspective would be critical to a well managed and staged set of economic and social policy interventions.

Finally, as we move further away from any pandemic or crisis, there is a clear need to ensure that tools and data enabling pandemic response are transformed and sustainably utilised for the next set of crises that depend on geospatial data.

Global readiness depends on long term vigilance. Leadership and international cooperation will be required in the GGIM academic community and well beyond in order to ensure all nations are able to attain the necessary levels of technical and data readiness.

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30

Geospatial Intelligence in Dealing with COVID-19 Challenges in Czechia

Milan Konecny, Jiri Hladik, Jiri Bouchal, Lukas Herman and Tomas Reznik

This chapter deals with aspects of geospatial support to manage COVID-19 in Czechia. The first three cases of the disease were confirmed on March 1, 2020. Geospatial intelligence has played an important role in analysing and predicting the spread of the disease, in designing and optimizing measures against it, and in reducing harm. Three categories of applications were identified and described when following the conducted analysis of the content and purpose of COVID-19-related geospatial applications and solutions. The first, the visual analytics of COVID-19-related health statistics follows the concept of multiple coordinated views and dynamic queries. This category of applications uses various official or semi-official sources of geospatial data and their presentation in interactive web maps. The second, different tracking applications or tools for analysis of people's movement and identification of risky contacts was implemented. In the Czechia, these are for example eRouska mobile application and movement tracking in the Mapy.cz application. The third category represents decision support systems for public administration, emergency services and volunteers. Example of this category is the interactive map of registered volunteers used by coordination centre established by Masaryk University (MUNI) in Brno, Czechia. The advantages, limitations, and possible future directions of the mentioned applications of geospatial intelligence are discussed in the conclusions.

30.1 Introduction

The United Nations Global Geospatial Information Management (U.N. GGIM), which includes the core idea of creating a global geospatial integrative data ecosystem with potential applications in various situations (incl. pandemic) and on all geographical levels (incl. local and regional), is fundamentally based on the Spatial Data Infrastructure (SDI) concept. The COVID-19 pandemic has again highlighted the need of societies to deal with various kinds of data and to enrich and integrate them "on-line" or "near-online". One of the necessary preconditions is to analyse data fast and provide visual representations such as digital maps and other types of models. Geospatial intelligence proved itself to be an useful bridge combining the already existing authoritative spatial data (as in the Infrastructure for Spatial Information in the European Community - INSPIRE and national SDIs) with referenced health information regularly collected by special governmental institutions (in Czechia, this is e.g. the Institute for Health Information and Statistics - IHIS) or obtained by everyday measurements based on COVID-19 testing among various population groups and regions of Czechia. This paper describes theoretical and practical approaches based on state-of-the-art geospatial intelligence.

Based on the analysis of the content and purpose of existing and newly emerging geospatial applications and solutions [1–3], the authors of this paper have integrated three approaches to improve dealing with COVID-19-related problems:

- Visual analytics of COVID-19-related health statistics,
- Tracking and analysis of people's movement and identification of risky contacts, and
- Decision support systems for public administration, emergency services and volunteers.

30.2 Visual Analytics of COVID-19-related Health Statistics in Czechia

The main goal of visual analytics is to provide interactivity through utilizing the concept of multiple coordinated views and dynamic queries to emphasize the impact of changes in analysed phenomena. A number of applications have been developed around the world for the visual analysis of geospatial data on the spread of COVID-19 [1–3]. Many of these applications are global and use data from the World Health Organization (WHO). Several applications use data from Johns Hopkins University in Maryland; this data source is created by combining several primary data sets (such as WHO) by supplementing them with additional information. In Czechia, applications that visualise global data have also been developed alongside visualisations built to analyse domestic data. Those focused on Czechia primarily use the data provided by the Ministry of Health of the Czech Republic, as well as the IHIS data, which are included. Data collection process includes an aggregation of data from individual Regional Public Health Stations. These data are freely available [3].

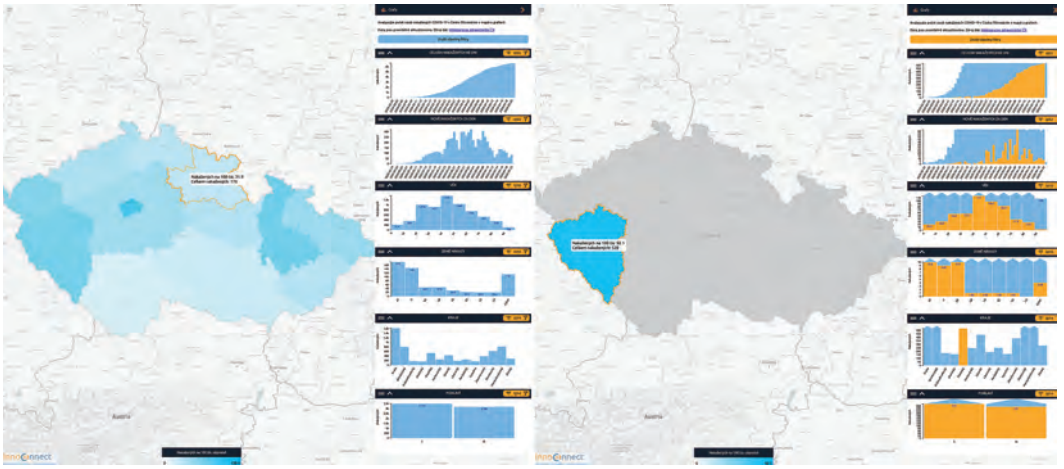

FIGURE 30.1
An interactive map of COVID-19 in Czechia*. Note: choropleth maps show the number of infected per 100 thousand inhabitants. Graphs in columns are used to select according to the infected persons' age, region and gender, or according to the date and source country (if infected abroad) of the infection. The map on the left shows the overall situation in Czechia; the situation in the Pilsen Region is displayed on the right.
* *http://mapa-koronavirus.innoconnect.net*

A map of COVID-19 spread in Czechia[1] is an example of this kind of visual analytics application.

[1] https://mapa-koronavirus.innoconnect.net/

The map allows to analyse the number of people infected by COVID-19 through implementing multiple linked views to present the data. Each of the views (map and charts) enables different interactions, such as brushing, relationship analysis, and filtering that trigger an instant update of the other views. Different combinations of filters can be applied for deeper insights, for instance by selecting a single source country of infection: the distribution of cases originating in that country is then visualised according to time, region, gender and age (Figure 30.1). It is also possible to select people over 70 years of age as a group and highlight the regions with the highest number of infected senior citizens. These functionalities are implemented on top of the WebGLayer open source library[2].

30.3 Tracking and Analysis of People's Movement and Determination of Risky Contacts

The application and procedures described in this section form the technological basis for the deployment of the "smart quarantine system". The main part of this system in Czechia consists in creating "memory maps" based on processing of an individual's movement data obtained from the relevant mobile operator. There are two facts that need to be emphasized. The individual must agree to data processing and no data belonging to any other persons are used in the process. The aim is, therefore, to help the person remember all the places he or she visited and then identify all people (s)he came into contact with. The use of memory maps is supplemented by other voluntary technologies such as the eRouska (eMask in English) mobile application[3] and movement tracking in the Mapy.cz application[4].

eRouska is a mobile application for smartphones that helps authorized officers from Regional Public Health Stations to easily and quickly identify people with whom an infected person came into contact with and who are therefore also potentially at risk of infection. The application uses Bluetooth and records close contact with other users of the application. Tracking within Mapy.cz uses location history data collected by mobile devices. Thanks to location sharing, an increased probability of infection can be calculated; this probability is determined on the basis of whether the observed person stayed in the same place for a significant period of time as a person who has tested positive for COVID-19. By July 2020, 1.4 million users have volunteered to share their location data using the Mapy.cz application (out of the total of 10.7 million inhabitants of Czechia).

The aforementioned tracking data from mobile phones can also be used to improve the population estimates in certain areas, e.g. due to the increased incidence of COVID-19 in these areas. Kubicek et al. [4] describe a proof-of-concept application of tracking data from mobile phones in a crisis management context. A similar approach can also be used in the future to improve the estimates of current population in smaller areas affected by COVID-19 in order to facilitate closure planning or to plan services.

30.4 Decision Support Systems for Public Administration, Emergency Services and Volunteers

Geospatial applications can also serve as a platform for volunteers, community groups and those who need help in connecting with each other, as well as for local authorities and individuals or groups of volunteers matching specific locations and other criteria. Maps can display information and help in navigation to hospitals, clinics, grocery stores or pharmacies, places where personal protective

[2] http://webglayer.org/
[3] https://erouska.cz/en
[4] https://napoveda.seznam.cz/en/mapy/covid-19/

equipment can be purchased and similar. In affected areas, this information and connections could improve the organization of assistive services and thus potentially save lives.

Masaryk University (MUNI) in Brno, Czechia, has established a coordination center for volunteers right at the beginning of the COVID-19 crisis[5]. The help offered consisted mostly in the manufacture of face masks, food or medicine delivery to vulnerable people, babysitting, teaching assistance and similar. Both volunteers and requests for help and assistance were collected through online forms, e-mails and phone calls. All data thus obtained included geospatial information; Geographic Information System (GIS) support has been introduced across all these activities to increase the coordination center's efficiency.

An interactive web map based on the Leaflet library[6] has been established to display the location of all registered volunteers. The map also features browsing by attributes and filtering and address search to help operators locate people who are asking for help and to assign a suitable volunteer nearby (Figure 30.2). Input data from Excel sheets were processed using a Python script. To obtain geographic information from the addresses provided, two geocoding services are used: the national Registry of Territorial Identification, Addresses and Real Estate – RUIAN geocoding service[7] operated by the Czech Office for Surveying, Mapping and Cadastre on the one hand, and the geocoding service provided by the Czech online and mobile map application Mapy.cz[8] developed by the private company Seznam.cz on the other hand. The output point dataset was visualized using Leaflet.markercluster plugin[9]. The data processing script was executed automatically every 10 minutes to keep the data in the application up-to-date.

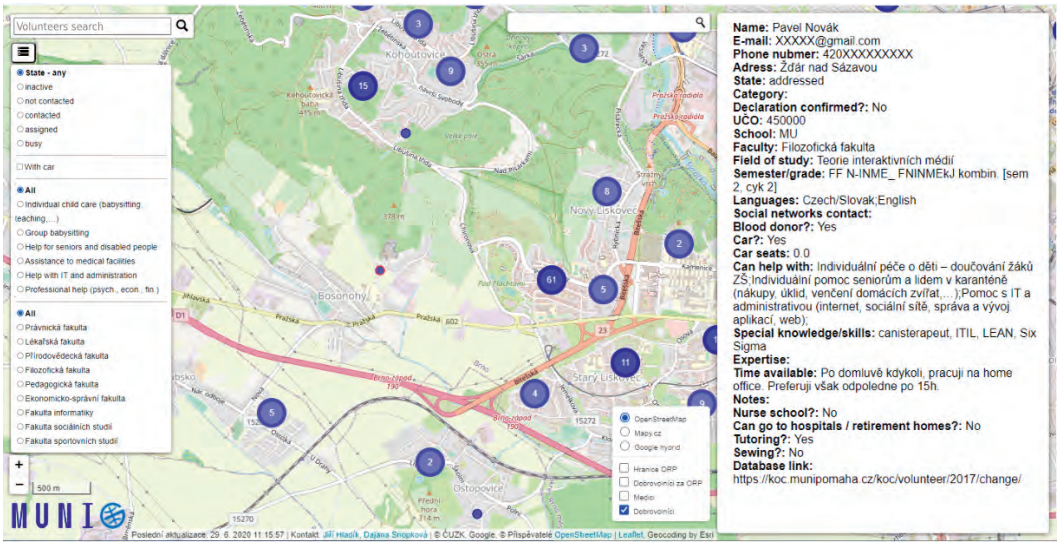

FIGURE 30.2
An interactive map of registered volunteers. Note: elements on the left contain a search bar and data filtering; the right panel contains information on the selected volunteer.

A similar application was established for public use in order to promote the activities of the coordination center and, simultaneously, to invite more help-seekers by providing information on available volunteers nearby. To ensure protection of the volunteers' privacy, the amount of sensitive information was reduced, location data were anonymized and aggregated. The internal version of the map of volunteers was used by 30 people, usually 7 workers per day. Overall, more than 4,000 volunteers have registered, and the center has successfully resolved 2,405 requests for help. The

[5] https://munipomaha.cz/en/i-need-help
[6] https://leafletjs.com/
[7] http://ags.cuzk.cz/arcgis/rest/services/RUIAN/Vyhledavaci_sluzba_nad_daty_RUIAN/MapServer
[8] https://api.mapy.cz/geocode
[9] https://github.com/Leaflet/Leaflet.markercluster

map has also helped coordinate efforts with other volunteer groups where they had a shortage of people.

30.5 Conclusions and Discussion

Geospatial information has been an irreplaceable tool across the activities to combat the COVID-19 pandemic in Czechia, regardless of whether the particular application has been provided centrally by the government/public administration, the private sector and/or volunteer activities. Location information, mapping and GIS tools have been used at all stages, from preparedness in areas without infected persons, through response at hotspot areas, to mitigation across the whole country. Open source as well as customized national commercial products have been used with similar frequency. For such purposes, both, national map data sources/registries and open data like OpenStreetMap are combined.

Several applications have been created quickly and spontaneously, many of them initially containing several cartographic mistakes or shortcomings that were later gradually corrected. A typical shortcoming was, for example, the use of a choropleth map to display the absolute number of infected people instead of showing a share of the infected in the population, or using proportional map symbols. Geospatial applications visualizing COVID-19-related health statistics have also suffered from data quality issues such as different data reporting practices in different regions. Potentially, data errors can also occur in processing or in combining input data from different sources.

This use of Geospatial Intelligence based on a combination of the three approaches in dealing with the COVID-19 pandemic represents one of many possibilities. It can also be applied in other crisis situations, other cities, countries and continents if high-quality geospatial data are available.

The tasks related to the COVID-19 pandemic were in public administration and public health bodies firstly addressed via spreadsheets, notes etc. Geospatial intelligence was employed in early stages of the pandemic as it resulted in such bodies in (1) significantly faster processing, (2) more complex tasks, (3) sophisticated predictions and (4) shortening the supply chain. All these benefits are demonstrated during the second wave of the COVID-19 pandemic[10] that is even stronger than the first wave in spring 2020.

Acknowledgement

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31

COVID-19 in France: A Multiphase and Multidimensional Approach to a Complex Societal Imbalance

Carmen Martin and François Pérès

This chapter focuses on the effects of the pandemic in France. The first part describes the phased evolution of the perception and treatment of the virus in the first half of 2020. In the second part, a multidimensional analysis describes the societal impact of the health crisis and its negative and positive effects on France in general and, by analogy, in Europe and the world. The study first presents the temporal characteristics of the pandemic associated with the mix of scales, phase shifts, delays, inertia and the random and unpredictable dynamic nature of the crisis evolution. Secondly, a view qualified as functional, depicts the virus in relation to the different roles it played in terms of its capacity to reveal phenomena, accelerate dynamics, divide or reconcile communities together, bring about new behaviours, eliminate or restore weakened entities and generate a questioning of the very meaning of the existence of our societies' lifestyles.

31.1 Introduction

This chapter looks back on four months of exploration of this new world and the experimentation of life in the presence of a deadly virus. A first part deals with the factual nature of the events observed during the first six months of the crisis. An analytical and instantaneous vision of the situation in France is proposed in a second part. Two angles are considered, respectively approaching the temporal and functional views to describe the dynamic parameters characterising the evolution of the crisis and the role played by the virus in the envisaged societal upheavals[1].

31.2 Observation

31.2.1 Evolution of the Crisis, Health Measures, and Risk Perception

The Covid19 pandemic in France followed a phased process. Each of the process stages is to be brought closer to the level of risk perceived or proven by the population and its governing bodies (Figure 31.1)[2].

[1] Due to the uncertainties about the evolution of the crisis and the countermeasures imagined to contain its consequences, the sustainability of the ideas developed and the forecast data is not consolidated. Perhaps the future will deny or correct some of the forward-looking ideas or solutions reported here.

[2] This graph is only a snapshot of the evolution recorded during the first half of the crisis. At the time this chapter was written, the evolution of the pandemic was on a downward slope. However, many experts believe that a second wave should hit France at the end of the summer.

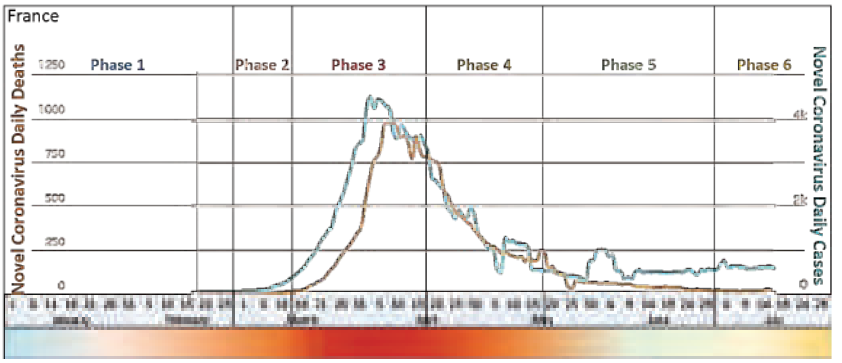

FIGURE 31.1
Graph of the Evolution of the Number of Cases and Deaths in France in the First Half of 2020

31.2.1.1 Phase 1: Observation and Denial - November 2019-February 2020

Even with the announcement by China of the discovery of a new Coronavirus by the Chinese authorities on January 1, 2020, France observes but is not worried [1]. Reinforced by the finally not very alarmist announcements of the World Health Organization, a feeling of indifference reigns, associated with a (false obviously) perception of invulnerability and a denial of the risks of contamination.

31.2.1.2 Phase 2: Awareness and Projection - Early March 2020

Even though the French generally trust their local health services, there is growing concern among the population. Debates are flourishing at all levels of decision-making, on masks usefulness as a protective barrier, on hydroxy-chloroquine effectiveness as a curative treatment, on the choice between distancing strategy and herd immunity [2]. On March 16 2020, the President announces "France is at war". The general confinement of the population is introduced.

31.2.1.3 Phase 3: Adaptation and Resignation. Mid-March to Mid-April

Except for a few derogatory measures, 67 million French people have to limit their movements to what is strictly necessary. The French are taking the full measure of the seriousness of the epidemic situation: 70% of those questioned consider that COVID-19 is particularly contagious [3]. In a volatile public opinion, the Covid-19 epidemic sharpens fear, rehabilitates the performative function of the presidential speech and unites the French around the measures taken by the executive branch.

31.2.1.4 Phase 4: Fatigue and Hope. Mid-April to Mid-May

The first month of confinement is well accepted, and the French (no doubt for fear of sanctions) adhere to the measures taken by the government. But, in France more than elsewhere, the credit given to leaders never lasts very long and, one month later, mistrust takes over with a 58% rate of dissatisfaction. Faced with this prolonged crisis and the executive's procrastination on several subjects (tests, masks, etc.), the confidence of the French people has not collapsed, but it has significantly eroded. Besides, in one month, the number of deaths rose from 150 to nearly 18,000 (Figure 31.2), which understandably cannot drive euphoria. The peak of contamination is reached between 6 and 10 April, and the epidemic begins to recede. The anticipated announcements of deconfinement and a date for its entry into force give new hope. The measures taken by the

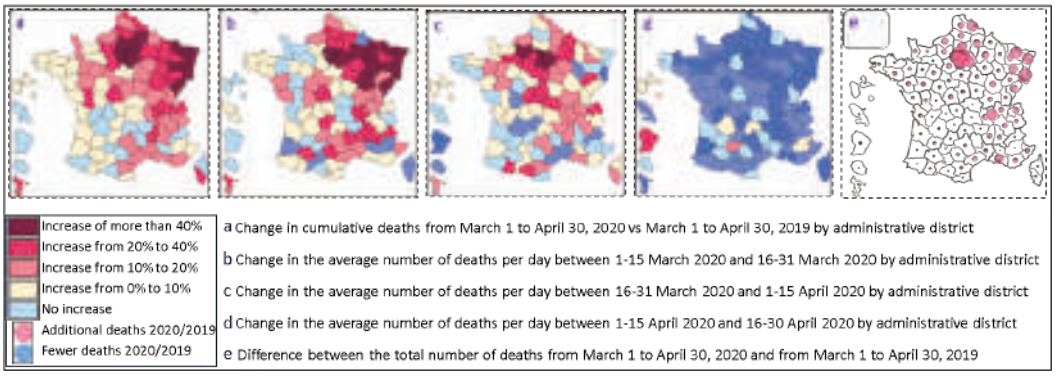

FIGURE 31.2
Spatial and Temporal Evolution of Mortality Linked to COVID 19 in France

executive to support short-time working and the social protection nets set up to help individuals and legal entities cushion (temporarily?) the effects of the health crisis, doubled in an economic depression.

31.2.1.5 Phase 5: Liberation and Concern Mid-May End June 2020

On May 7 2020, the end containment measures are officially announced for gradual implementation from May 11. The government policy is based on a three-pronged strategy: (i) living with the virus, (ii) acting progressively, (iii) adjusting locally. Indicators are established for the implementation of the various measures (reopening of schools, shops, public transport, residences for the elderly, places of worship, parks and gardens, beaches, cultural sites, etc.).

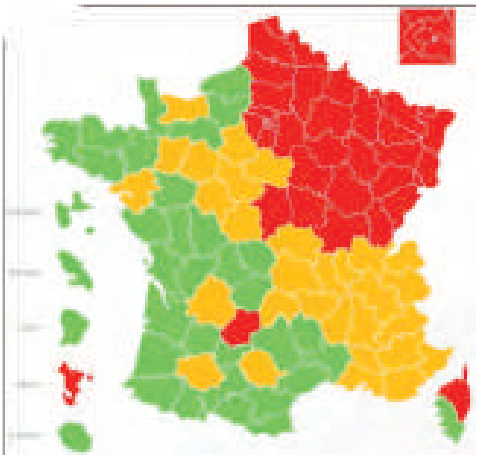

FIGURE 31.3
Spatial visualisation of the virus incidence rate indicator on May 7, 2020

These indicators indicate whether a department is classified as green, orange or red zone (Figure 31.3). They are based on the incidence rate of new cases accumulated daily over seven days, the virus reproduction factor, the occupancy rate of resuscitation beds by patients with COVID-19, the positivity rate of tests collected three days previously, and the number of tests performed. The deconfinement phase is a relief for a majority of French people. It is also a source of concern. Health

authorities are worried, however, about the slackening observed at the end of the containment period and the feeling of a few that the war is won. Warnings are constantly being repeated to remind people that the virus is still circulating and that barrier gestures remain essential.

31.2.1.6 Phase 6: Learning and Release July 2020

Even if this number remains relatively constant, one still observes, in a somewhat irrational way, a downward trend in the systematic adoption of preventive measures. This decline in vigilance is undoubtedly linked to deconfinement which favours social interactions and makes it more challenging to adopt physical distancing measures. It is also related to the decrease in the number of hospitalisations and deaths, which may question the usefulness or relevance of maintaining the systematic adoption of these behaviours. (Figure 31.4). It should also be noted that among preventive measures, the wearing of masks is gradually becoming part of everyday life.

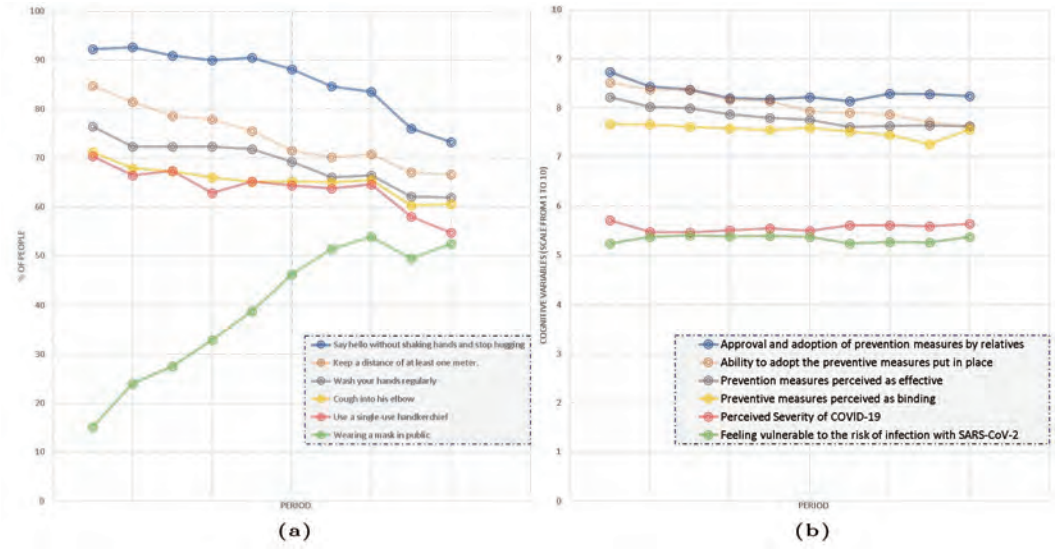

FIGURE 31.4
(a) Social Distancing and Barrier Gestures Application (b) Perception of Risk and Preventive Measures

31.2.2 Synthesis

The study of this phased process and the observed behaviour of the French population highlights the definition of risk, based on the exposure between a potentially vulnerable entity and a potentially dangerous event. The perception of risk requires being able to evaluate these different components (levels of vulnerability, danger and exposure), to aggregate them into a single measure and then to compare its value to a reference system capable of providing information on its level of criticality. The exercise is not simple, and very often, the perceived risk is not related to the real threat [4, 5].

Unable to refer to scientifically validated figures or statistics representative of their specific environment or lifestyle, the French have constructed their own indicators based on their interpretation of the signals received, mainly relayed by the media. Still, the distinction in risk assessment according to age groups combined with morbidity factors shows that the severity index is really taken into account in the perception of danger. On another level, the possible distortion between perceived risk and real threat can also be induced by a multiple relaxation risk. The probability of catching the virus is not equal to the likelihood of dying from it. Many people are

asymptomatic and do not suffer the pangs of the disease they carry within them. If it does occur, it is usually mild and flu-like. If, however, a worsening is observed and hospitalisation is necessary, only a small proportion of patients will be transferred to intensive care. Here again, the chance of survival is high. In the end, the risk of death can be minimised by the various emergency exits along the path of the infected person.

31.3 Multidimensional Analysis

The analysis proposed in this paragraph, which is inevitably incomplete, focuses on a few particularities related to different dimensions, in particular those connected with the temporal, functional and sectoral views of the health crisis induced by the appearance of the virus.

31.3.1 Temporal View

Beyond the different chronological phases discussed in the observation paragraph, one of the major difficulties in the management of this health crisis can be explained by temporal factors [6]. Several phenomena appear to coexist in this respect. We detail them below.

31.3.1.1 Time Scale Mixtures

Two crises overlap: a health crisis with immediate effects and lethal consequences and an economic crisis with delayed impact and societal repercussions. The short-term solution aimed at annihilating the virus by confining the people, vectors of its spread, has proved its effectiveness in health terms but leads to economic and social disaster on a more distant horizon. Conversely, refusing to give in to the pandemic comes down to sacrificing thousands of people on the altar of growth and prosperity without any real control of the human cost generated. Both paths seem to be dead ends, and only a subtle compromise should make it possible to limit the damage. At the political level, there is also confusion. The short-term view aimed at keeping endangered businesses alive by rapidly releasing financial aid leads to indebtedness with perhaps postponed devastating consequences in economic terms. The political and the economic horizons differ, as do the time frames at the individual or collective scales.

31.3.1.2 Dephasing

Delayed effects are also very significant in the Coronavirus crisis. First of all, there is a natural delay between infection and symptom appearance or between the different stages of the pathology's evolution. Acting on this dephasing seems to be futile. However, some delays can be reduced due to the slow or delayed effects of political or medical strategies. These delays are due to a lack of knowledge of the pathogenic agents or the evolution of the disease. This is the case, for example, in the search for curative treatments (anti-viral drugs, steroid anti-inflammatory medications, triple therapy, etc.), the results of which are still pending because of incompressible development times but also because of regulatory complications associated with normative issues. Sources of delay may also be linked to a lack of logistical support.

In France, several controversies emerged concerning this issue. First of all, the obligation to wear a mask was declared ineffective by hazardous state communication. The delay in the application of this barrier gesture was, in fact, linked to a lack of masks and an inability to produce them on French soil at the required rate. The same observation could be made about the diagnosis procedure. Implementing virological or serological tests was delayed by the lack of available structures and material shortages. Another controversy was widely talked about, related to the delay (or even absence) of attention by care structures for older adults affected by the coronavirus in retirement homes due to a lack of hospital beds.

31.3.1.3 Space-Time Shift

The erratic spread of the virus highlights a two-speed process.

The circulation of the virus between continents or between countries was not immediate; at the level of the large blocks of contamination, South East Asia was first impacted. Europe was then affected with a delay of about two months. One month later, the United States was hit hard. A few weeks after, South America, Russia and India were in turn, overwhelmed.

When a region is affected, however, the spread can be very rapid, with cases of contamination that can increase at a rate corresponding to an R_0=4 (one person contaminates four others on average) and a number of daily cases increasing exponentially. In France, this discrepancy has been observed between regions. The Great East was first affected, then the Ile de France, the Hauts de France and Burgundy. The rest of the regions were spared overall. However, the paralysing effects of the pandemic affected all of France. The same measures were applied throughout the country. This spatial and temporal gap amplified the immediate effects of the crisis and contributed to the blocking of economies by desynchronisation of supply and demand in the framework of interregional or international industrial relations.

31.3.1.4 Inertia

The temporal view also concerns the economy [7]. While the cessation of a commercial or industrial activity may be rapid, recovery can sometimes be more complicated as it cannot be achieved alone and relies on the one hand on synchronisation with the upstream and downstream logistics chain and, of course, on the return of consumption and customers. The recovery, just like the start-up of a business, is likely to come up against the so-called "Bullwhip" phenomenon. This phenomenon, which is well known in production management, is generally initiated by the uncertainties inherent in the demand of each stakeholder in an unstable market. It leads to distortions between current needs and effectively committed production. In addition to the unnecessary increase (or reduction) in production and the associated additional logistics costs, it results in undesirable inertia related to the number of links in the supply chain and their reactivity in processing information (order taking) and in the production (delivery of goods or provision of services).

This inertia is all the more critical in a health crisis that the state of the partners involved in a supply chain is subject to a high uncertainty level (on the partner responsiveness but also the expected product quantity, itself depending on the pandemic evolution).

The launch in France of the manufacture of respirators is the most typical example of this. Companies that were not in the business (notably industrial groups in the automotive sector: PSA, Valeo and Schneider Electrique), commissioned to speed up the marketing of this medical equipment have been confronted with this phenomenon. The inertia induced by the start-up of this new activity combined with a lack of awareness of the need for respiratory assistance devices led, on the one hand, to significant delays in delivery and, on the other hand, to overproduction. The newly manufactured respirators were not needed anymore. The essential nature of the demand and the emergency logistics put in place to meet it eventually led to costly and prohibitive expenses without any return on investment or profitability.

31.3.1.5 Chaotic Dynamics

Even if day by day research is making progress and the state of knowledge is improving, the transmission factors and conditions necessary for the transmission of the virus remain poorly understood. Some variables seem to be preponderant (age, morbidity factors, etc.). Others require confirmation (gender, antibody generation, pollution, climate, etc.). It is difficult to explain, for the time being, the low level of contamination in Africa compared to South America, for example. The seasonality of the virus is not certain either. Has a periodic phenomenon been initiated requiring, like the flu, an annual vaccine? Is it, on the contrary, a "one-shot" cellular disorder caused by a natural or human-made accident? Virus mutation, improved detection techniques or advances in treatment are also likely to change the curves. The uncertain nature of all these factors makes it impossible to rationalise the dynamics of evolution and renders challenging to forecast the number of people infected and the projection in terms of expected mortality [8].

In France, the dynamics observed showed a radical effect of containment and barrier gestures in the spread reduction of the virus. Knowledge of the time constants: incubation (1 to 14 days), contagiousness (8 to 37 days) turned out to be accurate and in line with prognosis. What will happen when life returns to normal? What trajectory will the pandemic follow? At the time of writing, all is conjecture.

31.3.2 Functional View

This paragraph discusses the contributory role attributed to the coronavirus. For the most part, the effects of the pandemic are obviously deleterious and have resulted or will result in human and social (excess mortality, depression, domestic violence, school dropout), economic (corporate bankruptcies, debt) tragedies. Nevertheless, as a famous French expression says, "à quelque chose, malheur est bon" which means that however unpleasant an experience can be, you will probably learn from it. The appearance of the coronavirus does not deny the precept. Faced issues, new situations, lived experiences can be sources of inspiration and renewal. In this sense, and without erasing or compensating for the harmful effects of the pandemic, the health crisis can have a role to play and a beneficial character. These aspects are briefly described below. A synthesis in the form of a table is available (`https://tinyurl.com/covidappendix`); this presents a more comprehensive view of the contributory character of COVID 19 on nine major themes: Health Medicine / Economy Business Work / Ecology Sustainable development / Tourism Leisure Sports Culture / Education - Schools - Universities / Society - Lifestyles / Politics State / Justice / Science Technologies.

31.3.2.1 Detector, Scanner and Demonstrator Function

The appearance of the virus has had a significant role in confirming or highlighting the qualities and defects that were until then inconspicuous, or even invisible, of all our systems (immune protection, health management, etc.), organisations (political, industrial, etc.) or strategies (economic, environmental, social) [9]. In France, like a scanner, it has revealed unsuspected weaknesses or, on the contrary, hitherto unknown forms of resilience. It should be noted that the revelation of negative aspects is in itself something positive in that it allows us to ask ourselves questions in order to remedy them and thus offers indirect benefits.

We list below some of the main lessons revealed by the crisis in France:

- **Vital Importance of Public Service and Role of the State.** The vital and unconditional support of the state has marked a disassociation from purely liberal doctrines. Based on market self-regulation and individual self-management, these policies are proving unsuitable for identifying and implementing solutions based on collective and social utilities.
- **Highlighting a Need for National or, at the Very Least, European Sovereignty.** The lack of medicines, health equipment or the shutdown in logistics chains due to the outsourcing of markets has revealed in a patent manner the need to sustain on its soil the means and knowledge necessary to maintain industrial autonomy.
- **Central State Limitations and Administrative Burdens.** The uniformity of containment policies, the slowness observed in the implementation of directives descending from Paris to the regions have shown a need for decentralisation of decision-making, a policy more based on territorialisation and administrative simplification.
- **Impact of Pollution on Health and the Need for a More Environment-Oriented Policy.** While coronavirus has already claimed more than 30,000 victims, fine particles and nitrogen oxides are responsible for approximately 67,000 deaths (lung cancer, stroke, heart attack, ...) every year. The recovery plans devised for a new future must integrate this ecological dimension.
- **Preponderant Role of Feminised Professions in Crisis Management.** Carers, nurses, cashiers,... these often feminised and poorly paid jobs, found themselves in the front line and of vital importance. A pay rise for these professions and a rebalancing of skills within social categories are necessary.

31.3.2.2 Enabler, Trigger, Facilitator, Catalyst, Promoter, Accelerator Function

The pandemic facilitated the outbreak of many phenomena that could not have been observed or would not have developed so rapidly without the presence of the virus, its consequences and the solutions put in place to counter it [10–13]. This role as a catalyst has had consequences, often positive and sometimes negative, by creating the conditions necessary to promote new practices, encouraging the development of new activities and stimulating novel ideas or theories.

A non-exhaustive list of this almost chemical function assigned to the virus in France is provided below.

- **Accelerating the Development of Alternative Energy Vehicles.** The crisis seems to have precipitated environmental awareness and encouraged energy transition. In the automotive sector, manufacturers are favouring the hypothesis that the crisis could accelerate the spread of electric or hybrid models.

- **Enhancement of Scientific Output.** Coronavirus-related research has been boosted: publications, clinical trials, and modelling have increased to unprecedented proportions. However, biases have appeared in the development and results validation, as well as in the monitoring capacity required for the professional to process this surplus of knowledge.

- **Increase in Governance Mistrust and Crisis Communication.** The discredit of the institutional voice (politicians, scientists, media) accelerated during the crisis. Polemics about the effectiveness of treatments and barrier gestures fuelled suspicions of manipulation and lies.

- **Simplification of Labour Law.** MPs adopted the bill on various legislative measures related to the health crisis, which relaxes the rules governing relations between employers and employees. These changes, justified by the need to allow companies to adapt to the consequences of the recession, have however been criticised by the opposition.

- **Amplification of Conspiracy Theories.** "Citizen-investigators", extremist militants or populist leaders refer to scientific studies, often contradictory, in support of their sometimes collusion suspicions. These plot ideologues aim to criticise authority figures and use them to discredit theories hostile to their models which often remain unclear.

31.3.2.3 Unifier or Divider Function

COVID 19 has also contributed to bringing together or federating, previously distinct domains, based on the observation of common interests, behavioural similarities or structural affinities [14]. It has also favoured the reconciliation, sincere or opportunistic, of historically divided entities but reunited again around shared problems. Conversely, the pandemic has led to separations or divisions by highlighting imbalances in treatment, differences of opinion and distinct perceptions of the situations to be managed [15].

This role of matchmaker or splitter is illustrated in the following examples.

- **Convergence Between Pandemic and Climate Change.** The decline in activity induced by the crisis led a Stanford researcher to state that "reducing pollution in China probably saved twenty times more lives than those lost to the virus". Perhaps the demonstration that economic deceleration or decline would be strategies for the future.

- **Divergence Between Health Protection and Individual Freedom.** French experts have diverged on the technical solutions proposed to facilitate the identification of "contact cases" of the virus. The reliability of the technologies and their health effectiveness, but above all, the risk of state surveillance or ethical questions have deeply divided the scientific community.

- **Coordination Between Science and Society.** The crisis showed that involving in the decision-making, those who will experience its application leads to more appropriate and better-lived choices. Crossing social and scientific issues requires a body to coordinate public debate, decompartmentalise disciplines and bring together experts and politicians to guide the governmental action.

- **Ecological and Social Opposition.** COVID 19 has shown the impossibility of achieving carbon neutrality without creating mass unemployment. In order not to dissociate the pillars of sustainable development, the ecological transition must, therefore, reconcile environmental constraints, strategic independence, localism and decarbonised and rural reindustrialisation.

- **Reconciliation of Retired Population and Working People.** The lack of resources dedicated to the elderly must lead to a redefinition of the policy on old age. This sector appears as a source of employment and an opportunity for researchers and companies to create innovative solutions. Retired and working people come together in a win-win logic.

31.3.2.4 Singular Point or Emergence Function

The Coronavirus crisis has imposed or will impose a brutal change on our (old?) world and the observed pandemic will undoubtedly be considered in history as a singular point at which lifestyles, behaviours and political strategies will be at odds with past attitudes. Nevertheless, the "France of the future" will not be achieved in a snap of the fingers. Consciences have evolved, which no doubt was the sine qua non condition for the revolution to get underway. Many obstacles to change remain, mostly related to the financial capacity to make the necessary structural changes but also to the possible release of emotional factors once the crisis is over. The health and economic damage caused by the virus seems to have triggered the emergence of irreversible trends [16].

Some illustrations proposed below come to illustrate this singular character.

- **Digital Revolution.** Digitalisation has shown the extent of its capabilities in the treatment of the coronavirus crisis. E-work, e-education, e-commerce, e-services are all areas of activity whose usefulness has been revealed by confinement. A digital upheaval has begun in France. It goes beyond the framework of the State and will be amplified in the future.

- **Break in Hospital Policy.** The neo-liberal trend observed recently in the hospital has undoubtedly had its days. The ethical rule of appropriate care for the patient at the least cost to the community must prevail over the commercial rule of seeking profitability based on the optimisation of its value chains and billing maximisation.

- **Urban Exodus.** The Covid-19 pandemic has highlighted the fragilities of contemporary urban globalisation. By paralysing global operations and freezing metropolises under confinement, the present epidemic has triggered a movement of depopulation of large cities (Paris, Toulouse Bordeaux, Lille, ...), to the benefit of medium-sized towns and rural areas.

- **Changing Traditions.** Sanitary crisis obliges, the kiss disappeared. This affectionate greeting, very French, had nevertheless crossed the centuries and civilisations until it became a tradition. New signs have begun to replace the kiss: the "elbow to elbow", the hello with the feet, the inclination of the bust, the hand on the heart... Definitive rupture?

- **European Debt.** The virus has enabled a decisive political breakthrough for the affirmation of Europe's sovereignty. On a Franco-German proposal, the historic resolution to issue a mutualised European debt on the financial markets triggered a new political era enabling Europe to catch up with the major economic blocs.

31.3.2.5 Purifier or Sanitiser Function

If preserving the planet means accepting the rules of nature, perhaps human mortality should be considered as an adjustment variable. This hypothesis is obviously not audible to society, but nature, through this health crisis, should perhaps ask us about the intrusive behaviour of our lifestyles and their deleterious role in environmental imbalance. Like cyclones leading to the renewal of wooded areas and the elimination of debilitated species, nature seems to be setting up natural purification processes eliminating the weakest elements to encourage the growth of the strongest. The pandemic engendered by the coronavirus and its induced or forced consequences seem to be part of this logic. It thus takes on, in turn, the function of a cleaner, leading to the elimination of the most feeble entities, or a sanitiser by natural consequences or via the implementation of anthropic actions to restore systems or situations affected by the crisis [17].

Examples of this function are given here below.

- **Deaths of Vulnerable Individuals.** People with physiological co-morbidities or heavy therapeutic treatments (chemotherapy, dialysis, organ transplantation, ...) are more likely to suffer from and succumb to a severe form of COVID 19. Independently, social precariousness, another form of vulnerability is also a risk factor for death.

- **Cessation of Payment or Bankruptcies.** Business insolvencies in France could increase by 80% in 2020 as a result of the crisis. Businesses already weakened before the pandemic (airlines, car manufacturers, restaurants, leisure activities, ...) are the first to be affected. Some emerging countries that have defaulted on payments are also close to bankruptcy (Angola, Zambia, etc.).

- **Reduced Noise Pollution and Improved Air Quality.** While containment has significantly reduced pollutant emissions, another more insidious pollution has decreased: noise. Marked by the decline in industrial activities, car or air traffic, a reduction in the average noise level of between 4 and 6 dB has been observed. Unfortunately, the truce is only provisional.

- **Smoking and Drug Use Cessation.** Even though 25% of French smokers have temporarily increased their consumption, the increased risk of infection by the coronavirus and the severe forms of the disease it might cause has prompted many of them to stop smoking. Moreover, difficulties in the supply of drugs have led to a decrease in drug trafficking.

- **Retreat of Extremist Ideas.** In France, extreme parties have not taken advantage of the effects of the crisis to increase their hold. Worse, they have regressed. By deciding to close the borders, the leaders have deprived the extreme right of their flagship argument. The sterile polemics launched by the extreme left on the government's negligence have not received favourable echoes.

31.3.2.6 Questioner and Validator Function

Beyond the simple questioning of the biological and medical aspects related to the appearance of the virus and its curative or preventive treatment, the global and multisectoral crisis engendered by the pandemic has questioned all social and professional categories in every field of activity. The exceptional nature of the scenarios provoked by this type of cataclysm, never experienced or even imagined in the contemporary era, has provided a breeding ground for scientific questions [18]. It also offers a real test basis for the experimentation and validation of the answers that could be given to this type of event or to others with similar consequences.

Without attempting to answer them, we list below a few high-level questions among all the scientific questions raised by the health crisis and its management.

- **Democracy or Totalitarianism.** Which regime is best suited to deal with this type of crisis? How far can freedom go if individual behaviour harms the majority? Is free will compatible with collective security? Are totalitarian regimes better suited to ensure security through coercive or even repressive measures?

- **Globalisation of Health.** Do the economic interests of pharmaceutical companies in the development of a vaccine and the confidentiality that it requires match the need for its rapid availability calling upon nations for transparency of data, sharing of ideas, and results? Is non-profit health globalisation conceivable?

- **Moving From Protectionism to the Precautionary Principle.** Should quality standards and norms replace customs tariffs? Should people first be protected from the risks they face or should companies (and their employees) be protected from competitive threats? Is the resilience of a state a higher value than the efficiency of its economy?

- **Emergency and Caution.** Should administrative or scientific protocols, which are sources of rigour but also of slowness, be relaxed in times of crisis? Therapeutic trials are subject to a methodology and legislation guaranteeing respect for the individual, non-maleficence and justice. What level of urgency can legitimise the lifting of these procedures?

- **Dynamics Between Science and Politics.** The health crisis has raised the question of the contribution of research to government action. Is academic expertise sufficient to legitimise decision-making in times of pandemic? How to reconcile scientific advice and political measures? Are the time horizons of science and politics aligned?

31.4 Conclusion

This chapter aimed to give a panoramic view of the impact of the coronavirus crisis in France. After an observation round describing the phased evolution of the course of events, an analysis was proposed. Considered from a multidimensional angle, dissociating temporal and functional views, the study highlighted the notions linked to the dynamics of the evolution of the phenomena induced by the crisis and the contribution of the virus to proven or potential societal modifications. The analysis shows that all facets of our lifestyles are affected, in one way or another, by this crisis of such an exceptional nature. The impact is, of course, negative in the short term, but looking at the longer term, the fallout from the crisis may have paved the way for beneficial changes in our society. All major social issues are concerned: health, freedom, solidarity, justice, globalisation, sustainable development, national sovereignty, ... The academic world must now take up these subjects. Physical sciences, life sciences, social sciences, applied sciences, engineering sciences, the entire research community must now act in a coordinated manner to find solutions to the harmful effects of this virus but also take advantage of this crisis to build the foundations of a safer, fairer and more respectful world.

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Part IV

Stakeholder Perspectives

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32

Digital Earth: A World Infrastructure for Sustaining Resilience in Complex Pandemic Scenarios

Richard Simpson

This perspective makes the case for an improved multidisciplinary global collaboration that more effectively leverages our technological prowess to improve how we share and communicate the best science-based information. The concept of Digital Earth - the aspirational digital representation of our physical, social, and natural world - is introduced to serve as a critical digital infrastructure for proactively informing policy, investment, planning, design, and our behavioural responses to managing crisis situations, including pandemics.

32.1 Spatial Information During a Pandemic

We live in an intricately interconnected and increasingly globalised world. Within hours a viral infection can rapidly spread throughout a community. Despite the advances in sciences and technologies, a pandemic such as COVID-19 can cost the global economy many trillions of dollars and have far reaching global social, economic, and political consequences.

Spatial information has long been recognised as a critical enabler in the forensic management of infectious diseases ever since 1854 when Dr. John Snow, one of the founders of modern epidemiology, applied maps to trace the source of cholera outbreaks to a single contaminated pump in Broad St. Soho, London [1].

During the COVID-19 pandemic there has been a plethora of innovative applications using spatial information to resolve issues at specific points in the response, and also recovery phases. These location-enabled apps have in many instances been helpful to specific tasks such as contract tracing, drug delivery and presenting signage via drones and robots, finding ventilators, dashboards, spatial enablement of e-learning and e-health systems, finding availability and location of public services, and informing us on lock-down policies.

However, despite the benefits of impressive technological and scientific advances, we are still effectively applying maps as Snow did over one and half centuries ago, except now the maps are digital. With uncoordinated international cohesion; siloing of information across disciplines, organisations and jurisdictions; and a lack of trusted integrated information resources, we have seen a cargo cult emerge with Government organisations practicing rituals to win public and political favour as hero warriors in this 'war' on the virus. We are not facing up to these challenges and their multi-dimensional dynamics as emergent complex adaptive systems, instead we are too often simplifying problems down into the arbitrary domains convenient to focus mono-disciplinary application of commercial-off-the-shelf point 'solution' technologies. We also lack adequate regulations, policies and data mandates to support the governance and sustained use,

provisioning and sharing of spatial information. The accumulative crisis now facing humanity and our inabilities to address it objectively is the result of failing to account for the aggregate impact of decisions initially made for short-term comforts and political gain.

New thinking is sought to revitalize these cultural and societal approaches towards spatial information and its metaphorical expression of objective science and our own identity and associations with places. This renaissance culminating in the realisations of a Digital Earth will expand our horizons for the interpretation of events, and create new ways for expressing our situational awareness through the arts, philosophy and scientific inquiry.

32.2 A New Paradigm of Thinking

To advance beyond this stalemate we need to shift the paradigm and adopt a more holistic and deterministic perspective on the challenge. We need to consider spatial information as an integrating enabler for a common open and innovative digital infrastructure, not just as a location enabler for point applications.

The rapid urbanisation, easy mobility and dense interconnectivity of cities is creating environments where pandemics will thrive. There is irony in the fact that the built and social environments of our city centric civilisation has made us more vulnerable to severe impact from disasters. Unbridled complexity of our built environment exposes our cities to risks of catastrophic failure. We have seen this demonstrated repeatedly in recent history with floods, earthquakes, bushfires, wars, tsunamis, landslides, and cyclones. The intensity of these disasters is increasing in the wake of our changing climate, and accelerating competition for essential resources.

Disasters can happen concurrently, as demonstrated by the spread of cholera following the Haiti Earthquake in 2010 [2]. The Spanish flu of 1918 brought acute illness to over a quarter of the world's population and death to an estimated 40 million people in the aftermath of 10 million killed in World War One.

The likelihood for disasters to happen concurrently is now more probable with the changing climate and city-driven global economy in the wake of rapid urbanisation. The significant human impact on the Earth's ecosystems and climate change increases the risk as this is creating situations more conducive to breeding pandemics [2].

Snow's identification of a contaminated water pump illustrates how even the infrastructure we depend upon and trust or fresh water and sanitation in a city can fail with disastrous consequence.

Despite so many advances in asset information management, for the greater part maintenance practices still remain reactive – just as they would have been in Snow's time. There is a pressing need for our cities' utilities to transform their business processes, policies and mandates to shift their traditional practices to a paradigm where there is massive integration of trusted evidence-based spatial data with real-time cyber-physical systems. Through this more dynamic ability to digitally mirror the objects and processes of the physical world such organisations and their supply chains can improve resilience with the applications of AI and machine learning with more proactive predictive and prescriptive asset management [3].

Similarly, decision making must also be driven by scientific evidence and effective use of spatial information to more effectively meet the challenges of pandemics such as COVID-19. Government and business institutions have traditionally been enabled by technical data and information but the power structures from twentieth century mean decisions are often made for short term vested interests rather than public good. Recent wide access to emerging communication technologies and social media platforms have revealed an emerging public capability for use and sharing of expert data in more productive ways to inform human behaviour for survival.

This pandemic has demonstrated that effective responses demands transparent governance and collaboration between all tiers of Government, related agencies and civilians. Snow's achievement not only illustrates the power of maps in the visualisation of correlated data, but also how spatial indexing helps build evidence with veracity and provides a referencing system for the aggregation of the collated information. Any disaster, especially a pandemic demands a coordinated

real-time response from diverse interdisciplinary teams that may include scientists, politicians, health workers, supply chain operators, data scientists, foreign diplomats, and technologists.

It therefore helps if all these stakeholders have access to the same trusted spatially referenced data. For population wide implementation of an emergency response, such data needs to be communicated clearly and accurately to the civilian population in ways that engage their cooperation and inform their personal choices to change habitual behaviours.

32.3 Digital Earth

Digital Earth is a multidisciplinary collaboration to build a comprehensive digital twin of our planet's built, natural and social environments [4]. It is envisioned as a massively integrated multi-disciplined digital representation of our knowledge expressed through spatial metaphor of a globe. For example, a Digital Earth could spatially integrate our planet's thermodynamic performances with associated environmental, epidemiological, economic, and other social phenomena so we can more effectively monitor situations and inform better decisions during all phases of a disaster. Digital Twins are the building blocks of a Digital Earth. They integrate multi-dimensional geometric, topological, behavioural and semantic representations with Internet of Things (IoT), artificial intelligence (AI) and analytics. Graph based digital threads trace all lifecycle transactions and associations to ensure the integrity of this cyber-physical coupling [3]. Through metaphors such as virtual globes [5] we can apply this digital framework to build a deeper and more collaborative understanding of the complex dynamic interactions in our physical world and what bearing these may have on our individual and collective wellbeing.

As a global scientific project, Digital Earth sits on a seamless multi-scaled continuum with other big-science initiatives including the Physiome project [6] to model our physiology for drug discovery and testing, and its predecessor the Human Genome project to functional and physically map our genes. These mathematical models provide insight into the dynamic complex adaptive systems that we have evolved into and become part of.

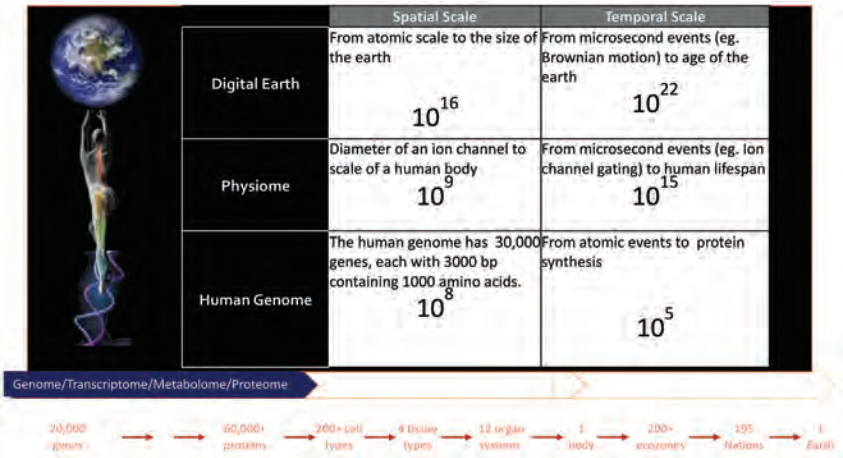

FIGURE 32.1
Big Science continuum - Adapted from Hunter, PJ and Borg, TK. Integration from proteins to organs: The Physiome Project. *Nature Reviews Molec & Cell Biol.* 4:237-243, 2003

For example, the models could reveal the interaction between COVID-19 the environment and physiological functions at different scales from genes to the whole living organism to the environmental factors. At the scale of the Physiome, genome and other initiatives in this continuum

such as the metabolome and transcriptome [6] valuable insights are being sought to accelerate the quest for a vaccine and improve patient treatment. Similarly, at the next magnitude in scale there is exciting potential for Digital Earth to provide predictive early warnings and deliver trusted evidence-based prescriptive course of action in real-time at every phase and inter-phase transition of a multi-hazard crisis situation.

A Digital Earth could also serve as an integrating foundation for a next generation of digital passports to enable us to safely travel and serve as an augmented super-sense to protect us from harm. This will only be possible if the Scientific and technical developments underpinning this project are effectively shared with, questioned, and trusted by civilian populations so they become a part of the civil and political process of learning and reconceptualising our impact on our shared global habitat and the laws for our engagement with each other.

32.4 Conclusion

There are remedial lessons to learn from this pandemic about appreciating how we are all connected, and how technologies can shape our daily existences and our survival outcomes. In the past we have embraced a vision of a world of machines for living in and enabling our mobility on demand. Until now we have only superficially applied technologies to conveniently interpret the realities of the world as a simple metaphor. Even with the benefit of computer technologies we model this world rather simplistically with a domain-based point 'solution' approach, avoiding complexity of the multi-disciplinary and massive data integration. This has so often given us a mistaken mental picture of possibilities and led us astray. There is now some urgency to rethink the design of our habitats, make scientifically informed decisions, transparently communicate trusted information and to consider how we can cyber-physically engage in the flux of the emergent complex adaptive systems of the world we live in rather than the one we picture.

A Digital Earth is a critical digital infrastructure to ensure our future survival as it consolidates our collective knowledge and liberates new wisdom. Realising a Digital Earth will demand prioritisation, fresh new 'moon-shot' thinking and international collaboration and determination. There are many intellectual, ethical and philosophical challenges, but a Digital Earth may become the most significant scientific and technological achievement in our civilised history and the definitive achievement of the 21st Century.

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33

COVID-19: The Open Data Pandemic

Jamie Leach

The COVID-19 pandemic highlighted the need for trustworthy data and science to guide the response of authorities, institutions and the public. Open data, open and collaborative science are needed to hasten the development of solutions to bring this pandemic and any future crisis to an end.

33.1 Unlocking the Value of Data

I wouldn't be the first to compare data to raw material. Data in isolation and without context is as useful as a piece of rock ripped from the Earth. But what if that rock was polished, washed, cleaned, smelted and extruded? Suddenly that piece of innocuous rock may resemble the makings of steel created from Iron Ore.

Data in isolation lacks purpose or value and may pose little danger to its custodian from privacy or from the ability to manipulate it. Before COVID-19, data was coveted by its creators. The owners or custodians of data either protected it for fear of breach or recognizing the economic value in the data locked it up for future benefit and gain.

33.2 From Data Sharing to Open Science

The advent of COVID-19 has shaken the world with anxiety levels of the public and governments rising to a fever pitch. Suddenly, the potential for greater good through collaboration to overcome a united enemy has prompted the barriers to data sharing to be rapidly lowered, and in some cases, removed altogether [1–3].

Through a shared desire to find treatments and cures for the pandemic, and through a need to fact check directives issued by governments and world leaders, data is being shared at unprecedented levels. Frustrated by swathes of policies and political advice, more people are turning to science.

Examples of COVID-19 data sharing is occurring around the globe. In Europe, the launch of several COVID-19 data portals is enabling collaboration between Bioinformatics Institutes and their partners [4]. By creating a shared space, the portals address a need to share data, create an accessible and safe storage facility and analysis tools for future data development and manipulation.

Another partnership between NASA, the European Space Agency and the Japan Aerospace Exploration Agency strives [5] to find a cure to COVID-19 and to utilize the learnings to further progress sustainability. No stranger to the concept of citizen science and crowdsourcing of ideas, the

partnership participants have long been affiliated with innovation and mountains of data. Wanting to lend a hand to fight the Global pandemic, scientists and engineers' thought the best way to find solutions, would be to work as collaboratively as possible, and nothing screams collaboration as loudly as the Hackathon they held in May 2020 [6].

Not all governments have been slow to react, however. Renowned for its tech-enabled civic culture with Taiwan's revered Digital Minister Audrey Tang at the helm, a bottom-up information sharing approach, coupled with the public-private partnership model, has resulted in a participatory collective action; central to the country's success in handling pandemics and regional crises [7]. Based on hard-learned lessons from the 2003 SARS epidemic, Taiwan has experienced significantly lower COVID-19 cases than other nations. Minister Tang stated that no one decision alone had yielded their low rate of infection, but rather a unified approach to data and technology has contributed significantly [8].

33.3 The Future

Despite the groundbreaking results of data sharing between the scientific and research communities, factions of the government are resisting the adoption of open and transparent data processes. The urgent and pressing need for a cure is forcing researchers and scientists to put the benefit in front of the legalities: sharing models, research and analytics accelerating science ahead of regulation. I hope that this surge in open data, open research and overall sharing for the greater good will not only aid the quest for a solution for COVID-19, but will forever change large-scale attitudes towards data sharing and open science.

In the number of months since the pandemic recorded its first case, open science has led to the isolation of the virus, a standardized list of symptoms, COVID-19's genome has been sequenced and shared, multiple formats of testing have evolved and the potential of global vaccines have been developed across multiple jurisdictions. Prior to the pandemic, science was largely publicly funded, but not publicly accessible. To progress the current breakthroughs of the scientific and medical fraternities post pandemic, a standardization of data practices, maintaining open access and a willingness to continue mass collaboration is essential. To create and promote resilience across the community will come from their faith in a united scientific community, achieving a solution to bring this pandemic and any future crisis to an end. If open access, open science and open data are maintained, this becomes the new normal. Anything less will be regression without justification.

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34

The Challenge of Mapping COVID-19 Data

Menno-Jan Kraak

This perspective discusses the design choices to make while dealing with multivariate COVID-19 data; the most common errors made in this process; and how to avoid them and present data in meaningful and effective ways.

34.1 The Mapping Challenge

In reporting about the COVID-19 pandemic, many plots, maps and other diagrams showing the current situation at local and global levels and comparing regional developments have appeared in the media.

The complexity of these graphics varies both in design and technology. You can find ingenious online story maps and simple single variable maps in the print media. The data behind the graphics is most often related to three different variables: the infected, the hospitalized and the dead. It is quite a cartographic challenge to visualize all these numbers properly, especially together. This because there is a wide variety over space and time, and a large range between the lowest and highest values, as well as between and within these variables.

The numbers available can be very revealing but also should be interpreted with caution. It is revealing because when plotted over time they show where the pandemic started and how it spread over the world. Caution is needed because countries do not necessarily have the same definition for each variable nor follow the same data collection approach. Some publish everything while others virtually nothing. Some numbers only include those tested while other also those suspected. Numbers after a weekend tend to be higher because most weekend cases are reported only after the weekend. Reading this you might wonder how do we then create trustworthy maps? My advise is that we look at maps critically and realize that there might be a data problem.

34.2 How-to

Here I would like to address two issues:

1. professional cartographic design challenges and choices; and
2. the mapmakers problem (or the most common cartographic mistakes in the media).

Let us discuss the challenges based on variations of three familiar questions: where? what? and when? At what spatial scale do we map? Like nearly all phenomena, a pandemic is not

homogeneously distributed over space. In some places one would prefer a larger scale than in other locations. In addition, the collecting of the numbers does not necessarily happen at the same level of geographical units, and even if so, these might vary in size quite a lot. Inset maps for the more crowded areas could be useful.

How do we symbolize the numbers? The large range between the lowest and highest values is often a delicate design problem. How to select symbol sizes that avoid the big symbols covering the whole map, but still allow us to see the smallest values? This problem gets amplified when all high values are in the same region. One solution is to classify the data, and group individual values together according to a formula. The choice of a classification method is critical because you want to avoid hiding existing patterns or reveal non-existing patterns. It would also be possible to apply logarithmic scales, but one can wonder if users (esp. the public) can easily understand and interpret this. Yet another commonly applied alternative is to normalize the data, for instance display the number of infected per hundred thousand inhabitants.

How do we visualize the trends over time? Similar to the non-homogeneous distribution over space the course of the pandemic over time is also erratic. The depiction of time can be done in a single map, but more often is done in a set of maps or even by animation. Often dashboard like views are used, allowing the display of multiple perspectives with maps and additional time-line diagrams.

34.3 Case in Point

A final design will be based on a combination of the above considerations with the overall purpose of the map in mind. In Figure 34.1, we see a detail of a COVID-19 related map of Europe providing data on country level. The map background supports the theme, and shows roads, airports and harbors, the human infrastructure potentially used by the virus to enter a country. The red half circles represent the number of deaths, and the blue halve circles the number of infected. Both half circles have a different scale because the number of infected is a magnitude bigger than the number of deaths. This stresses the importance of a clear map legend. To avoid that the large circles covers too much map, they have been made transparent above a certain size, as for instance can be seen for France and Germany. More information on this map's design choices, can be found in [1]. Following this lead, you can also download this and other maps.

From a cartographic domain perspective, it is great to see so many maps on COVID-19 in the news media. However, despite the creativity of the mapmakers, bad design choices have been made. The most common error is the choice of the wrong map type, especially when the mapmakers try to visualize absolute numbers. Some just plot the number as text in the geographic unit, but such maps have to be literally read unit by unit and will not provide an overview. The 'worst' mistake is when, instead of a map with proportional point symbols like in the map in Figure 1, a choropleth map is used. This map type is only suitable for relative data. The problem is that two geographical units in the same class could differ substantially in size and this results in an over attention for the large unit. Also, the overall pattern might be misleading. Often these choices are due to the default options in the software used.

When choropleths are correctly used, for instance, to display normalized data, such as the number of infected per hundred thousand inhabitants the choice of a map projections is also critical. Since people use these maps to discover patterns and compare regions, only so-called equal area projections should be used. A common error is the use of the Mercator projection which disproportionally exaggerates the size of land masses towards the north and south pole. Its use is - again - often driven by the default options in the software used.

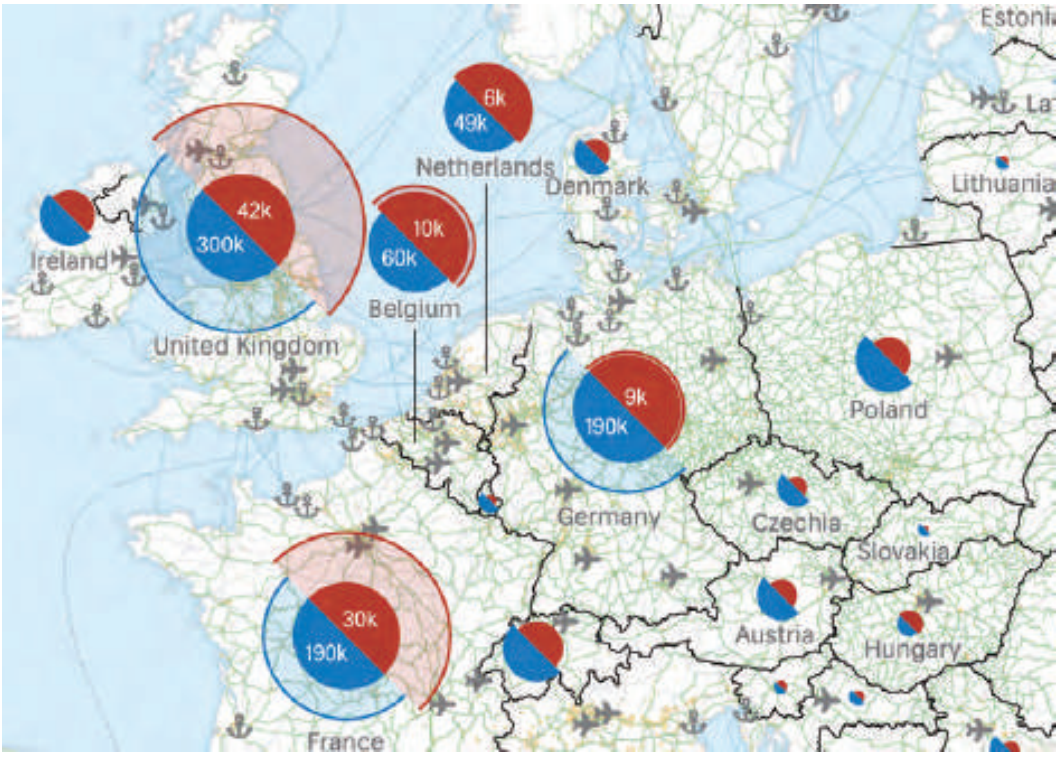

FIGURE 34.1
Detail of a map about the COVID-19 pandemic in Europe

34.4 From Data to Insights... to Actions

The dynamics and variability of the data related to pandemics such as COVID-19 is a real challenge for cartographers and requires creative but critical thinking about solutions which are also influenced by the final environment where the maps are published. Well-designed maps will attract attention and enlighten, providing insights that tell the story at hand and lead to appropriate decisions and actions.

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35

Better Engagement to Build Smarter, Resilient Communities

Alice Kesminas

Community resilience can be better achieved with geospatial information and technology, but only if we can determine what needs to be done for them to be accepted by communities. The challenge of trust, and concern about what else might be done with personal data beyond its initial purpose, need to be addressed to enable geospatial information to be used effectively to plan and manage resilient communities. We need to extend data anonymisation techniques to big data and understand what their limitations are when multiple data sources are linked.

35.1 Introduction

Geospatial information can improve our insights, understanding and management of events such as the COVID-19 pandemic, as well as the ongoing administration and planning of resilient communities and cities. Emerging technologies offer the opportunity to monitor our cities in real-time and gain an unprecedented level of location intelligence from a range of inputs – including mobile and wearable devices and other sensors that can identify an individual or household. Community reactions to tracing apps during the current COVID-19 pandemic have demonstrated that the public's concerns and expectations about technology and the privacy and security of their personal location data will determine how information can be used by decision makers. In this instance, technological capabilities have come second to the expectations of our communities. Community resilience can be better achieved with the help of geospatial information and technology, but only if we can determine what needs to be done for them to be accepted by communities.

Even with the potential for life-saving benefits, only around 7 million of Australia's 17 million adult population have downloaded the Australian Government's COVIDSafe app to date. "Like any health-care intervention, coronavirus apps need to conform to the highest standards of safety and efficacy. And yet, and there are no global standards" [1]. Lack of standards coupled with concerns about government use of data are possibly factors behind the current resistance to tracing apps. More than 60% of the population are "very concerned or concerned about their data being used by the Australian Government to make unfair decisions" [2]. Nonetheless there is support for data being made available to researchers (especially those in universities) and being used within government but there is much less support for multiple sources of data to be linked. The challenge of trust, and concern about what else might be done with personal data beyond its initial purpose, need to be addressed to enable geospatial information to be used effectively to plan and manage resilient communities.

35.2 Learning from Experience

Open data is critical to smart growth and urbanisation. Sharing of sensor data, such as traffic flow, can allow multiple parties to develop insights that can improve day-to-day liveability and, via planning, the sustainability of our cites. While the benefits of sensors may be clear to councils, the installation of sensors to capture data has been known to cause issues. The City of Darwin found their "smart city" installation of sensors and cameras created issues within the community. In response to community expectations and privacy concerns, The City of Darwin committed to establishing a Privacy Framework to set the expectations and decision-making criteria for deployment of technology and data collection and management. They found it necessary to go beyond current privacy laws and help the community understand when their personal information is being collected and limit its use [3].

In retrospect, better community consultation could have reduced risks to the Victorian Smart Meter rollout. The technology was backed by a strong business case for better customer service, networks and safety but there was a need to clearly communicate benefits to individuals and address their concerns and lack of understanding about the new technology [4]. The sale of smart meter data to third parties to market alternative electricity plans and products to reduce energy consumption was pitched as a benefit by champions of the technology but is seen as a risk by some consumers. This mandated rollout was met with strong opposition and demonstrated that individual choice needs to be considered.

Engaging with the community from the outset was the key to success in the implementation of the Yackandandah mini grid [5]. By talking about the proposed new technology and listening to communities' concerns and vision, it was possible to co-develop a solution that would provide the network operator valuable insight into how to adapt to accommodate distributed energy resources and help the community to achieve their renewable energy vision. This is an example of what can be achieved when community, industry and government work together. We can learn from projects such as this by laying the foundation of trust and transparency for emerging geospatial technologies.

Community engagement can be costly, but there is also a cost when technology is not widely accepted in the community. The COVIDSafe app offered the promise of benefits to the community via reduced transmission, fewer lockdowns and less economic impact but still the download numbers were relatively small. The Australian Government's COVIDSafe app also suffered from public confusion about whether it even worked on some operating systems. If there was clearer communication, improved implementation and higher downloads, would we have captured critical transmissions earlier and avoided further costly lockdowns? What is the price we are paying, for not knowing where COVID-19 cases are sooner and having more robust contact tracing? What is the cost of not having community trust and acceptance of this technology?

35.3 Extending Anonymisation to "Big" Geospatial Data

With the increase in data being generated by the individual and analysed, maintaining privacy levels will be an increasingly complex issue. Data privacy has been identified as one of the biggest issues of the next decade [6]. There are several existing approaches to providing privacy for location data that includes sensitive or personal information such as address. These methods have been developed so that researchers and decision-makers can perform valuable spatial analysis, without the loss of personal privacy. Methods of anonymisation include, but are not limited to, aggregation and a range of masking, such as isomasks, where spatial analysis is performed in an offset location. As data and systems evolve, there is a need for new ways of ensuring privacy in increasingly complex systems. To achieve this, we need to extend data anonymisation techniques to big data and understand what their limitations are when multiple data sources are linked to support artificial intelligence. Once we understand privacy expectations, we can build the required solutions and legislation

to support them. This means undertaking research now to ensure privacy can be guaranteed in increasingly complex systems, understanding de-anonymisation risks and determining who has the responsibility for protecting against them. It also means understanding the limitations of current acts as we transition to big data.

35.4 Building Trust for Future Resilience

Government, industry and communities can work together to: build trust and a mutual understanding of benefits technology offers to building resilient communities; provide expected levels of geospatial data security and privacy and; develop the standards and legislation that underpin these factors. Then we will be able to use smart technologies and geospatial data effectively build resilient communities.

The COVID-19 pandemic has provided valuable insight into the gap between technological possibilities and community acceptance of technology. As we ramp-up development digital twins as virtual replicas of our physical world and roll-out technology for smart cities technology, the reaction to tracing apps provides a timely reminder. Community engagement needs to underpin the process, not come as an afterthought. A range of issues have contributed to people's decision not to download tracing apps including bad press, rushed roll-out, platform incompatibilities and concerns about on selling of data. Similar issues in the future could be addressed with better community engagement as well as better design and implementation. If the community understands and accepts new geospatial technology, we can better use these technologies to build community resilience. We have an opportunity to learn from the reaction to tracing apps and achieve better outcomes in our future cities.

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36

How the Coronavirus Could Change Urban Planning

Frank Friesecke

Does urban planning determine humanity's chances of survival in our cities during periods of pandemics? The great importance of sustainable and health-promoting urban development is already evident from history. This chapter clarifies the connection and offers initial considerations as to whether and how the distance between humans, cars and buildings should be reappraised. The city of the future will be more digital, it will have to become more resilient to future pandemics, all of which will lead to a different planning culture. The basic functions of existence for urban society, namely living, working, basic essentials and mobility, are used to examine how the current corona crisis affects architecture and urban planning. The explanations in this chapter show that integrated urban development solutions are possible, without fundamentally calling into question the compact and dense city built on the principle of mixed use.

36.1 Introduction

Closed schools and shops, cordoned off children's playgrounds, deserted squares, buses and trains, orphaned pedestrian zones and virtually car-free streets: The effects of the corona crisis on urban areas are immense and can be observed worldwide. Whether it be Wuhan, New York or in the cities of Europe - the images are similar despite the great differences in architecture and urban planning.

Although the topics of hygiene and health promotion have played a role in the urban development debate since the second half of the 19th century at the latest, due to the current pandemic it can be assumed that the planning culture will once again change fundamentally as a result of the coronavirus.

Currently more than half of humanity lives in cities or urban conurbations. This trend will continue. By 2050, it is estimated that three quarters of the world's population, i.e. around 7 billion people, will live in cities [1]. Does the Smart City, however, including tracking the movement profiles of infected city dwellers, provide the ideal image for the city of the future? Or, as a corollary of pandemics, can we anticipate a return to cities of shorter distances, in which the jobs in the "home office" or in co-working spaces are located, and where online retail has largely replaced brick-and-mortar retail premises?

The chapter deals with these and other questions. After a brief review of the urban development governing principles and concepts of the past, the intention is to present a first vision of the direction in which the city of the future could develop towards in the light of corona and other potential pandemics of the future.

36.2 Present: Urban Development in Corona Times

With the spread of the coronavirus, urban planning and urban development are once again obliged to address hygiene in cities. While until recently the lack of affordable housing and, above all in Europe, the climate debate were the determining factors, the urban development policy debate is now expanding to include epidemiological issues.

Of course, the subject is not completely unknown even today. The current debate on clean air and noise reduction planning in smog-contaminated cities, as well as health promotion measures in socially disadvantaged urban districts, testify to the importance of eliminating social and health inequalities. What is new, however, is the imperative of "social distancing", i.e. measures to control infection with the aim of spatial distancing. Since it is not a matter of social isolation of individuals, the terms "spatial distancing" or "physical distancing" would be more appropriate but have not become established in the English language. In everyday life, spatial distancing means in particular keeping physical distance and avoiding physical contact (1.5 to 2 m distance, no hand shaking, no group formation, mask protection etc.), in the most extreme case up to restrictions on outdoor activities and contact bans.

Not only for the individual, but also from the point of view of urban planners, these restrictions are enormous, for after all the main aim in designing squares and other public and semi-public spaces is to create opportunities for social interaction. The importance of one's own living environment, local amenities, as well as parks and urban squares, is one of the key findings of recent months. Public spaces have made the pandemic more bearable. While jogging, walking or sitting on a bench, city dwellers rediscovered their surroundings, so to speak. It is likely that green spaces have never been appreciated as much as in spring 2020, when people moved outside to escape isolation at home.

In addition, the inner cities and district centres are determined by trade and consumption, by festivals, art and culture - in corona times the urban infrastructure seems strangely skeletal and meaningless. While shopping in stores poses a risk of infection, shopping at home on a smartphone or PC is completely risk-free. It is feared that numerous owner-operated shops, but also theatres, clubs, cinemas and pubs, will have disappeared after the crisis.

The current impact of the corona crisis on mobility structure has been profound, and indeed initially significantly positive. Social distancing and in particular working from home ensure less traffic, less traffic jams and fewer accidents. The proportion of people traveling to work or training places every working day has decreased significantly as a result of mobility restrictions that have been in effect almost worldwide since mid-spring 2020. In many cities, empty lanes are released for healthier forms of mobility, in particular the bicycle or e-bike, preserving individual freedom and thus becoming a solution to the many hindrances produced by the crisis.

However, there is also a major loser in the transport sector: the declining number of passengers in public transport is posing serious concerns for the future of municipal transport companies. How can the risk of infection be reduced in buses, underground and suburban trains, but also in long-distance transport? Will the car become the winner arising from the crisis after all?

36.3 Future: The Smart, Participatory and Resilient City

Cities are social organisms that are constantly changing. It is therefore not surprising that urban planners and architects, but also philosophers and scientists, are constantly thinking about the future of our cities. The desired spatial (and usually also social) future state is usually quickly formulated. However, a look into the past also shows how quickly a designed vision of the future can prove to be a mistake or has already been replaced by the next vision of the future.

Current developments, which in many ways represent an unprecedented watershed, require us to be cautious about coming to premature conclusions about future urban development. To call

fundamentally into question the viability of the densely populated city in the wake of corona ignores the fact that at least Asian cities such as Hong Kong, Singapore and Tokyo have so far successfully dealt with the crisis. So density in itself is not the problem. It is about being well organized and well designed.

It cannot be denied that certain developments will accelerate significantly in the course of crisis management. The top priority is the digitalization of administrations and public institutions - digital offerings and work from home have so far not yet been standard in many countries. The digital transformation enables more transparent, more efficient processes; actually having to visit authorities can be circumvented thanks to new online procedures. In the medium term, there is no way around e-Government. It should also be noted that the digital city needs an administrative apparatus that can keep up with the rapid pace of technological progress.

36.3.1 The smart city

Smart City solutions can improve the quality of life in existing and new urban structures, which ultimately also serve to enhance public space. A city is considered "smart" if intelligent solutions for very different areas of urban development such as infrastructure, buildings, mobility, services or security are achieved in it through the use of innovative information and communication technologies [2]. The challenges in setting up these solutions currently lie less in data collection, storage and processing than in the development of inter-faces between the individual "sub-markets" of the smart city (Smart Mobility, Smart People, Smart Economy, Smart Environment, Smart Government and Smart Living). In many European countries, corona warning apps have been developed on behalf of governments, which turn the smartphone into a warning system. Not only in China, the colour of the personalised QR Health Code scanner on the smartphone now determines whether the person should go into quarantine or is allowed to visit a reopened restaurant (red/green).

Beyond the undisputed advantages of digital solutions, the Smart City is also about personal rights issues in the area of conflict between informational self-determination and digital monitoring and control. Which personal data may be used in the event of a pandemic? A "real" Smart City would use digital technologies not only for hazard prevention or public safety, but also for less relevant public issues with urban spatial relevance.

The Smart City has not yet established itself as a model for urban development, at least not in Europe. However, the current crisis shows us more than clearly how important digital technologies are in periods of social distancing.

36.3.2 The participatory city

While the Smart City describes an overarching, strategically designed solution approach, the issue of citizen participation in urban development requires short-term municipal action. Ongoing planning and dialogue processes, which up to now have mainly taken place "offline" in the form of information events, future and idea workshops, but also outreach activities such as site inspections and activating surveys, must be adapted, and in many cases completely rethought.

The "digitalization of participation" [3] through websites, apps, social networks and web-based communication platforms has long been used, but habitually only in addition to analogue formats.

In these times of the corona crisis new ways of participation will have to be followed. These include online dialogues in large groups, online surveys and virtual residents' meetings. With the digital participation system DIPAS, citizens in Germany will in future be able to call up digital maps, aerial photographs, plans, 3D models and geodata and provide precisely localised feedback on planning projects. DIPAS is currently being developed by the Hamburg Ministry of Urban Development and Housing together with the State Office for Geographic Information and Surveying and the City Science Lab of the HafenCity University Hamburg (HCU). The software is open source and is to be made available as "Public Code" to other institutions for subsequent use and further development from the end of 2020.

Some European cities have already opened online participation portals, and the number of users is likely to increase significantly during corona times (see www.stuttgart-meine-stadt.de).

In order to prevent a Hamburg resident from voting on planning processes in Stuttgart, registration is required that is tied to his or her place of residence. Inappropriate comments will be deleted immediately by an online editorial team.

FIGURE 36.1
Participation and social distancing during Corona times, Stuttgart, Germany, Source: die STEG Stadtentwicklung GmbH

In addition to the Internet, video conferences in the exchanges between administrations and planning offices have become an everyday medium within a very short time - inevitably the question arises whether some travel routes could not have been avoided even before the crisis. It is also conceivable that consultations with owners in urban renewal areas via telephone or video could be used, but the physical surveying of the building condition of the property on-site still seems to be a continuing necessity in the future.

Despite the proven advantages of web-based interaction, it is to be hoped that the tried and tested communication channels can be used again as soon as possible after the pandemic has been overcome. Civic participation is more than just a website; good communication still always requires meeting in person.

36.3.3 The resilient city

From the point of view of urban decision-makers, it will be essential to review the resilience of a city or infrastructure in the future with regard to pandemic events. Adaptation concepts have so far mainly referred to natural disasters such as earthquakes, floods and heat waves [4, 5], but not to epidemics and, in the worst case, pandemics.

As many people live together in a relatively small area in cities, many people are affected all at once when a disaster occurs. At the same time, however, spatial concentration also creates opportunities for dealing with risks and giving better control options. The decisive factor in determining whether these advantages can be effectively utilized or whether an event turns into a disaster for many people is how these risks are handled. New York serves as an example of a metropolis that was severely affected by the coronavirus in March 2020, but was also able to contain its spread quickly through a large number of coordinated measures [6].

A good plan for urban resilience is based on a multi-dimensional approach. Holistic strategies for resilience in the event of the current corona crisis lead to a change in the planning culture, which primarily extends to the areas of living, working, shopping and moving around. The following section deals with the initial approaches that will have an impact on future urban planning and architecture.

36.4 Rethinking urban planning

What can we learn from the corona crisis for the future? On the one hand, the current pandemic is challenging the resilience of our society and especially our cities. On the other hand, coping with it will trigger processes of change that offer a wide range of opportunities for sustainable urban development.

Unintentionally, the corona crisis is becoming a kind of real-life laboratory for the city of the future. So what can cities learn from the lockdown? What structures for the resilient city after corona are already emerging?

Based on the essential functions of existence for urban society, namely living, working, basic essentials and mobility, the following outlines the changes resulting from the current crisis and which solutions urban planning and architecture can respond with.

36.4.1 Housing

As an elementary basic need, housing is one of the central urban functions. However, the demands on housing are very heterogeneous and vary greatly according to region, social affiliation and individual preferences. Housing needs depend on demographic, technical, social and economic parameters that are volatile over time and can only be controlled to a limited extent.

Despite these differences, it has become clear, especially in the current crisis, that the single-family home in the suburbs or in the countryside, which has been critically judged for decades, was a relatively pleasant place to spend lockdown: stable neighbourhoods, long-standing and personal shopping relationships, private garden areas and generous floor plans for one's own family and home office are extremely helpful to this end. Owners were also often at an advantage over tenants because they were able to generate added value through repairs and improvements during the period of short-time work.

However, this is not the only reason why the demand for housing will increase even more than expected in the future: thanks to digital technologies, many companies have made it possible to work from home, and many working people may not even return to their open-plan offices. Yet, there is still a lack of flexible floor plans at home that allow living and working in a home office and that provide sufficient privacy and retreat.

For architects, this means building apartments in such a way that different forms of living coexist in one house. So small apartments, large apartments, and that there is perhaps one dedicated apartment for guests set in every apartment building. That there are work or common rooms in the house, which can be shared not only in times of crisis. It is about establishing forms of living that bring living and working closer together again.

For urban planners, this means making public spaces that were often neglected in the past more attractive when planning new quarters, but also in existing areas. If the expensive city apartment is small, the living environment becomes even more important - public green spaces and places within walking distance, short distances to shopping and to medical practices. More open spaces on which urban agriculture is practiced can also be a solution along the lines of the urban gardening movement. The demand for allotment gardens, at least in Germany, has more than doubled compared to the previous year. The waiting time for one of the almost 1 million allotments in certain regions has been several years [7].

In principle, the city has everything to survive quarantine periods - if it is planned consistently. What is new is that there should be an overview of the necessary separation distance areas, especially in public facilities, shops and restaurants.

36.4.2 Work

As can be seen from the previous section, the urban functions of living and working are mutually dependent and cannot be substituted for a functioning city. A return to the functionally segregated city is no longer appropriate in times of climate change anyway.

Overall, it can be assumed that corona will have the most lasting impact on the world of work. Working from home will become a permanent and steadily growing part of the working world. As a result, oversized office buildings and even more space will become available in the city. The role of the central office could be taken over by the study in the (larger) apartment, but also by decentralised offices close to the apartment. In their own neighbourhood or district, between grocery stores, hairdressers, snack bars and cafe's, people could work in co-working spaces and thus avoid commuting to work.

Structural changes will not be avoided for the hitherto open plan office space. An obvious concept is the return to the so-called Cubicles. This technique of dividing an open-plan office into smaller personal areas, which had been in use since the 1970s, had actually seemed to have run its course, but is now experiencing something of a renaissance.

On the other hand, in the medium term it is necessary to convert offices in the city centres that are no longer needed. Demand has been great for centrally located apartments not only since corona, yet in many places the (still) very high prices for condominiums and the high rent level prevent affordable living in the city. This could change in the future, since in addition to office properties, retail properties are even more threatened by non-occupancy. Living and possibly also working in a previous office premises converted into an apartment - or a former ground floor shop - this too could represent a future for the city centre.

36.4.3 Retail business

One of the greatest threats to the inner cities has already been identified. The gradual creeping disappearance of the classic activity of going shopping, at least in the city, has been now greatly accelerated by the pandemic.

The competition against brick-and-mortar retail is already clear: Online business is the great beneficiary of the crisis. When non-food stores in the inner cities had to close, many consumers switched to existing online offerings. Although not all industries benefited equally from the boom in online retailing, online giant Amazon alone was able to increase its sales by 26 percent in the first quarter of 2020 compared to the previous year [8].

In order to prevent city and town centres from becoming deserted, one of the aims will be to designate smaller core zones in which trade has priority over other uses. Outside these areas, vacant buildings will be given a new use, either by conversion or by demolition and new construction. In growing cities, it will be primarily residential use that will replace the previous retail use.

In many cases, however, quick, creative solutions are also needed to mitigate the crisis: In Berlin, Boston, Paris and elsewhere, "pop-up street restaurants" have been approved relatively easily – restaurateurs are allowed to use adjacent parking spaces as extended outdoor terraces.

In order to prevent a final decline of the inner city as a location for basic essentials, it will be important to actively shape the structural change. The affected owners must act jointly in the same direction, and this requires above all new forms of cooperation. Municipal authorities will have to play a leading role in the renewal process, but private initiatives can also make their contribution to strengthening the inner cities (e.g. business improvement districts). Much of this will only work in small-scale – property by property, street by street.

For urban planners, the change in consumer behaviour also impacts the outskirts of cities: If the currently forced change in shopping behaviour continues to move in the direction of online trading, this will be accompanied by an increase in logistics centres, warehouses and other large-scale infrastructures. For a long-term and resilient urban development, the high-quality design of these new commercial megastructures is absolutely essential.

In order to avoid these area-intensive developments, considerations regarding more compact spatial production structures should also be realized in urban areas. One approach could be the "urban factory" concept, which integrates industrial production into the urban context by means of a city-factory interface [9].

In the light of current events, the overall question is whether certain services should be decentralised, not only in the health sector but also in the provision of care in general. This in turn has implications for urban planning and architecture.

36.4.4 Transport and mobility

Does the pandemic also serve as an accelerator for new urban transport concepts? The spread of the coronavirus and the resulting initial restrictions led to a forced, unprecedented, breathing space for traffic. People have reduced their everyday mobility to a minimum and shifted it significantly: The proportion of walking and cycling has increased, while that of local public transport has fallen dramatically [10].

During the crisis it has become clear that urban transport areas are not divided up according to demand. In the current situation, at least 1.5 meters distance from other people in public spaces should be kept to minimize the risk of infection. Narrow or non-existent bicycle lanes and sidewalk parking make it difficult to comply with the prescribed distance rules.

Many cities have reacted to the changed mobility behaviour with appropriate measures in the short term. In Brussels, the city centre (Pentagon Zone) is being converted to an extensive pedestrian and cycling zone, Paris is investing 300 million euros in new (pop-up) cycling infrastructure to connect the entire city and prepare it for increased cycling after the lockdown. Oakland in California has developed the concept of slow streets, where 10 percent of all roads are closed to through traffic. Already today, one in two households in the inner city of Berlin no longer owns a car, simply because they no longer need one [11].

Is the car-friendly city a thing of the past? Against this background, the size of a city makes a significant difference. The smaller the city, the higher the proportion of car journeys, the longer the distances travelled and the lower the proportion of public transport. Even if mobility after corona will not be different everywhere, the same is true for small towns: Urbanity is created primarily where people get around on foot or by bicycle, and not by a solid line of cars meandering through the city centres, district centres or town centres.

In addition to the newly forming traffic flows, it is digitalization and smart technologies that are leading to more efficient traffic control. This applies in particular to motorised private transport, which is one of the great benefiters of the crisis. An infrastructure that thinks ahead helps to steer traffic flows in such a way that traffic jams do not occur in the first place. Finding a parking space can soon be a thing of the past if networked vehicles know where the next gap in the parked cars will be.

A great many people are already traveling intermodally, so they use several means of transport on their journeys. IT applications and apps on smartphones can link data on the location of vehicles and people, tariffs and route information and both create new, networked transport offers and facilitate access to them.

Is the corona crisis a catalyst for changing transport behaviour? Will the old mobility patterns return afterwards? The everyday behaviour of each individual will depend on whether transport and urban planners succeed in making public space attractive for health-promoting forms of mobility.

36.5 Conclusion

How pandemic based must future urban planning be? In his major work “The Man Without Qualities”, first published in 1930, Robert Musil came to the following observation: “Modern man is born in the clinic and dies in the clinic: therefore he should also be living like he is in a clinic” [12].

Even if the requirements of leading architects at the time of the Neues Bauen are judged differently nowadays, the question of integrating hygiene regulations, larger spacing and changed floor plans for apartments, retail, offices and public facilities into urban development is still being raised. The illustrations in this chapter show that (urban) construction and architectural solutions are possible in this respect, without fundamentally calling into question the compact and dense city built on the principle of mixed use.

With regard to the changed trading and transport behaviour in corona times, only the future will show whether there will be a reversion to old consumption and mobility patterns, or whether

there will be a sustainable and lasting change. Conversion strategies for empty properties require ideas to make commercial and district centres more attractive again, but also eco-nomic stimulus programmes are needed in order to be able to finance the necessary measures in the foreseeable slump in municipal finances.

One conclusion is thus obvious: The far-reaching changes in all essential functions of existence for the urban society, i.e. living, working, basic essentials and mobility, do not only mean loss or deprivation, but above all an opportunity for future urban and transport planning. Urban development and spatial planning do not have to be reinvented, but what is required is an urban experimentalism in the cities, combined with municipal decision-making power and civil society commitment [13].

For a successful integration of adaptation measures in urban planning and development, a societal process is required that can only succeed if it is anchored beyond politics and administrative spheres involving private sector stakeholders (including retail, housing industry) and involving residents too. There is no doubt that digitalization and new technologies will play a significant role in this process.

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37

Toward Agile Strategies for Enhancing Community Resilience Following the COVID-19 Pandemic: An Interview Study

Hossein Mokhtarzadeh

The global Pandemic as a result of a recently discovered coronavirus has affected every aspect of our lives. In this observational study, I interviewed a small group of experts in different fields on how they cope with this global crisis. Have they modified their strategies to achieve their goals and whether this has affected them negatively or positively? The interviewees were from academia, and industry. Almost all participants found the lockdowns quite positive, however, a sentiment analysis revealed a negative outcome with moderate confidence (54.3%) with Australian participants; and positive (96.2% confidence) when all participants were included. Some of the positive outcomes included more time with family, more physical activities, and creative ways to perform tasks. Negative outcomes involved some of their team members who could not handle the new norms. Further research is required to be conducted with a wider range of stakeholders to better understand how we can recover more efficiency from this pandemic in Australia and beyond.

37.1 Introduction

Global pandemic was announced on 11 March 2020 by World Health Organization (WHO) as a result of COVID-19 outbreak. Since its first identification in Wuhan, China, in December 2019, these tiny (i.e. 65–125 nm) coronaviruses [1] traveled by humans across the globe in a short time thus changed our lives for good. Since its inception, COVID-19 disease has taken over 875K lives and infected 26.6M worldwide at the time of writing (on 6 September 2020) [2]. Finding a cure or effective treatment for COVID-19 is yet to be identified. As a result of its devastating consequences [3], governments have implemented serious measures such as stay at home orders, mandatory wearing masks in public, shutting down businesses and disrupting international travels. These extraordinary steps to contain this infectious disease have led to both health and economical disasters [4]. For instance, Australia may be facing its first ever recession in the last three decades [5]. To successfully overcome the COVID-19 crisis, adaptation to new norms and agile mindsets are recommended; however, some argue that agile and adaptative governance may not always go hand in hand in crisis response [6]. These negative side effects of pandemic require optimal strategies stemming from governments and ordinary people backed by science that can be swiftly tested and readjusted. Having these challenges in mind, I turned to experts to better understand how they evaluate the situation, how they cope with the pandemic, and how they think industries and businesses can thrive following/during the pandemic. Therefore, in this observational study, I

interviewed experts [7] from academia, industry to gain their insights regarding the consequences of the pandemic and whether they plan to modify their strategies to achieve their goals.

37.2 Method

I interviewed six experts in different fields from industry and academia from April to July 2020[1]. Originally, I prepared some predefined questions (Table 37.1); however, the discussion was open for the interviewees to share their observations during the pandemic. I did not necessarily follow the questions in Table 37.1 as the discussion progressed. The main aim was to ask them whether they have changed their strategies following pandemic.

I produced word clouds of transcripts of all interviews. I first collected transcripts of all interviews from YouTube's free transcription tool embedded in each video. Then, a sentiment analysis was performed on the whole interviews using a simple online tool from `https://monkeylearn.com/`. Sentiment categories of positive, negative and neutral were done automatically on the transcripts of interviews. Finally, top 20 keywords from the interviews were extracted from a keyword extractor tool on MonkeyLearn website.

TABLE 37.1
Some predefined questions to ask participants during interviews. Not all the questions were asked during interviews.

#	Questions
1	How pandemic has changed your strategies in your own career and company?
2	Are you still adjusting to new ways of working (e.g. WFH, collaboration, etc.)? If yes, why and how?
3	What is your highlight of this period for you?
4	What are you learning now that you may apply in other unexpected events in the future?
5	What are our advantages/disadvantages in Australia regarding building industries considering pandemic?
6	Who would you like to hear about their strategy these days or as your role model?

37.3 Results

Interviews took over 3 hours with a mean and standard deviation of 32±5 min for each. I observed that the interviewee's description of events were quite positive; however, using sentiment analysis, it was categorized "negative" (54.3% confidence) when all Australian participants were involved. Nevertheless, the sentiment analysis presented positive (96.2% confidence) when all participants' data was analyzed.

Among the top 20 keywords extracted from the transcripts using an online keyword extractor were the following words: "people"(197 times), time (81 times), "jobs" (64 times), "industry" (56 times), "strategy" (55 times), and "pandemic" (39 times).

Almost all participants were fine by working from home (WFH) which has also been recently confirmed in a large scale study in the US [8]. Academics in this study agreed that future directions of education could be hybrid combining face to face and in person trainings. CEOs agree that most

[1] All these interviews and their details are freely available on YouTube (`shorturl.at/clsxH`).

senior managers are quite busy during pandemic and consider it as a new opportunity even if one needs to look a bit harder to find them.

37.4 Discussion and Conclusion

In this observational study, I interviewed six experts in different fields regarding their professional and personal strategies during the pandemic. The interviewees agreed that the pandemic provides new opportunities despite health and economic challenges. For instance, these opportunities included being with family as a result of working from home and finding creative ways to adjust the business and return of cashflow during the pandemic. However, given a small sample size, I found that certain occupations (e.g. human performance and sense of balance) which deal with mind-body illustrated more positive (high confidence) category compared to interviewees from Australia when transcriptions were analyzed using sentiment analysis. These differences could be related to the type of questions I asked during the interviews and cannot be generalized. The pandemic arguably challenged most of our established methods (or strategies) of performing tasks. Work from home, online education, telemedicine and even online job interviews are widespread and acceptable, which may even be a new norm post-pandemic.

The top keywords extracted from the interviews referred to "people", "time", "industry" and "jobs" which may show the extent of concern individuals would have regarding job security in a timely manner. These findings indeed were interesting since the interviews were not necessarily about the job security. Though the findings require further scrutiny, such interviews and their analyses may provide a framework to explore how individuals' strategies can lead to prosperity post-pandemic [9]. Such understanding enables us to better choose our future endeavors and the values we appreciate. Collectively, this preliminary project reveals that we can develop agile strategies in a short time and be quite adaptive.

In conclusion, this preliminary study could pave the path toward more agile mindset to optimize our strategies in achieving our goals. Such an approach can be extended to larger scale decision making processes in a city, state, country or global challenges. Moreover, future studies can take advance of qualitative methods such as Interpretative Phenomenological Analysis to identify the underlying challenges everyone undergoes during the pandemic [10]. We need to develop these methods in advance to avoid the next global crisis affecting community resilience which may appear in a form of another pandemic or other disasters such a climate change.

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38

COVID-19 Pandemic in Finland: Converting a Forced Digitalisation into an Opportunity

Kirsikka Riekkinen

COVID-19 pandemic challenged the Finnish society in terms of economic, institutional, and social aspects. Quick measures to support economic stability and institutional resilience were undertaken by the Finnish government. Private entrepreneurs could apply for funding to convert their products into digital format or develop digital platforms. The digitalisation of public services has been ongoing for years, but institutional change is slow and has tendency to resist the change. The sudden disruptive situation caused the change to speed up. The geographic location, sparsely populated country, and lack of digital skills especially among the oldest citizens have, however, brought challenges in the resilience of the society. While the preparedness for converting public and private services into digital format was high, the willingness or ability of citizens to use them have led to awareness of social resilience as part of recovering from the shock. For building and supporting the design of even better digital tools and services, the role of geographic data has become more important. Economic, institutional and social resilience rely heavily on this data, which emphasizes the importance of open and accessible data.

38.1 Many Dimensions of Resilience

Resilience overall is described as ability to recover from a shock. This spring has shown that resilience is needed on multi-level scale throughout our society. The complexity of the multiple levels can be simplified by dividing the problem into institutional, economic and social resilience [1, 2]. Institutional aspect of resilience during this pandemic covers the public administration and decision-making in a situation where the traditional in-person, paper-based administrative decisions have decreased their role in decision-making. Economic resilience in this situation is discussed and visible all over the world, and recovering from depression will be one of the key questions in the success of resilience after the pandemic. Social resilience, on its behalf, has roots on the cultural background of people. Will there be personal tragedies, how relationships between people are recovering, what happens to the most vulnerable members of society? Next, I will examine these aspects together with the use of geographic information in the Finnish context.

We have seen a sudden change in social and working life. In order to remain resilient, this has risen the need for digitalisation in all the dimensions of resilience. Due to several restrictions on social distances and still to keep the stones of public services of society rolling, the public administration has been forced to take a leap towards forced digitalisation and distant working. This has been enabled by temporary laws. The public administration has been slowly introducing different digital services for a long time, but their popularity amongst citizens has not been huge.

For example, electronic platform for property transactions was introduced already several years ago, but nevertheless, the vast majority of property transactions (97% in 2018, according to National Land Survey) has been done by paper so far. However, the digital services gain popularity, especially in commercial services. According to one of the two largest grocery sellers in Finland, the rate of online grocery shopping has risen by 500% during the pandemic. The economic support activities for digitalising services reached up to 30 000 companies. The regular ecommerce activities rose by 75% compared to previous year. And this all happened, even though there were no restrictions in opening times of physical shops. Digital services together with open access geodata have played a major role in economic resilience. Even though we have seen our economy declining, the government decided to invest in companies of every sizes to support the innovation of new digital services.

38.2 The Importance of Open Geographic Data and Social Inclusion

The topographic data in Finland provided by the National Land Survey is open, and it has been used in different new location based applications to provide new commercial services. At the same time the role of location data and maps has increased, especially due to changed consumer and customer behavior. Due to restrictions, restaurants were not allowed to serve food within their premises, but delivery services have gained interest. Online shopping for groceries has increased in average by 500% compared to last year. Half of these orders are delivered to home addresses, so we also have received new users for location information to find the route for delivery. From social resilience, the requirement for digitalisation is obvious. We see our relatives, friends and colleagues online. Social distancing has been the key in social relationships for the spring. There is a possibility to go beyond physical location, and having a glass of wine via Zoom does not seem such a silly idea anymore. But, again there are two sides of a coin: those who have already been in a risk to fall out of the society due to social distance, most likely do not have the possibility to use digital tools, and thus this situation increases social exclusion.

According to the Finnish experience, one key to resilience is trust towards decision-making bodies of the society. This requires the possibility to understand the data behind decisions restricting citizen's rights. We can say that we are going through times where open data plays a major role in both sustaining social peace and enhancing resilience, for example in terms of economic resilience, and maintaining trust towards decision-makers. It is crucial to maintain discussion about public decision-making, by opening the data behind the decisions for open access. But, the role of open geographic data could be even bigger in fighting the pandemic.

One of the globally most used strategy to stop the pandemic is the 'test, trace, isolate, support', and Finland makes no difference. The question of how to trace the exposed persons is urgent in this strategy. Ideas and openings of using geospatial data stored by mobile devices has been under discussion several times, and companies have started to develop such a method. But, we face the fundamental issue of person-related geographical data: who owns the data and can it be used for such purposes? Eventually, the question lies on public and private interests and rights. If the use of geographical data together with personal data is necessary to stop the pandemic, but it is violating basic human rights as restricting the freedom of a person, can we still use it? Coronavirus has proven to be transmitted in large crowds, and several countries including Finland, posed restrictions on number of people are allowed at the same place, same time. Geographical data could be used to track people's location and alert if too many are in a too small area. The fundamental question would lie on the legislation - there should be tools to take short-term legislation efficiently in to use, but the possibilities to ensure that this information is not used when it is no longer needed to stop the pandemic, is problematic.

For the large public, also professionals visualizing information of the pandemic on maps have had a major chance of influencing the mindset and behavior of people. GIS provides endless opportunities to steer people to different directions. Showing numbers on contagious people in different areas in dark red creates visions on people's minds. The fear of other people may be

boosted by presenting most contagious areas on a map, when in reality the difference between areas might be small. This was evident when presenting number of confirmed infections in the capital, Helsinki. Maps can lie, and the responsibility for presenting the information not misleading is of utmost importance. Location information had also one totally new form or role during the past few months in Finland, and it was the distinction between 'us' and 'them', based on where people were living. We can say that the social dimension of location has had a totally new meaning.

38.3 Lessons Learnt from Finland

What have we learned during this spring and summer? People have changed their way of living forced by an external force to take a massive leap towards digitalisation. The society moved towards remote working, which will most likely to be the new normal from now on. This chance should be used to digitalise public administration and services, since citizens and other authorities are now much more ready to utilize these services. However, rapid digitalisation creates issues regarding for example data and privacy, especially regarding the location data. On the other hand, the meaning of open data in the society is getting more crucial to gain acceptance for the public decision-making processes. As a conclusion, we can say that eventually the battle against COVID-19 will end and it will leave marks to the society for good. We will be referring to these times as 'time before' and 'time after'. But what will remain, is the mindset of digitalisation, and also the mindset of how we all were in this together. Social distancing, with the help of tools of digitalisation, turned into social inclusion, supporting economic, institutional, and social resilience.

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What's the Future of Greek Cities in the Post-COVID-19 Period? New Perspectives on Urban Resilience and Sustainable Mobility

Efthimios Bakogiannis, Charalampos Kyriakidis and Chryssy Potsiou

COVID-19 would be recognized not only as a health crisis but also as a socio-economic emergency situation that brings to mind the concept of "urban resilience." Social distancing came into the forefront and many countries have been forced to adopt such measures immediately. Such early steps to contain the virus earlier than most European countries have been characterized as the key to Greece's success. People have been alienated from public space. Even now, during the second phase of the strategy against the COVID-19 pandemic, while the economic impacts are becoming obvious, the influence of public spaces still remains uncertain. However, decision makers have to schedule for the following day: an individualistic context came to the fore. Nevertheless, it is necessary to rebuilt communities' trust in public spaces in order to reconstitute future cities. To face such a challenge, a strategy combining urban resilience with sustainable mobility is going to be required. To gain this goal, case studies review analysis was implemented and best practices have been concentrated. Considerable emphasis has been placed on the intervention plan carried out by the Municipality of Athens, Greece. By implementing such a plan, there is hope that coronavirus might offer to modern societies an opportunity to radically reassess their values and the way they function.

39.1 Introduction: A Brief Review of the Pandemic

The disease COVID-19 outbreak is an on-going pandemic caused by the coronavirus SARS-CoV-2, first reported in Wuhan, the capital of Hubei Province, China on December 31, 2019 [1]. The novel coronavirus SARS-CoV-2 is now quickly spreading worldwide through a human-to-human transmission [2]. According to the John Hopkins University database [3], more than 10.5 million cases have been recorded in more than 215 countries around the world, by the end of June (30/06/2020). During this 6-month-period more than 512,000 deaths have been attributed to this virus infection.

Focusing on the epidemiological profile of COVID-19 during the early stages of the pandemic, the number of registered cases doubled in size every 7.4 days since the mean incubation period was 5.2 days [4]. It is obvious that the degree of transmission was great enough to maintain this rate of infection: according to Surveillances [5], until February 11, 2020, a total 44,672 cases were reported across China.

On January 30, 2020, the World Health Organization (WHO) declared this outbreak to be a

global public health emergency [6] and declared it a pandemic on March 11, 2020 [7], as the virus spread to other countries like Thailand, Japan, Morocco, South Korea and Taiwan. The outbreak reached Europe, too: as of March 20, 2020, Italy has the second largest number of COVID-19 cases after China. That was the reason why, on March 8, 2020, the Italian Government introduced extraordinary mitigation measures to limit viral transmission by limiting social interactions [7, 8]. Other European countries, like Spain, France and Germany [6], appeared to be in a similar situation, "with a short time-lag of a couple of weeks" [7]. Thus, restrictive measures to limit viral diffusion were adopted. (Sweden and the UK preferred to follow a different strategy, earlier, based on the "heard immunity" model.) Similar measures were adopted in Greece where the first case was reported on February 26, 2020.

The measures put in place in Greece were strict; however, they also were among the most proactive in Europe and have been credited on a worldwide level for limiting the spread of the pandemic and kept the number of deaths among the lowest in Europe [9]. However, when the post-lockdown period was approaching the Greek Authorities faced a major dilema: which could be the best plan for the gradual lifting of the restrictive measures and restarting of business activity in the post-lockdown period? In response specific guidelines were adopted in order for shopping centers, recreational activities, schools and religious groups to function. Similar hygienic rules have been applied for hotels, cinemas, pools and gyms.

Nevertheless, another important issue had to be addressed: the way in which public space will have to re-open to the public again. Looking to the future, planners, academics and decision makers in Greece started to think about this topic and how this crisis will transform people's relationship with public space, as many others do, worldwide. The fruits of such discussions were some initial plans and interventions most of which have already started to be implemented. They focused on the Athens Metropolitan Area where the majority of the country's population is concentrated, with a large number of visiting foreigners. At the same time, the Ministry of Environment and Energy has published technical instructions to promote the creation of temporary pedestrian streets and cycle lanes, as well as the development of temporary traffic-calming zones (speed limit is reduced to 30 km/h).

This chapter focuses on the implementation works took place in Athens. They are presented and examined, taking into account similar decisions that other countries have taken. Finally, although there is a great uncertainty about the way COVID-19 pandemic will impact future urban planning and design approaches, an estimation of the results is considered.

39.2 Initial Ideas About an "Anti-social" Planning Policy: How Easy is to Combine such a Policy to the Sustainable Mobility Paradigm?

Public squares and streets consist of the main components of the public space of a city. They are spaces serving everyday needs [10] and are characterized by a symbolic function [11]. Both of those reasons urge people to concentrate on such spaces that are related to a high degree of psychological health of people [12], sociability [13] and democratic culture [14]. Taking all of the above into consideration, public squares and streets are mainly considered to be social spaces [15, 16].

Researchers whose studies focus on Greek cities [10, 17–20] agree to such an opinion. Nevertheless, after the lockdown period, a growing body of academics bemoans the decline and degradation of public spaces [21–24]. Honey-Rosés, et al. [25] and Scott [26] are interested in such a topic. Although the effects in other sectors seem to be more intense [27], Honey-Rosés, et al. [25] underline that, in some years, extensive changes are also expected in planning practice. According to the same authors [25] some interesting queries may be raised in the near future.

Some of the above questions (i.e. *Will our perceptions of public space change?; Will we experience infringements on civil liberties?; Do we need a new typology for public space?*) seem to be of a future concern. On the other hand, some others (i.e. *Will streets be redesigned?; Will*

green space planning need new designs, uses and practices?; What will happen to micro-mobility and mobility sharing?) have already arisen during the lockdown period, not only abroad but also in Greece. Discussion about the principles for resilient cities [28] came again into the forefront. By examining those principles, it could be concluded that, resilient cities have aspects in common with compact cities. Indeed, both city planning models focus on transportation and environmental protection policies by promoting coherence and high-density building [29]. At this point a dispute has risen about whether high-building density is connected to social-distancing enforced by the protocols for the COVID-19 crisis management:

- How the compact city, based on small local residences, will manage to attract the people more to their homes – while until now it urged them to be in public spaces – in order to remain safe (to ensure that, social distancing –especially between individuals of sensitive groups or deceased – is necessary)?
- How the compact city, based on public means of transportation and sharing culture, will contribute to the protection of public health?
- Whether the practice of office workers to stay at home, performing their tasks from a distance from other workers during the crisis, will prove to be a preferred form of "distance employment" when the city returns to normal inter-social activity. If so, what will be the effect on commuting from the suburbs, traffic, parking, public transportation and other city services?

The above questions are being raised by the opponents of the urban density planning model. This oratory refers to the basic arguments against the adoption of the compact city, that namely it does not contribute to the development of adequate microclimate, does not permit the satisfactory solarisation, lighting and airing of buildings and considerably delimits the urban green in the urban fabric. However, those questions have been discussed in the past [17] and the compact city model has been evaluated as the most viable solution. Indeed, the European Union has sought to promote the compact city model since the 1990s [29].

The two new questions posed above have occupied urban planners all around the world. The answer to these refers to the answer of some of the questions posed by Honey-Rosés, et al. [25]. In particular:

– The small size of unattached houses does not seem to raise concerns regarding the virus dispersal in the cities, since it limits the direct association to individuals of the same household. The size of residences does not absolutely guarantee the observance of distances within the household but refers more to the layout of residences and the individuals' mentality. To the contrary, the small size of houses – usually entailing a narrow front - implies that adjoining residences' balconies will be close to each other and thus the neighbors will be able to communicate more easily among them. Such a thing is prevented in areas with spare housing. The communication between neighbors – so visibly passive [30, 31], as much as active - is the one that prompts Souvatzidou and Belavilas (in [32]) consideration of the balconies as substitutes for the city square; even future public squares, in case the pandemic persists.

– The compact city model is not based only on public transport; in terms of transportation, a city can be considered as a compact one when an ideal combination of sustainable means of transport (walking, cycling, scooters and public means of transport) is active. That is the reason why WHO [33] declares that there is a strong encouragement in order for cities to improve and upgrade their public space and citizens move on an easier and safer mode.

– Despite this, the establishment of a sharing culture is important for the promotion of the compact city; during a pandemic it can be expressed in different ways, such as sharing of public space while some walk, cycle or talk to others.

These are the key-points in order for public space to be reformed in the post-COVID-19 period; accordingly, an answer can be offered to some of the queries raised. Such directions can be underlined through a brief review of case studies around the world. Indeed, many cities have already completed a series of interventions in order to be quickly transformed into resilient and - at the same time - sustainability, as well. Some case studies are presented on the following section in order to be compared to the actions that have been implemented in Greece.

39.3 Case Studies: Combining resilient city strategy with compact city strategy

In many cities across the world various sorts of temporary measures have been quickly implemented in order to keep citizens as safe as possible by taking precautions to "flatten the curve." Those measures can be categorized into 2 main groups: (a) Enhance walking and (b) enhance cycling. More specifically:

(a) Enhance walking: In most of the cities, sidewalks tend to be crowded. Their width - if they exist - is not ideal while most of the time they are occupied by street vendors, trees and street equipment. People need more space on the streets. This need was obvious even before the COVID-19 era; now, it is a necessity, taking into account social distancing measures. In that condition cities must implement low cost and temporary interventions on streets in order to urge people to walk and stay outside. Actions that promote walking (Figure 39.1) include:

(a1) Closing streets to private vehicles. Vienna, Austria has created nine temporary meeting zones by reallocating road space from motorized traffic to pedestrian traffic. Such an intervention was chosen to be implemented in neighborhoods where the population density is high enough while sidewalks are narrow and open spaces are limited. Moreover, 20 other streets have been fully pedestrianized [34].

(a2) Extending existing sidewalks. The city of Hammersmith, London has temporarily widened the sidewalks in two busy streets providing city dwellers with social distancing. Apart from enabling pedestrians to pass each other while social distancing, through this intervention pedestrians are allowed to queue safely for essential supplies from pharmacies and food stores. The pavements have been widened by locating on the streets barriers, water-filled bollards and weighted cones. At the same time, signage has been put in place to inform not only drivers but also pedestrians of the new street design [35].

(a3) removing crosswalk "beg buttons." The city of Des Moines, Iowa automated pedestrian walk signals at crosswalks so that pedestrians do not need to push the beg buttons. Currently, approximately 45% of the signaled crosswalks are automatic. They are mainly located at the city center and there consideration for expanding this measure to other areas of the city, as well [36].

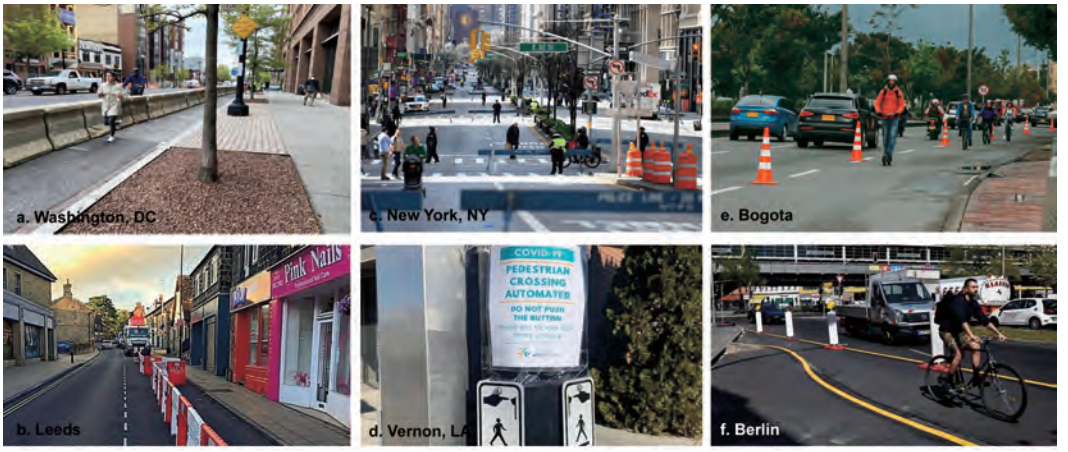

FIGURE 39.1
Case studies worldwide. Source: a. [39]; b. [40]; c. [41]; d. [42]; e. [43]; f. [44]

(b) Enhance cycling: In many cities, cycling was not a popular means of transport until the lockdown period. Citizens tended to prefer private cars or public transport for various inner-city travels, although bicycle-friendly policies had already started to be applied (i.e. bike sharing schemes). After the COVID-19 outbreak such policies have been intensified in order to contribute to behavioral changes and the effective adoption of the bicycle, replacing a portion of public transport (and private car) trips with bicycles. The city of Bogota offers one example. Back in 1976, Ciclovia was introduced; it is about a program under which specific streets became car-free on Sundays and holidays for 7 hours per day. In that way a 585 km network of connected streets and bicycle lanes was developed thereby minimizing the construction costs. This initiative was extended to all days of the week, after the lockdown period [37]. Those streets are now the only way for citizens to move around the city while social distancing and exercising themselves. In spite of the fact that the interventions are not permanent, it turns out that such a measure seems to be one of the most resilient.

(c) A similar approach was applied in Budapest, where the use of public transport has been reduced by approximately 90% after the outbreak. Temporary bicycle lanes have been established on some important streets in order to provide citizens with an alternative and safe way to move around the city. Due to the fact the overall traffic is decreased, no significant traffic congestion is expected. Concerning the phases of the renovation, central locations are the priority [38]. Another action is related to bike sharing systems. Cities like New York and Chicago that have invested in bike sharing schemes and cycling infrastructure during recent years, have seen their systems surge in demand. To face the increased demand, new bicycles have been added. Moreover, the systems have been made entirely free for essential workers that had to move around the city.

Finally, it should be mentioned that another set of measures have been applied. It is related to public transport and contains measures like: (a) extending the timetable for the metro and tram lines, (b) increasing the number of itineraries, (c) promoting all-door bus boarding and (d) keeping stations and vehicles clean. However, we have not focused on such measures because they do not transform the form of urban space although they have a spatial footprint.

39.4 What's Happening in Greece? The Case Study of Athens

The management of public space preoccupied the General Secretariat of Civil Protection but also academics and urban planners in Greece. From the first weeks of lockdown, decisions were taken for the prohibition of access to public spaces. At first, the entrance and stay in the parks of Attica was forbidden. Typical are also the cases of the New Waterfront in Thessaloniki and the Waterfront (Argonauton Str.) in Volos. These prohibitions were the result of intense overcrowding of citizens. Nikiforidis (in [45]), referring to the case of Thessaloniki, underlined that overcrowding is not necessarily a result of citizen insubordination but is an element that designates the absence of public space. Gospodini [46] arrives at the same opinion, characterizing the decision for the closing of the waterfront in Volos as wrong. Since there is no central square, the streets are narrow with narrow sidewalks and pedestrian network is limited.

Although the authorities' intention was not the total prohibition of pedestrian movements but the prevention of congregation, the citizens' reaction was intense because of the deprivation of public space which is of vital importance for the smooth operation of the cities. Such decisions can be justified in periods of pandemics (lockdowns) and especially in any unprecedented situation in which the scientific community was unable to manage an unknown virus. However, their long-term extension is discouraged since, beyond the operating issues of the city, the connection of public space with factional disputes is unavoidable. Typical is the case of Agios Ioannis Sq. in a neighborhood of Athens that constituted the object of discussion for whether the specific square should be open to the public or the access to it should be prohibited.

Beyond the first - possibly unfortunate but effective - decisions for public space, the issue came again in to fore during the planning for the lifting of the restrictive measures. Taking into consideration the resumption of business activity and the normalization of city life, the question was whether measures could be taken quickly and effectively to restrict the spreading of COVID-19 without circumventing the role and operation of public space. In this context, the Transportation Engineers Association (SES) [47] was against the increase of automobiles that, in combination with walking and bicycling, was proposed as an ideal solution for moving around the cities by the infectious disease specialists team [48]. In parallel, it proposed [49] the immediate development of pedestrian and cycle networks in Greek cities, something that can take place with a series of interventions like those in cities abroad. Thus, beyond the temporary transformation of parts of road networks to spaces of exclusive pedestrian and cycle movement, the delimitation of parking, the widening of pavements and the liberation of pavements from obstacles, the SES [49] proposed the decrease of vehicle speed limit from 50 km/h to 30 km/h; the development of small parklets; the movement of pedestrians to be safe and overcrowding to be considerably limited, since the proposed socializing spaces will be of small size and capacity will be limited.

In this context, the Ministry of the Environment and Energy proposed a provision with which procedures have been quickly enacted for the temporary creation of cycle lanes and footpaths [50]. In Athens those directions were integrated in a uniform planning by the municipality of Athens for the city center, called "Great Walk" (Figure 39.2a).

It is an integrated plan of revival of the historic center that creates new paths for pedestrian and bicycle movement. These routes will connect the neighborhoods of the historic center of Athens as well as the archaeological areas, changing the image of the city. Through the interventions of this program, about 50,000 m2 will be devoted to pedestrians and cyclists. The total length of the course comes up to 6.8 km, while 1.9km of new bicycle paths are expected to be created in the center of Athens where the infrastructure is considerably limited today [51].

FIGURE 39.2
The interventions proposed in Athens. Source: a. [52]; b. [53]; c. [54]; d. [55]; e. [56]; f. [57]

As Figure 39.2 points out, the regeneration scheme includes 3 types of actions: a) closing streets to private vehicles; (b) extending the existing sidewalks; and (c) developing cycle-lanes. All of the three types of interventions have also been implemented in other cities abroad, as was mentioned in the previous section. More specifically, the regeneration scheme contains the following interventions:

- The redevelopment of Panepistimiou Str. The plan is based on closing three of the six traffic lanes. On that part of the street, a new cycle-lane has been developed. The pavement has also been extended. Concerning motor traffic, 2 car lanes and one bus lane have been preserved. In that way, two main squares of the city (Syntagma Sq. and Omonoia Sq.) have been connected by a green route and the "Trilogy of Buildings" (National Library-Central Building

of the Kappodestrian University of Athens – Academy of Athens) has been vindicated. This intervention is also connected to another street redevelopment: It is about Patision Str. (from Omonoia Sq. to Egypt Sq.). On that part of Patision Str., an extension of the sidewalks and a new cycle-lane have been adopted (Figure 39.2d). The cycle-lane is going to end in Kifisia. According to the Minister of Environment and Energy this cycle-lane is one of the two additional interventions that will take place, apart from the "Great Walk of Athens." It should be underlined that such interventions are also proposed by the recent Regulatory Plan of Athens (2014) (Act No. 4277/2014). According to that plan, a whole cycling network is proposed to be developed. This provision compensates the absence of planning for cycling in the context of the General Development Plan for the Municipality of Athens which is old enough (1988) and obsolete.

- The redevelopment of Omonoia (Concord) Sq. was scheduled before the COVID-19 outbreak (Figure 39.2f). However, it is considered to be part of the "Great Walk of Athens" because: (a) it is spatially related to the interventions and (b) this scheme is an inspiration from many years ago (see below).

- The redevelopment of V. Olgas Ave. (Figure 39.2c) has been one of the works of great significance. It is about a narrow street that is characterized as an "avenue" due to its great importance; it is the street in front of the Zapeion Megaron. Until the COVID-19 outbreak it was a typical street for car-movement. A tram-line was also located within the street. After the interventions, the Kallimarmaron Stadium is well-connected to other important monuments such as the Parthenon, the Oden of Herodes Atticus, the Areopagus (Mars Hill) and the Museum of Acropolis. The intervention contains widening of the sidewalks and the development of a cycle-lane. The tram-line and one car-line have remained.

- The redevelopment of Herodes Atticus Str., Athenas Str., Ermou Str. and Metropoleos Str. includes the convertion from a road to a pedestrian street. However, specific cars of special purpose (ambulances, fire tracks, food supply tracks, hotel vans, taxis, etc.) and residents' cars are allowed on those streets.

- The redevelopment of Syntagma Sq. (Figure 39.2e) The plan is based on limiting car movements (in Stadiou Str.) to only three lanes. A bus-lane and a bus-stop-lane have also been developed. On the rest of the road space two elongated parklets have been developed. In that way, the sidewalks of the two blocks facing Stadiou Str. have been widened.

This plan is not a new inspiration. Many years ago (early 2000s), there was a proposal for the unification of archaeological sites of Athens. Through that idea, the previously separate archaeological sites of the historic center could be connected in order to create a large archaeological park enhancing the historic image of the city. A major part of the plan was implemented before the Olympic Games 2004. The most interesting intervention was the redevelopment of Dionysiou Areopagitou Str. which is now considered one of the best pedestrian routes in Europe. However, the regeneration scheme was not totally implemented. One part of a great significance was the one between the Temple of the Olympian Zeus and the Panathinaikon Stadion (V. Olgas Ave.). This part has been included into the "Great Walk" plan. Concerning Athenas Str., there was a prediction in the previous plan about a small scale pedestrianization (close to Omonoia Sq.). Through the "Great Walk" regeneration scheme, the whole length of Athens Str. has now been pedestrianized.

Moreover, the redevelopment of Ermou Str. was also proposed by Vlastos (in [58]), as an extension of the works took part before the Olympic Games 2004 although people - especially store owners - disagreed with that opinion. After a decade, this intervention has also been implemented (even partially due to the reactions of public).

Finally, the idea of pedestrianizing Panepistimiou Str. first appeared in 1983 by the Greek Ministry of Public Works, in the context of the Master Plan of Athens. However, no works were implemented until 2010s when the idea of a partial pedestrianization of Panepistimiou Str. came again to the forefront (Rethink Athens) (Figure 39.2b). In that context the tram line was proposed to be extended from Syntagma to Patissia, through Panepistimiou Str. A strong debate regarding this regeneration reached immense proportions and had a huge political and urban planning impact

[59]. However, the project was not implemented after the European Commission rejected the funding due to the economic crisis. Almost a decade after that, this is intervention has now been implemented.

It should be mentioned that, the "Great Walk" is also combined with other small-scale redevelopments that have been scheduled before the COVID-19 outbreak. Such interventions are the pedestrianization of the Historic Triangle of Athens and the redevelopment of some of the squares of the city center. The cost of the interventions (at the time, it is about a pilot implementation) was 2 million euros.

39.5 Brief Discussion

The "Great Walk" scheme manages to materialize interventions that for decades were not achieved. The concession of large areas of the city to pedestrians and cyclists took place with particularly quick procedures. As much the realization speed of the interventions as the turn to the prevailing concept for the city - from a car-centered point of view to a pedestrian-friendly one - are classified to the benefits of the action. To the benefits of the interventions we can factor in the financial benefits that result from the possibility of exploitation of a larger part of the pavements from the roadside establishments, without hindering pedestrians. In parallel, however, the positive effects extend to the social level since socializing is encouraged through the placement of benches. Some may be concerned considering that social contact could not coexist with social distancing. However, the one situation does not contradict the other. The instructions by the infectious disease specialists mention social contact by paying attention; it has not mentioned anything about isolation. Social contact by paying attention can be possibly adopted in large spaces where the benches are placed well apart and permit social distancing. Therefore, such a perspective advocates for the conservation of large open spaces that seem to constitute an advantage for a city, even during a pandemic. Honey-Roses, et al. [25] arrive at this opinion underlining the importance of existence of such spaces in the context of urban resilience.

The above benefits, however, were initially opposed by the opposition of the municipality of Athens. This part of the municipal authority, as well as by groups of citizens and architects, was not in favor of the redevelopment for the following reasons: (a) non-compliance of the provided procedures, since no consultation preceded them, (b) unsatisfactory aesthetic result, (c) insufficient urban planning considering the movement of individuals with restricted mobility, (d) non-viability in terms of environment since it creates congestions, and (e) cost of the project.

Most of these points (b-d) can be easily refuted since the interventions will become permanent in the second phase of the project, after the completion of which, a limited movement of motor vehicles (as a result, the total number of car trips within the city will be reduced; this is something that is considered a public health necessity for most people in America and elsewhere [60] is expected. Easier access by all users (pedestrians, cyclists, disabled, old people, etc.) is also expected.

Finally, it should be underlined that the case of Athens is not a typical one: although the planning policy has been implemented in order for the transmission of COVID-19 to be limited, it seems that the regeneration plan aims to something bigger than that. The ultimate goal is to promote useful interventions that upgrade the city's form and image by establishing permanent solutions to a series of urban and traffic planning problems.

39.6 Conclusions

In this chapter, a brief consideration of the effects derived from the COVID-19 outbreak in the cities and public spaces was attempted. The topic is particularly important as public space constitutes a field of expression of human life in the cities which historically were designed based on health

criteria. Typical are the examples of the Renaissance and the post-industrial revolution period, as well as design practices proposed in the context of utopian idealism and modern movement. Cities evolve and the change of their form is not strange when public health is a major concern of the citizens.

In the post-lockdown era, a large number of cities have decided to change their form by suggesting interventions of great significance. Widening of pavements, closing streets to private vehicles, developing cycle-lanes and removing crosswalk "beg buttons" are only some of the mainstream strategies applied, worldwide. In Greece, discussion of those practices came to the fore when the need for restrictive measures for limiting the virus transmission became obvious.

In fact, the Municipality of Athens has immediately adopted a large-scale action: the "Great Walk of Athens" regeneration scheme.

It is a project that includes the concession of road space to pedestrians and cyclists by limiting motorized traffic in the historic city center. The action was accepted with mixed reactions by the authorities and the citizens. However, as mentioned, the positive effects are more than the negative ones. In support are the results from other countries where respective policies were adopted. Nevertheless, it could be said that the degree of positive feedback by the local public in such measures is related to two parameters: (a) the degree of the virus transmission as well as the number of recorded cases and (b) the mobility culture in each country that reflects its cultural identity. The low number of cases in Greece and the absence of sustainable mobility culture are the reasons why a negative climate was developed during the construction phase. However, the fact that the intervention proposed by the Municipality of Athens is in line with the principles of a sustainable, compact and resilient city, entails long term benefits for the city and its citizens. This is the reason why the permanence of the projects is encouraged despite the fact the implementation of the SUMP has not been completed.

It should be underlined that, although the "Great Walk of Athens" is a scheme of integrated measures of great significance, they are not the only ones that can be applied (i.e. crosswalk beg buttons have not been removed and bike sharing system has not been developed - the acquisition of bikes was subsidized, according to the Ministry of Energy and Environment decision). However, even those measures are superior to the corresponding ones that have been taken in cities of other countries where the outbreak was more intense. That proves that decision-makers in Athens were interested in acting as early as possible. On the other hand, no special interventions have been proposed in order for the cities to be safer in the post-lockdown era. The reason why no special interest have been expressed is probably related to the urban sprawl observed in most of them (e.g., buildings are located at ideal distances; building density is higher only in the center of cities). The good point is that many cities have already implemented SUMPs or have expressed interest in their consideration; some cities where many COVID cases have been reported fall into this category.

Taking all the above into consideration, it could be said that Athens is one of the cities across Europe where brave decisions have been taken. The whole format of the city center has been changed; a large pedestrianized space has now been developed that gives the opportunity for everybody to social distance and stay safe. After the COVID-19 outbreak, Athens has been considered as a resilient city. Nevertheless, this positive outcome could not have been attained had the National Technical University of Athens, other scientific organizations and local authorities not previously supported such studies. Hopefully, the ex-post evaluation will prove that through such actions cities can greatly benefit, not only for citizens to be protected from the pandemic but also for cities to be transformed into economic, compact and resilient urban cores.

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40

COVID-19 Pandemic Challenges and Impacts on the SDGs 2030: Indian Perspective

Saied Pirasteh, Hishmi Jamil Husain and Tammineni Rajitha

This chapter discusses the understanding of COVID-19 issues and its influences on Sustainable Development Goals (SDGs) 2030, particularly the Indian perspective. We require adopting interdisciplinary efforts and determining the challenges of social and education, economy, and health. COVID-19 global disaster has given us a big lesson on how transparent and reliable data with spatial information is efficient during an unexpected issue. Nevertheless, today, the world needs to work together on various aspects of disaster risk reduction, mitigation, and prevention. For example, it is strengthening regional cooperation in geospatial data sharing for mitigation of COVID-19 pandemics.

40.1 Introduction

The 2030 Agenda of Sustainable Development was launched in 2015 to foster a new 'Global Partnership' for sustainable development of the world. There are 17 SDGs with 169 targets and 232 indicators that demand the transformation of current systems for an equitable society and a healthy planet [1]. The achievement of SDGs requires strong political will and ambitious action by all stakeholders. The year 2020 remarkably shows the beginning of a decade of action to deliver the SDGs by 2030 [2]. It is a significant period for fulfilling the agenda, but in a very short period of time, with the unfortunate spread of the novel coronavirus, a global public health emergency happened, and the years of progress has been reversed. This global health crisis has changed the world as we know it. It has attacked societies at their core. It has affected not only human health but also the economy and social structures. The International Monetary Fund (IMF) has reassessed the prospect for growth for 2020 and 2021 and declared a recession period. It projects recovery in 2021 only if the world succeeds in containing the virus and take the necessary economic measures. In such an unprecedented situation, there is a tangible impact on all 17 goals. A global level impact has been summarized by the United Nations Department of Economic and Social Affairs (UNDESA) in the following infographic [3].

The authors believe that the work towards achieving SDGs begins with taking the SDGs from global to local. The first step is setting the national and subnational context of the 2030 agenda. Once the context is set, the goals and targets have to be adapted from national to local levels, and indicators have to identify, local means and structures of implementation have to design, and monitoring frameworks have to be created from national to local levels [4].

This chapter is an effort to document the impact of COVID-19 on the progress and status of the 17 sustainable development goals in India. The impact on each goal is evaluated in-depth based

on the targets and indicators defined by India, using various reports by international agencies, newspaper reports and research publications.

40.2 COVID-19 Impact on SDGs

40.2.1 SDG-1

The goal-1 is No poverty and end poverty in all its forms everywhere. For India, there are a total of five national-level indicators that capture three out of the seven SDG targets for 2030 outlined under this goal [5]. In this study, we determined the local and global impact as follows:

The local impact of COVID-19 has been more disruptive to the urban workers who have lost their income sources than to the subsistence farmers. The subsistence farmers constitute the major percentage of the extreme poor in India, while urban workers majorly constitute the part of the population that has recently escaped from the 'extreme poverty'. The pandemic has pulled them back down, thus increasing the percentage of people living under extreme poverty in India. In addition to the above, IMF's World Economic Outlook Report 2020 has projected that India is likely to add 10 million to the poverty rolls this year and worldwide, more than 71 million [6].

The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) is a social refuge measure in India that aims to promise the 'right to work'. Under the MGNREGA system, the work dropped to 3.08 crore person-days in April in the aftermath of lockdown, which is 88.8% lower than April in the previous year [7]. Thus, leaving many people dependent on MGNREGA wages in rural areas with no income source. Therefore, the livelihoods of daily wage workers, migrant workers, agricultural labourers, fish workers, and others employed in the 'informal' sectors have been most severely affected. Overall, 4 million urban homeless people and 75 million inhabitants of informal settlements with no access to essential services such as water supply have suffered due to a lack of basic social protection measures [8].

In the global context, we determined that the first increase in global poverty as more than 71 million people worldwide are expected to exert back into extreme poverty [8]. Therefore, we will probably see the direct economic losses of $23.6 billion for the countries due to natural disasters.

Decreased labour income and poor job quality have disproportionately impacted the women and young workers more, creating disparities and has been exacerbated by the COVID-19 [9]. Therefore, the economies of the least developed countries are adversely affected. We can expect that 4 billion people not covered under any sort of social protection scheme have become exposed and are more vulnerable to the impact of COVID-19.

40.2.2 SDG-2

The goal-2 is Zero Hunger, which enhances end hunger, achieves food security and improved nutrition, and promote sustainable agriculture. For India, there are seven national-level indicators that capture three SDG targets for 2030 outlined under this goal. In this study, we determined the local and global impact as follows:

Almost in some countries, food security becomes one of the worst affected during these times of COVID-19 pandemic. The continued lockdowns across the country have affected labour and input availability for agricultural operations. This, coupled with the serious disruption in transport networks, has impacted food security [10, 11]. For example, in India, Punjab, Haryana, and Uttar Pradesh, the largest producer of wheat, faced a crisis at the time of harvest due to shortage of labour, transportation bottlenecks and unavailability of harvesting machines [12].

Besides, due to rumours regarding the association between poultry and COVID-19, it led to a loss of Rs. 22,500 CR to the poultry industry as many farmers destroyed their produce, and some sold at very low prices [13]. The demand for processed foods saw a huge surge, but due to a shortage of raw materials, manpower and exemption permissions, the production rate was low.

As reported in the Global Nutrition Report 2020, 37.9% of children under five years are stunted,

and 20.8% are wasted in India, which is bound to increase with higher incidences of malnutrition [14]. Agriculture gross value added (GVA) is projected to grow by 2.5% in FY21 as compared to the average of 3.2% till 2017 due to the effect after the pandemic [15]. Bumper production of grain and horticulture output is estimated at 152.7 million tonnes and 313.35 million tonnes, respectively, even after the pandemic [16].

Considering the global impact, we estimated that 2 billion people worldwide are facing moderate food insecurity, and 700 million are facing severe food insecurity. This will be exacerbated by the pandemic, climate shock and the locust attacks as the yield and supply chain is disrupted [17].

Globally, in 2019, 47 million children were suffering from stunting and wasting due to acute malnourishment. This is projected to increase by 6.5 million more children due to constraints on nutrition services and limited accessibility. The food prices were adversely impacted throughout the world as COVID-19 disrupted the already fragile supply chains, which resulted in high price volatility for farmers and expensive essential commodities for consumers.

40.2.3 SDG-3

SDG-3 is focusing on good health and well-being. It ensures healthy lives and promotes well-being for all at all ages.

For India, there are a total of eight national-level indicators that capture five SDG targets for 2030 outlined under this goal.

We determined that the hospitals are overwhelmed with COVID-19 patients, and it is hampering the standard care required for other patients with acute or chronic ailments. The number of children affected by the COVID-19 pandemic is very less as compared to adults and the elderly, but the pandemic has severely impacted their growth and protection against infectious diseases, indirectly. As the household income will go down, the children, women and the elderly will become more vulnerable, and an increase in infant mortality rate (IMR) is imminent.

Besides, according to a UNICEF report, India is projected to give birth to 20 million babies, i.e. the highest number of births this year during the pandemic. With the majority of healthcare services redirected for pandemic control, neonatal mortality is set to rise [17].

Considering the global impact, with the overwhelming pressure on health systems, disrupted routine health services and constrained access to nutrition services, there will be an estimated 9.8 - 44.8% increase in under-5 deaths per month and an 8.3-38.6% increase in maternal deaths per month, over a period of six months in the 118 low- and middle-income countries.

However, there can be a 13% increase in TB related deaths worldwide, a 23% increase in malaria cases in Africa and a 100% increase in malaria-related deaths if the prevention and detection campaigns do not get back on track in the next six months [18, 19].

40.2.4 SDG-4

SDG-4 is delivering quality education, and it ensures inclusive and equitable quality education and promote lifelong learning opportunities for all.

For India, there are a total of nine national-level indicators that capture four SDG targets for 2030 outlined under this goal. The followings deliver the local and global impacts on SDG-4.

In India, there are more than 15 lakh schools and 50,000 higher education institutions which were closed due to the pandemic. It impacted millions of students as, along with education schools, also took care of the nutritional needs of the children. The inequality of access to the internet across India increased the digital divide, and even though classes were resumed through online mode, many children were left out of the fold. In addition to the above, access to technology in rural India and urban slums is highly gendered. According to a survey by Young Lives, 80% of the girls in rural areas have never accessed the internet, and 62% have never used a computer [18].

In the global context, according to a UNESCO report, the COVID-19 pandemic will negatively impact more than 290 million students from 22 countries due to the closure of schools. We predict that extended school closures will weaken the fundamentals of students, and it leads to loss of human capital as well as economic opportunities in the long run. Also, according to the World Bank, COVID-19 will deeply impact countries in where education may be grappling with high

dropout or low learning outcomes rate. We found that several educational institutions had no choice but to embrace e-learning to sustain the momentum.

We have seen that in the last decade to now, encouraging to use e-learning has become more popular, and it witnessed an uptick due to ubiquitous internet connectivity, the proliferation of smartphones and significant advances in technology. Therefore, there will be a major shift in the curriculum and pedagogy in the post-COVID-19 era. For example, Climate Change Induced Disaster Management in Africa (CIDMA) has developed up-to-date courses in disaster management online courses. Many courses deliver by various institutions such as Coursera made it for free and learned online. For example, one of the courses is Do-It-Yourself Geo Apps, and it delivers how to use Web Application and to create Geo Application. Also, Southwest Jiaotong University (SWJTU) has planned to run MOOC courses, synchronous and asynchronous courses for students.

However, at least 500 million students globally are left out from the digital access to education. Such prolonged absence from school is associated with lower retention and graduation rates and worse learning outcomes, especially students from the disadvantaged section of society [9, 10].

40.2.5 SDG-5

SDG-5 is gender equality, and it stresses on achieving gender equality and empowering all women and girls.

The followings deliver the local and global impacts on SDG-5.

The local impact of COVID-19 under the lockdown, violence against women, has increased drastically. The domestic violence complaints in the period between March-May were at a 10-year high [19].

Perhaps post COVID-19 situations bring more and more behavioural and mental changes among women, particularly with huge post-traumatic stress. According to the Population Foundation of India, the disruption of routine health services, including pre- and post-natal health care, family planning and contraceptive supply, has put the health of women and girls at increased risk due to decreased access and taken away their control. The female labour force participation rate in India is 25 percent. 90% of working women are engaged in the informal sector or irregular formal sector, the majority of which is constituted by the hospitality and service sectors. The pandemic would force these women into more vulnerable jobs or result in their permanent exit from the market.

Finally, the pandemic has also disrupted the work of Self-Help Groups (SHGs), which had an important role in women empowerment. With only 46% of women having access to the mobile phone, digitized credit facilities will be out of reach for them [20].

Globally, we predict that 70% of the frontline healthcare workers are women putting them at greater risk from the pandemic [9–11]. The campaigns against female genital mutilation and child marriage have come to a halt due to the pandemic, which could severely affect the progress achieved till now. Therefore, due to the lockdown, the burden of unpaid household work and childcare is more than the pre-COVID-19 era, and it would have a long-term effect on women's health.

Besides, there are increased incidences of domestic violence against women during the pandemic lockdown. An estimated increase in 25-30% of reported cases has been seen in France, Argentina, Cyprus, and Singapore. And in many countries like Germany, Canada, Spain, the UK, the US and other countries, the demand for shelter homes by women has gone up [21].

40.2.6 SDG-6

SDG-6 is about clean water and sanitation, and it ensures the availability and sustainable management of water and sanitation for all.

For India, there are a total of seven national-level indicators that capture four SDG targets for 2030 outlined under this goal [5–10]. According to the above, we may provide the following local and global impacts on SDG-5.

Millions of Indians were already at risk due to the infectious diseases from unhygienic water and sanitation conditions. Therefore, we expect that water-borne diseases are more prevalent in rural Indian populations and urban slum dwellers because of inadequate hand washing and unclean

water. Like these water-borne diseases, the coronavirus can also spread easily when clean water is not available.

As we can see in the world, the pandemic outbreak is projected to slow down investments in the water sector globally [22]. We estimated that the high-risk areas during the pandemic with the most chance of spread are the areas with low access, reliability, and the quality of water, sanitation, and hygiene (WASH). Moreover, industrial water demand will decrease by 27% due to the pandemic. This would result in reduced revenues to water utilities. There is a partial suspension of water billing and moratoriums on water service cut-offs in low-income countries globally.

40.2.7 SDG-7

The goal-7 serves for affordable and clean energy. It ensures access to affordable, reliable, sustainable, and modern energy for all.

For India, there are a total of two national-level indicators that capture one SDG target for 2030 outlined under this goal.

The impact of COVID-19 on SDG-7 estimates as (a) people without access to electricity declined from 1.2 billion to 789 million in 2018, but the world was lagging behind in achieving the targets by 2030 even before the pandemic, this is not expected to improve now with a constraint on funds. (b) There are millions of deaths due to a lack of clean cooking fuel. The progress in this sector is also stagnant since 2010 and is not expected to change. (c) The share of renewable energy is growing at a pace of 1.7 percent only. It is difficult to meet the target at this pace. (d) There is an urgent requirement to provide electricity for 1 billion people who are relying on health facilities without electricity. (e) Global energy investment is predicted to reduce by 20%, or $400 billion. (f) Global energy demand could fall by 6% in 2020, which would also cause a decrease in Global energy-related CO2 emissions by almost 8% in 2020, with coal demand also projected to fall by 8% [23].

40.2.8 SDG-8

The goal-8 is decent work and economic growth. It promotes sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

For India, there are a total of seven national-level indicators that capture four SDG targets for 2030 outlined under this goal. We can determine the impacts of COVID-19 on SDG-8 as follows.

Locally, the economic impact of the pandemic has been disruptive, with the fourth-quarter growth of FY2020 has slipped to 3.1% according to the ministry of statistics. Research by State Bank of India estimates the contraction of gross domestic product (GDP) by 40% in the first quarter of FY21. Unemployment in India rose to 26% from 6.7% as a consequence of lockdown, i.e. at least 14 crore people lost employment.

The global impact of COVID-19 could increase the incidences of child labour and pose a serious threat to decent work for especially vulnerable women and men from the informal sector. With the reduction in working hours and economic decline due to the pandemic, labour productivity is expected to go down in 2020. It is estimated that the informal economy constitutes more than half of the workforce, amounting to approximately 1.6 billion workers who are vulnerable and severely affected.

40.2.9 SDG-9

The goal-9 is for industry, innovation, and infrastructure. We work together to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

For India, there are a total of four national-level indicators that capture three SDG targets for 2030 outlined under this goal.

We can describe the local impacts of COVID-19 on SDG-9 as (a) standard & poor's (S&P) Bombay Stock Exchange (BSE) India Infrastructure Index lost 35% of its value during the initial months of the pandemic. That is to say, there is a demand cut in the transportation sector, power

and industry, which would limit the growth with no clear recovery period insight [24]. Therefore, according to the government data, India's eight key industries in the infrastructure sector shrank 6.5% in March after the pandemic lockdown. The crude oil sector contracted 5.5%, natural gas 15.2%, refinery products 0.5%, fertilisers 11.9%, steel 13%, cement 24.7% and electricity 7.2% in the period of one month [25].

We estimate that the capital expenditure in the infrastructure segment would go down with limitations created due to pandemic for both private and government investments. India's monthly internet user base is estimated to reach 639 million, as reported by the ICUBETM report by Kantar. Currently is rural India, there being 264 million internet users, which is projected to reach 304 million in 2020 with students and housewives to adopting internet services. Some key elements that will drive the impact are Over The Top (OTT), hyperlocal services, social media, communication and online payments [26].

We have also seen that many industries and companies have focused on the development of new technologies and innovative devices and platforms. For example, GeoIME explored the innovative approaches toward reducing the number of inspections of vulnerability and risk estimation of buildings.

Globally 97% of people live within reach of a mobile signal, and 93% within reach of a mobile broadband signal. With the pandemic, there is an increased dependence on digital payments, e-learnings and many more, so the internet usage is bound to increase [9, 10].

40.2.10 SDG-10

The goal-10 focuses on the reduced inequalities. Everyone works on reducing inequality within and among countries.

For India, there are a total of nine national-level indicators that capture three SDG targets for 2030 outlined under this goal. We express the local and global impact as follows.

In India, the social distancing and lockdowns have led to the increase in income inequalities as the poorer segments of society who are engaged in informal sectors and other physical work for their livelihood are severely impacted as their work cannot be done remotely.

We observed that the educated white-collar employees working in Information Technology (IT) sector, finance and similar sectors had not faced many severe consequences as their work can be done remotely. Besides, the poorer segments have very few savings, which will be depleted by the end of this pandemic, and there is a lack of access to credit for them, which has put them in dire straits. Therefore, economists believe that due to the lockdown, there will be a widening in the gaps in access to quality education between high and low-income households. This will have far-reaching consequences in the future as the employment opportunities for low-income people reduce. Finally, the migrant labour community has suffered the brunt of the COVID-19 pandemic both economically and socially as they lost their livelihoods and forced to abandon the cities.

We also observed that globally the workers are receiving less share of what they help produce; with the pandemic, these workers have altogether lost employment, and with decreased production, their incomes have also contracted. Disabled people will be facing more challenges, be it the term of access to education, health care or the stigma attached. Finally, with the pandemic, there would be a reduction in the influx of money into developing and least developed countries from the developed nations of the world. This would turn back the progress achieved till now and widen the gap between the countries [9, 10].

40.2.11 SDG-11

The goal-11 provides sustainable cities and communities, and it makes cities and human settlements inclusive, safe, resilient, and sustainable.

For India, there are a total of five national-level indicators that capture two SDG targets for 2030 outlined under this goal. The impacts of the COVID-19 on SDG-11 can be considered for both local and global scales.

The air quality improved exponentially in Delhi, one of the most polluted cities in India. PM10 and PM2.5 concentrations in the air were reduced by half, NO2 and CO concentration also went

down. In the transportation and industrial locations, the air quality improved as much as by 60% [27].

India has made special guidelines for dealing with the biomedical waste generated from dealing with the pandemic. App-based technologies are being used to monitor and streamline the disposal of waste [28]. In addition to the above, the population living in slums has decreased exponentially due to the large-scale migration back to rural areas after the pandemic shock. But this is a temporary change which is expected to change. However, the pandemic has pushed to rethink the current model of high-density habitation in cities. The high-density populations in metros like Mumbai and Delhi have created diseconomies and hampered the efficient dealing with the pandemic.

We predict that on a global scale, the people living in slums and informal settlements have suffered because of a lack of access to basic amenities like water, sanitation, waste management and similar challenges and issues. They are overcrowded and social distancing in such places is next to impossible in such a scenario; these places became hotspots of the pandemic. We have seen that the need for more public transport has arisen throughout the world to tackle the problem of overcrowding and address the need for social distancing. Therefore, the pandemic has pushed to rethink the urban cities. It has made clear that for better public health and mitigation of people's vulnerabilities, urban planning is crucial. Of the 150 countries having some kinds of urban plans, many are revisiting the plans to make them more sustainable.

Finally, we can say that air pollution is estimated to have caused 4.2 million premature deaths globally in 2016. With COVID-19 induced lockdowns, many of the cities saw a major drop in air and water pollutants as the factories were closed, and the automobiles decreased [9, 10].

40.2.12 SDG-12

Responsible consumption and production are goal-12. It ensures sustainable consumption and production patterns.

For India, there are seven national-level indicators that capture three SDG targets for 2030 outlined under this goal.

The domestic demand for steel has reduced in the range of 12% to 20% in FY 2020-21, showing a slowdown in the consumption of end products using steel. Fertilizer sales increased by 45% even amid the pandemic as there was no restriction on the fertilizer industry. Besides, with the experts suggesting hand wash as the most effective precaution against the pandemic, the water demand is predicted to go up by 20-25% as per household would need 100-200 liters more water [29].

A study by Jal Jan Jodo Abhiyan has found out that in the water scarce Bundelkhand region, per capita water usage has gone up by 60% after the pandemic as people are washing hands at least five times a day [30]. If this continues, it will prove difficult in the long run for the state to manage water supply for every household in the region.

Globally 13.8% of the food produced is lost during transport, storage, and processing, which amounts to $400 billion annually. It is highest in South Asia and Africa. With the pandemic disrupting already fragile supply chains this year, the losses of perishables are bound to be higher than in previous years.

40.2.13 SDG-13

The goal-13 is climate action, and it takes urgent action to combat climate change and its impacts.

For India, there are a total of four national-level indicators that capture two SDG targets for 2030 outlined under this goal.

The impacts of COVID-19 on climate action are determined. According to experts and newspaper reports, the lockdowns established as a precautionary measure against the pandemic has resulted in improvement of air and water quality across the globe. Also, the pandemic has exposed the vulnerabilities within our emergency response, governance, and early warning systems, which are important from the viewpoint of managing the disasters occurring due to climate change.

We observed that climate action had taken a backseat, and it is predicted to be slower than before as the focus and resources at state and national level have been redirected towards dealing with COVID-19 in India. We predicted that with the visible positive effects of lockdown on the

environment, a stronger case for sustainability might be built with a greater push for alternative solutions like electric vehicles and rooftop solar power.

40.2.14 SDG-14

Goal-14 is for life below water, and it describes the conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

For India, there are a total of five national-level indicators that capture four SDG targets for 2030 outlined under this goal.

We determined the impacts of COVID-19 to SDG-14 are not only reducing the economic activities but also much needed time for the water bodies to recuperate. However, the impacts are (a) the reduced human and economic activities have given much needed time for the water bodies to recuperate, the ponds, irrigation canals and lakes are many cleaners [31, 32].

In addition to the above, the pandemic crisis has adversely affected the livelihoods of small-scale fishermen as the global demand for seafood reduced, and the supply chain disruptions happened due to transport restrictions and limited market access. Therefore, a pandemic can increase the incidences of piracy, poaching and smuggling in the coastal regions, and illicit fishing might also increase with fewer resources to monitor the coastal areas. Also, industrial fishing will come down due to the fear induced by the pandemic, and it would prove beneficial to the artisanal fishers who have now reduced competition from the industrial fisheries [33].

Finally, there is a reduced use of chemical fertilizers and other human activities near the water bodies and in coastal regions, which has helped improve the quality of water by reducing the biochemical oxygen demand.

40.2.15 SDG-15

It is for life on land and describes how to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

We have found that the impact of COVID-19 on many infectious diseases. These infectious diseases have been found to be of zoonotic origin, specifically transmitted from wildlife to human beings. The threat of such pandemic breaks increases with an increase in deforestation, habitat loss and illegal poaching.

For India, there are a total of five national-level indicators that capture five SDG targets for 2030 outlined under this goal.

40.2.16 SDG-16

Peace, justice, and strong institutions deliver in goal-16. It promotes peaceful and inclusive societies for sustainable development, provides access to justice for all and build effective, accountable, and inclusive institutions at all levels.

For India, there are a total of five national-level indicators that capture five SDG targets for 2030 outlined under this goal.

As we discussed in the previous sections, similar impacts almost have been seen in goal-16 as well. We describe the impacts as follows:

The pandemic has disrupted humanitarian aid flows, has limited the peace operations, and postponed or diverted the parties involved in the conflict from diplomacy. This might increase the unrest as conflicts arise within and among the countries.

We have also seen that there is already geopolitical friction created due to COVID-19 as the US has been blaming China for the novel coronavirus breakout, and China has been trying to gain favour by offering international aid to many countries. However, the authors do not believe this blame as it makes the current situation more complex to achieve the SDGs 2030, and these political frictions may create serious challenges and impacts on various collaborations, communications, and engagements.

Also, in some areas, there is also a chance of increased cooperation, as in the case of the UAE and Kuwait, who offered humanitarian aid to Iran. Moreover, China cooperated in providing humanitarian aids to several countries such as Iran, Italy, Argentina, Germany, and some African countries. The countries directly affected due to conflict have become vulnerable to the pandemic outbreak. Because their health systems are already broken, and the additional pressure of a global health crisis of this scale would put unprecedented demands on the system, which it is not capable of handling. For example, in Libya, during the war, most of the foreign medics had left the country, and in Venezuela, the political standoff had impacted the health system adversely.

40.2.17 SDG-17

Goal-17 encourages everyone to have a partnership for the above goals. It strengthens the means of implementation and revitalizes the global partnership for sustainable development.

Like the other SDGs, the impacts of COVID-19 have changed the nature of the collaborations. These impacts can be described as (a) remittances to low- and middle-income countries from international sources, which gave an economic lifeline for many poor households in these countries is projected to fall from $554 Billion in 2019 to $445 Billion in 2020. (b) Global foreign direct investments are expected to fall by 40% in 2020. (c) Net official development assistance from the member countries of the Development Assistance Committee (DAC) is expected to fall as the pandemic puts more pressure on the donor's aid budget. (d) There are instances where new partnerships have been forged. To develop a unified continent-wide strategy to deal with the pandemic and its impact, the African Union has established an Africa Taskforce for Coronavirus (AFTCOR). (e) The partnership between the African Union and the UN and has also been strengthened to deal with the pandemic outbreak [34]. (f) The European Union and the Member States have created 'Team Europe', which is helping the partner countries in dealing with COVID-19 through a comprehensive and decisive action to strengthen the healthcare, water and sanitation systems. Also, they collaborated to ensure fast and equitable access to safe, quality, effective and affordable tests, treatments and vaccines against coronavirus for the partner countries [35]. (g) WHO has initiated a Research and Development (R&D) Blueprint to accelerate the development of diagnostics, vaccines, and therapeutics for the fight against COVID-19. It has made a multinational coordinated research group for the purpose [36]. (h) In India, NITI Aayog CEO Amitabh Kant has reported the creation of empowered groups by the government, which constitute the NGOs, private sector and international aid agencies for tackling the COVID-19 crisis. The partnerships between these stakeholders are encouraged to lead an efficient fight against the pandemic [37].

40.3 Analysis and Interpretation

In the following diagram (Figure 40.1), the impact of the COVID-19 pandemic on sustainable goals has been mapped along with the interaction between different sustainable goals since each goal is affected by the progress of other goals (Table 40.1). The 17 sustainable development goals do not exist in isolation; there is a synergy among all goals. This synergy has been depicted through various linkages on the map. The analytical brainstorming and interpretational approach associated with some surveys attempted to define logical relationships among SDGs. We collected data and reports from various resources. We considered national and global level targets and indicators for SDGs. The SDGs targets and indicators are used as elements to interpret the relationships of 17 SDGs.

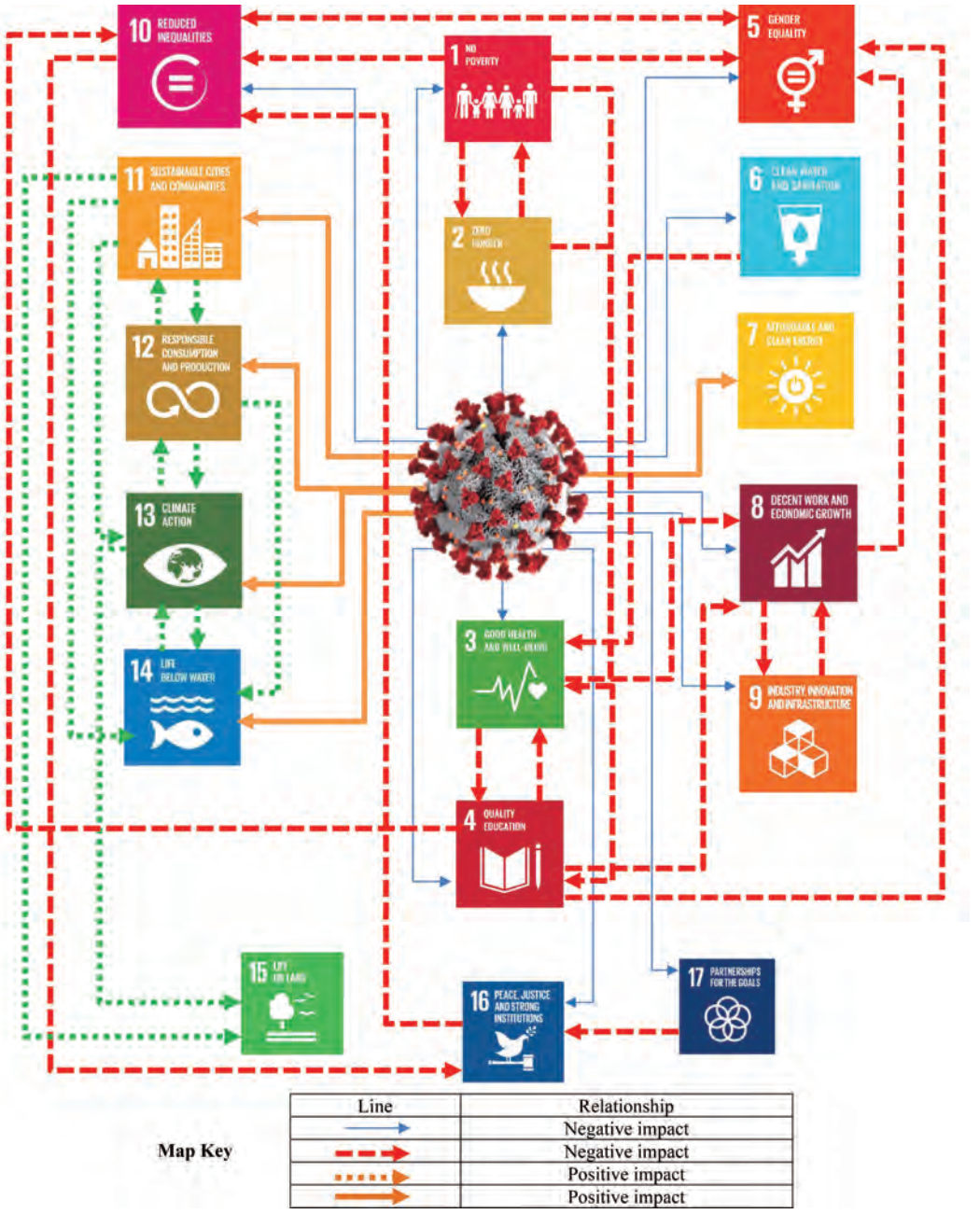

FIGURE 40.1
Impact of COVID-19 pandemic on SDGs 2030
(Source: Created by qualitative analysis of collated information of the impact of COVID-19)

TABLE 40.1
Summary of COVID-19 impacts on SDGs for local and global scales

Goals	Local Impact	Global Impact	Impact on Other SDGs
1 - No Poverty	India is estimated to have 68% population below $3.2/day because of lack of livelihoods and disruption of the informal sector which involves 90% of the workforce	Global poverty is estimated to go up by 8.8%. Decreased labour income and poor job quality will push people into extreme poverty.	**2,3,4,5,10**
2 - Zero Hunger	ICDS Scheme, Mid-Day Meal Scheme have been compromised. Food supply chains have been disrupted—heavy post-harvest losses even with bumper production.	10,000 child deaths every month are recorded. Nutrition services have taken a hit. More than 2 billion are facing food insecurity.	**1,3,4,5,8,10**
3 - Good Health and Well-Being	Most adversely affected. Lack of sufficient healthcare workers and facilities. TB and HIV care would be drastically affected.	Estimated double-digit increase in child and maternal mortality, TB and HIV related deaths due to disruption of routine healthcare services.	**1,2,4,5,8,10**
4 - Quality Education	Unequal access to technology is predicted to cause a 20% drop out of girl students, disrupt the foundations of all students, and hurt their opportunities of better jobs.	Globally 290 million students will be impacted across 22 countries, and 397 million have lost out on food due to school closure. 500 million children and youth are not able to take the benefit of digital learning.	**5,8,10**
5 - Gender Equality	Increased domestic violence against women. Loss of livelihoods which could result in a permanent exit from the market. Healthcare and nutrition for women are also severely impacted.	25-30% increase in domestic abuse cases. The shutdown of prowoman campaigns. Increased stress and burden due to lockdowns	**4,8,10**
6 - Clean Water and Sanitation	The burden on the sanitation system and clean water availability is stretched in the cities. More than a crore people have migrated back to rural areas putting stress on sanitation in rural areas where although the toilets are built, they still need to be cleaned manually.	Capital expenditure on water and sanitation is expected to go down by 7% as the industrial demand has gone down, and the funds are directed for COVID-19 relief.	**3**
7 - Affordable and Clean energy	There is an urgency to provide electricity to 1 billion people who are dependent on healthcare facilities without electricity. There is an estimated reduction of 20% in energy investments and 6% reduction in global demand.		**13**
8 - Decent Work and Economic Growth	Economic growth has slipped to 3.2%, and unemployment has risen to 26%	Child labour is predicted to increase. Women might be pushed into dangerous jobs. The informal sector is adversely affected. Tourism and hospitality industry too.	**5,9,10**
9 - Industry, Innovation, and Infrastructure	Investments in infrastructure have gone down. The sector has shrunk by 6.5%. Eight key industries, i.e. crude oil, refinery, fertilizers, steel, cement electricity and natural gas, all have shrunk. Internet and mobile users are estimated to go up.	Globally there is a 6% decline in the manufacturing sector. Internet users are projected to go up. SMEs are projected to decline due to a lack of credit facilities.	**8**
10 - Reduced Inequalities	Inequalities are bound to increase with many blue-collar workers out of jobs while the white-collar workers work online to earn their livelihoods. With education also impacted the inequalities will further increase in the long run.	According to studies on previous pandemics, it has been observed that inequalities undoubtedly increase after such shock. The gap will widen between developed and developing and LDCs as funding are diverted or stopped in the wake of the pandemic.	**5,16**
11 - Sustainable Cities and Communities	Air quality has exponentially improved. New processes for BMW management have been streamlined. Rethinking of high-density city planning is triggered.	Air and water quality in the cities have improved. Many of the 150 countries are rethinking the city plans to make them more sustainable.	**13,14,15**
12 - Responsible Consumption and Production	Water demand is estimated to increase by 20-25%. Fertilizer demand has also spiked. Steel demand has gone down and estimated to further reduce by 20%. Consumption is majorly focused on essential commodities now.	Local sourcing and online working promoted due to the pandemic has reduced the demand for unsustainable fossil fuels and made a start towards responsible consumption	**11,13,14**
13 - Climate Action	6% reduction in global emissions. Vulnerabilities exposed; space has been created for designing of policies. For now, funds have been diverted to COVID-19 relief so climate action might be limited.		**14,15**
14 - Life Below Water	Water bodies are cleaner due to reduced human and industrial activity. Local fishermen are benefitting due to reduced industrial fishing. Water bodies and the fish stock got the recuperation time during the pandemic season		**13**
15 - Life on Land	No direct impact of Covid-19 but as a result of increased awareness about zoonotic diseases the laws against smuggling, protecting wildlife etc. might become stricter.		**-**
16 - Peace, Justice, And Strong Institutions	Internal conflicts have been put to rest for the time being as countries grapple with the pandemic. But International conflicts might increase due to increasing friction between US and China and unscrupulous politicians as the diplomacy efforts are restricted during these times.		**11**
17 - Partnerships for the Goals	All new partnerships are being forged for dealing with novel corona virus. In the process other goals are getting side-lined. But all the stakeholders the government, NGOs, private businesses, and international organizations are learning to work together.		**16**

40.4 Summary and Conclusion

We concluded that the pandemic had had severe impacts on the whole world, including India and the world. This is a public health crisis of unprecedented proportions that came as a shock and caught the world unprepared. By the end of 2020, 21 of the 169 SDGs targets would have matured, but the progress was already slow as the world was lagging behind in achieving the mentioned targets. This lethargic progress is further impacted by the sudden shock of the pandemic. It is expected that decades of progress in achieving the goals might be reversed because of this shock. The degree of impact might vary, but each and every single goal from the 17 SDGs has been affected either positively or negatively. All the goals are interconnected with the impact on one goal will have an impact on the other. Some goals like SDG 1, SDG 2, SDG 3, have seen a serious rollback in progress with more and more people losing livelihoods and slipping back into poverty, increased hunger crisis and insufficient healthcare system capacities. This has negatively impacted SDG 4, and in the long run, it will affect SDG 8 as the opportunities for decent work go down with a reduction in quality education opportunities. With the limited resources, capacities, and burgeoning crisis, the inequalities will increase for women and the poor, thus reversing the progress in SDG 5 and SDG 10. Some positive strides have been observed for SDG 7, SDG 11, SDG 12, SDG 13 and SDG 14 as the pandemic forced people to rethink the way cities were being developed and the lockdowns gave space for the environment to recuperate, the pressure on water life decreased as people become more conscious and responsible about their consumption and production. The pandemic also gave time to think and plan about the seriousness of the impending climate crisis. It brought to the forefront the weaknesses in current social, economic and governance systems of the world.

The COVID-19 experiences from various countries indicated that the more information we can access and analyze, the more effective nations we have. Therefore, it leads partners, including multilateral organizations and citizens, to explore and determine solutions for a disaster such as COVID-19 pandemic. This collaboration of partners requires several key components, such as existing and accessible geospatial information and the spatial data infrastructure (SDI) built. The geospatial information requires the integration of statistics and use it in various geography in a local, national, and global scale. We need technologies to demonstrate our geographic dimension on a global scale. It considers information that can be conveyed in a clearer and more useful manner than statistical data [38, 39]. In other words, we are fundamentally beyond the technologies and track platforms to enable visualization. This process relies on the people partnerships and the method of collaborations on how to build the ability to come together towards a shared purpose to remove barriers. However, the experiences of partnerships to data sharing of spatial information can also be considered to support COVID-19 response and recovery at this hard-pandemic situation and SDG2 2030.

We suggest empowering the implementation of geospatial technologies and methods such as Web App and Geo App. However, perhaps India requires speeding up to adopt these approaches. The adoption of spatial approaches such as Web App, Geo App, and smart mapping to spatial epidemiology, disease surveillance, and implementation of health policies in India has great potential for both success and efficacy. It is because India has a large population, ongoing public health challenges, and a growing economy with an emphasis on innovative technologies.

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41

The Value of a Policy-Responsive Research Funding Model: The Geohealth Laboratory Collaboration in New Zealand

Malcolm Campbell, Jesse Wiki, Lukas Marek, Matthew Hobbs, Matthew Wilson and Simon Kingham

This chapter discusses the GeoHealth Laboratory (GHL) research model that is based on a relationship contract funding model between two parties, the University of Canterbury (UC) and the New Zealand Ministry of Health (MoH) around health geography, spatial epidemiology, and Geographical Information Systems (GIS). Further, the GHL seeks to produce high-quality research (i.e. journal articles) and policy-relevant outputs (e.g. in the form of plain English reports) in the fields of health and GIS. The chapter discusses the nature of the relationship and funding model, with examples of research from the annual research programme. We conclude by showing the importance of flexibility in research funding models, using emerging exemplars of research related to the COVID-19 response in New Zealand.

41.1 What Is the GeoHealth Laboratory?

The GeoHealth Laboratory (GHL) is a collective of researchers interested mainly in Quantitative Health and Medical Geography, based at the University of Canterbury (UC), New Zealand. The GHL began in 2005 as a strategic partnership between UC and the New Zealand Ministry of Health (MoH) [1] that provides a resource that is unique in the Southern Hemisphere. The aim of the collaboration is to build a strategic partnership between the two parties around health geography, spatial epidemiology, and Geographical Information Systems (GIS). It seeks to produce high-quality research (i.e. journal articles) and policy-relevant outputs (e.g. in the form of plain English reports) in the fields of health and GIS. The GHL programme has published across a range of topics including: inequity [2], inequity of mortality [3, 4], oral health [5, 6], social connection [7], obesity [8, 9] and natural disasters and health [10, 11] to highlight a few key themes. Researchers from the GHL also have a longstanding interest in policy relevant or responsive research. This includes using spatial microsimulation, a modelling technique, to understand the impacts on government health policy [12, 13] as well as in a NZ context to understand the social and spatial patterns in obesity [14]. The GHL also aims to increase research capability through a program of research degree scholarships, primarily through the Masters of Spatial Analysis for Public Health (MSAPH[1]) and

[1] https://www.canterbury.ac.nz/study/qualifications-and-courses/masters-degrees/master-of-spatial-analysis-for-public-health/

teaching, for example, a course entitled 'Spatial Analytics for Health'. This has resulted in a series of skilled graduates who are now employed throughout New Zealand and overseas[2].

41.2 The Funding Model

The nature of the relationship between UC and MoH means that the collaboration between the parties is funded[3] in advance, much like a research programme with several project outlines included as indicative components of the overarching programme. Subsequently, the precise detail of the research and scholarship projects are negotiated and co-designed by both academic staff and MoH staff (who act as a project stakeholder). An important aspect of the GHL model is that the projects are subject to change if circumstances require. This ability to change the direction of a research project provides flexibility, meaning that as research priorities change, so too can the research projects and the precise topics investigated. Enabling changes to projects, without changes to the whole programme, reduces the bureaucratic overhead in contracting and bidding for individual research projects, focusing instead on rapid delivery of timely results directly to policymakers. Thus, the funder of the research benefits from the transfer of effort from managing and administration of the bureaucratic overhead (for both parties) to the delivery of research outputs. The nature of the high level of trust in our collaboration and the built-in flexibility of the contract is a stark contrast to conventional funding routes. UC contributes a proportion of the time of two Directors (note in New Zealand, 40% of an academic's usual role is related to research, 40% to teaching and 20% to administration) and hosts the laboratory space in which the GHL. A key strength of the GHL is the critical mass of academic expertise in GIS and health. Moreover, being located within the multi-disciplinary Geospatial Research Institute (GRI) provides an opportunity to develop geospatial research in aligned areas for which health is an important factor, such as in the area of hazards research. Having a critical mass of academics and researchers with similar interests means that there is the possibility of securing additional funding and resources beyond the principal funding streams that come from MoH and UC. Historically the GHL funded has included a range of sources such as the Health Research Council (HRC), NZ Transport Agency (NZTA), Foundation for Research Science and Technology (FRST), The Cooperative Research Centre - Spatial Information (CRCSI), and Ministry of Health's Environmental Health Indicators Programme.

41.3 The Work Programme

The original work programme for 2019/20 consisted of six projects that were co-designed with stakeholders on the following topics: transient populations, major trauma injuries, alcohol-related harm, mental health, maternity and disability. However, with the need to support the Ministry's response to COVID-19 the work programme was reviewed to enable rapid delivery of outputs relating to data supply and the visualisation of COVID-19 cases (see Figure 41.1) as well as the identification of vulnerable populations based on demographic factors. Additionally, a project on population mobility was designed that utilises nationwide mobile phone data to analyse mobility patterns before, during and after national lockdown measures were implemented. This provides important information about the extent of population compliance to lockdown measures and how this varies during different periods of pandemic policy and alert levels[4], particularly by geographic area and socioeconomic status. The project also aims to allow for a better understanding of mobility patterns between places using a combination of traditional data sources such as Census travel data

[2] https://www.canterbury.ac.nz/science/research/geohealth/ (See "Former Postgraduate Students").
[3] The GeoHealth Laboratory is funded by the New Zealand Ministry of Health until June 2021.
[4] https://covid19.govt.nz/assets/resources/tables/COVID-19-alert-levels-summary.pdf

and the aforementioned mobile phone data. The results of the project are still emerging, however, we have reported the changing spatial patterns in mobility across NZ as well as the social and spatial differences that relate to the socio-economic position of neighbourhoods across NZ The ability to be flexible with projects provided significant advantages, ensuring the GHL work programme met the immediate and changing priorities of MoH.

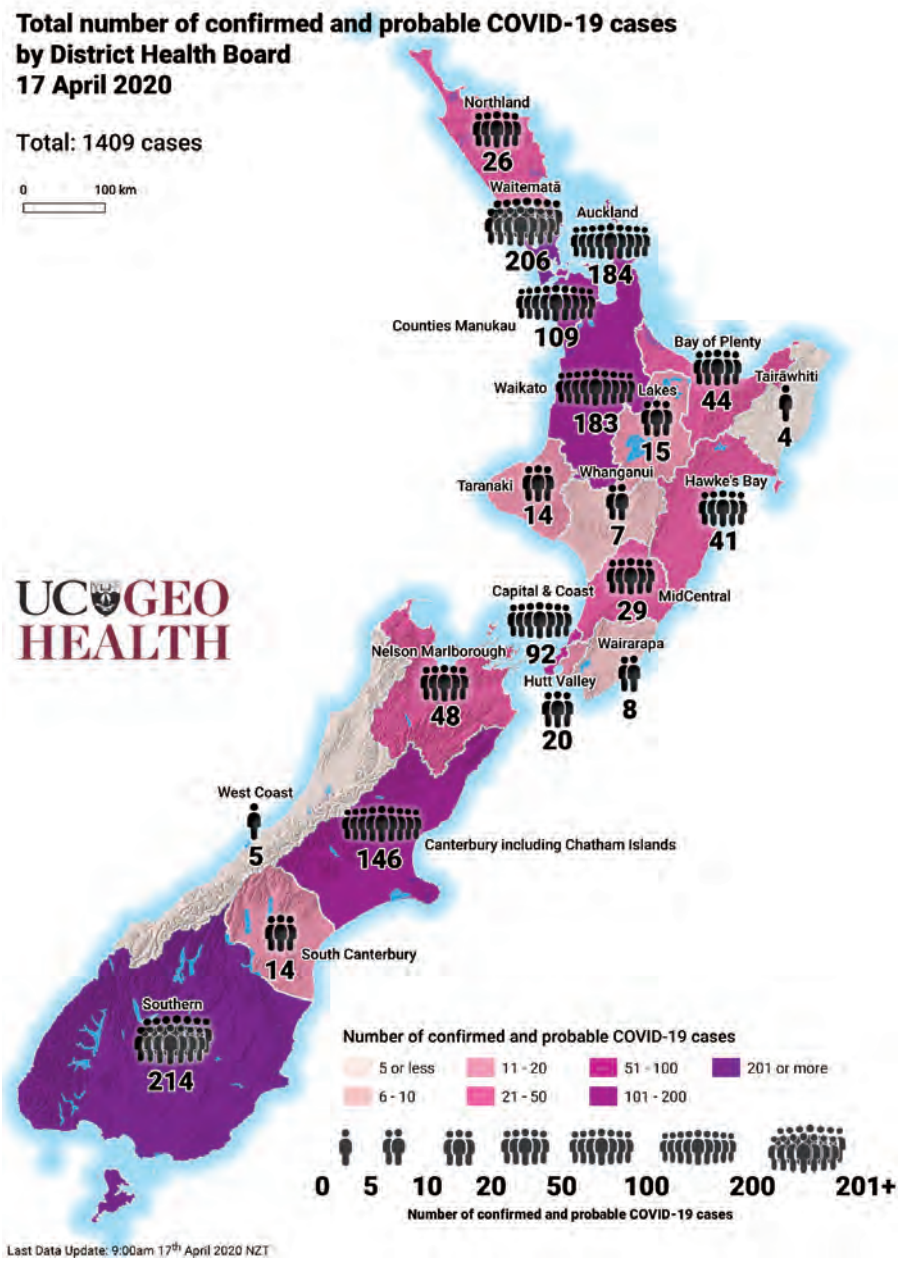

FIGURE 41.1
Spatial distribution of COVID-19 cases in New Zealand. 17 April 2020.

41.4 Conclusion

The key lessons learnt, from our observation and experience is that by utilising a relationship contract, rather than a project-based contract has particular advantages in times of significant disruption, especially when flexibility and responsiveness are required at short notice. Specifically, the ability to change projects which are valuable in the long term, but have no immediate urgency when compared to the rapid response needed for the COVID-19 pandemic. A project-based funding model is not as resilient or flexible to external events that require, or indeed that would benefit from a change in project scope. The GHL model mitigates this risk and allows the opportunity for research capacity to be redirected. Additionally, the GHL model is also more robust even when anticipated changes create a need for a change in projects and priorities. We would further argue that thinking about a relationship contract approach is particularly salient for those who contract and fund research due to the points discussed above. In a time of a pandemic, particularly in New Zealand, we have demonstrated that having skilled researchers and a flexible funding model produced an important contribution to national efforts to better understand and tackle COVID-19, thereby enhancing community resilience.

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42

Pandemic and the City: A Melbourne Perspective for Community Resilience

Mark Allan

Melbourne, Australia's most liveable city, has endured the nation's most severe lockdown measures as it plans for revitalisation. This chapter provides a snapshot of trends affecting generalised measures of liveability prior to and during COVID-19, and beyond. Collaboration between authorities and citizens is required for resilience and on-going adaptation.

42.1 Introduction

The coronavirus COVID-19 pandemic is a global crisis, it has taken lives and impacted the economies of developed and developing nations. Its impact on cities, in particular, has been unprecedented, requiring us to rethink ideas about sustainable built environments, urban proximity, density, and mobility. This paper presents some observations about Melbourne, a city with an enviable reputation for liveability and its response to COVID-19 and a future of co-existence with the pandemic.

Soon after the World Health Organisation's declaration of the COVID-19 pandemic in mid-March 2020, the Australian government implemented a program of financial support combined with travel restrictions, social distancing and other 'lockdown' measures. These restrictions generated considerable economic uncertainty and social anxiety in towns and cities across the country affecting households, government, and industry. By the end of June 2020 Australia's lockdown measures were showing comparative signs of success with some 7,008 people having recovered from the 7,767 reported cases of COVID-19 [1]. At about this time with states and territories reporting no new cases or small numbers restrictions began to be eased. In Melbourne, however, a second wave of COVID-19 emerged in July 2020 likely from a failure to adhere to hotel quarantine protocols. Community transmission of infection saw new daily case numbers rise from 15 to 20 in mid-June to over 600 by early August [2]. This led to stronger Stage 4 restrictions being introduced across metropolitan Melbourne for a six-week period on 2 August 2020, later extended. Server restrictions were also placed on movements between across state borders. During Stage 4 a curfew was put in place between the hours of 8pm and 5am requiring people to stay at home during these hours unless for work, medical care and caregiving. Face coverings were mandated when leaving home which was only allowed for permitted work, or to either exercise for up to one hour per day or for a sole member of each household to shop for food or essential items within a 5 kilometre radius of home. On 6 September 2020 'Victoria's Coronavirus (COVID-19) Roadmap to Reopening' was announced by the state's Premier. The 'Roadmap' sets out a four-step process to ease restrictions across Victoria staging expanded social interaction, and phasing in a return to

the workplace, education, sport, recreation, ceremonies, and special occasions. The 'first step' is scheduled to commence on 13 September 2020 with the 'last step' targeting 'COVID Normal' after 23 November 2020 subject to 'trigger points and public health advice'.

42.2 Growth of Inner-City Melbourne

Melbourne is a global and liveable city known for its multicultural diversity and its cosmopolitan inner urban core. Recognised by the Economist Intelligence Unit as 'the world's most liveable city' for seven consecutive years (2010-17) and currently ranked number two, it has a legacy of leading international liveability rankings [3]. Melbourne's inner-city communities' express cultural diversity and creativity, home to major universities, hospitals, parks and gardens. The city hosts the nation's major sporting and entertainment events and its vibrant laneways and café culture draw international tourists and visitors. Melbourne is Australia's fastest growing city and its inner area is the nation's most densely populated area with 21,900 people per km^2. In 2018-19 Melbourne's population grew by 2.3% to 5 million people fuelled by net overseas migration it was forecast to grow to 7 million by 2030 outstripping Sydney as Australia's largest city [4]. The ABS forecast net overseas migration to Melbourne will fall by 85% over the next 12 months.

42.3 Reshaping Cities

As we look to Melbourne for some contemporary lessons of resilience it is worth remembering that epidemic diseases have plagued, shaped and reshaped cities for millennia. The City of London responding to the great plague of 1665 enacted municipal orders quarantining 'infected houses' mandating inspections, requiring extra cleaning of housing and streets, restricting assemblies at theatres, and implementing trade embargos [5]. Responses to a succession of epidemics has profoundly shaped cities, housing forms, human behaviours, communications, and urban living environments. The reality of co-existing with COVID-19 and a succession of future pandemics will challenge how we plan, design and manage people-centric cities, public spaces and spatial connections in the context of epidemiological measures to control the spread of infectious diseases.

42.4 Melbourne's Response to COVID-19

The lockdown measures introduced in response to the first and second waves of COVID-19 in March and July 2020 have severely impacted inner Melbourne's visitor economy, international education, and the services economy. Melbourne's population increase was immediately halted and the number of weekly payroll jobs in central Melbourne significantly reduced. The million daily visitors to Melbourne's Central Business District (CBD) reduced more than 30% as international students and professional service workers stayed home and retail premises and hospitality venues closed. Weekday road traffic levels across Melbourne were down and pedestrian movements around train stations in central Melbourne were down by up to 42% in July [6]. The Melbourne City Council reported the average number of pedestrians in Bourke Street mall dropped from an average of 25,000 to 6,476 per day with an estimated 1 in 3 shops closed or vacant. Vacancy rates for CBD offices typically at 5% rose sharply to 7.6% in March, with real estate agents reporting student accommodation occupancy-rate falls in inner Melbourne of between 20% and 50% [7]. The immediate response gave priority to health and wellbeing, emergency accommodation was provided to the homeless and city

cleaning regimes increased. In addition to financial loans and grants to small business, economic stimulus projects are planned to include infrastructure, housing and construction and affordable housing. Inner Melbourne fast tracked approvals for 12 km of temporary cycling lanes and has committed to plant 150,000 trees, shrubs and grasses (an increase from the 3,000 planned) [8]. The importance of high-quality public realm and open spaces for people to safely exercise and enjoy fresh air has been underscored during the pandemic.

42.5 Impacts of COVID-19 on Central Melbourne's Liveability

The observations presented in Table 42.1 are grouped into categories using headings form the seven targets in the United Nations Sustainable Development Goal Number 11 (SDG 11) for 'Sustainable Cities and Communities'. The SDGs comprise 17 global goals with interrelated targets and indicators aimed at delivering globally sustainable development by 2030 [9]. Table 42.1 presents a 'snapshot' of trends affecting generalised measures of Inner Melbourne's liveability immediately prior to COVID-19, during and potential future responses. Movements are summarized by symbols, upward and downward 'arrows' or a neutral 'square' with traffic light colours green, red or amber indicating positive, negative or neutral impacts on liveability.

42.6 Planning to Co-Exist With COVID-19

The trends summarised in Table 42.1 reflect optimism in the people of Melbourne's resilience and capacity to respond to both the current and the future impacts of the COVID-19 health and economic crisis. Reduced housing demand will place negative downward pressure on property prices, however, this will ease rental costs and increase affordability in some locations. While intimate partner violence and social isolation has generated social hardship during the pandemic increased mainstream media attention has helped raise public awareness and prioritised the importance of good mental health and public policy. A reduction in traffic congestion is expected to continue with less commuting by those with the flexibility to work from home. Fewer public transport trips, capacity constraints and increased cleanliness will necessitate revised pricing, implementation of new technologies and changed operations likely to reduce future investment. The design and management of buildings and public spaces will see a greater emphasis on human health and wellbeing. Spaces will need to be adaptable and able to accommodate physical distancing as demand for flexible outdoor spaces increases. Digital communications will play a larger role in connecting people and maintaining social ties.

The short-term halt in Melbourne's rapid population growth in the view of Professor Giles-Corti of RMIT University provides an opportunity for the state's planners to recalibrate how Melbourne grows and to better integrate urban development and infrastructure provision for a more sustainable city [10]. This may also assist planners to implement urban policies embracing of 'local liveability' including '20-minute neighbourhood'. This concept prioritises local transport and jobs with high quality public realm connecting services so that people's daily needs are met within a 20-minute walk from their home [11].

The built environment has a key role in developing the health and wellbeing of communities and responding to impacts of climate change. During the COVID-19 pandemic communities in cities like Melbourne have rapidly embraced working from home, video conferencing for education and tele-medicine and increased online shopping. Rethinking our cities as healthy places will likely increase the cleanliness of public transport and change the way we move about the city and interact socially in terms of proximity and density. Delivery of urban strategies to reallocate road space to create wider footpaths and more bicycle lanes combined with increased tree planting and public

space and other investments in the public realm offers real potential to improve the mental, physical and immunological health of communities.

TABLE 42.1
Inner Melbourne Liveability, Trends in Response to COVD-19

Legend: ▲ Positive upward; ▼ Positive downward; ■ Neutral; ▲ Negative upward; ▼ Negative downward

Category	Pre-COVID-19 Trends	2020 Response/Trends	2022+ Response/Trends
Safe, Affordable City (Refer SDG11 Target 11.1)	▲ Rapid population & housing demand ▼ Affordability ▲ Homelessness ■ Real & perceived personal safety ▼ Access to services in car dependent low-density outer suburbs	▼ Population growth & migration halted ▲ Protection for tenants & economic stimulus ▲ Emergency homeless accommodation ▼ Vacancy rates ▲ Intimate partner violence	▼ Housing demand ▲ Supply of affordable & crisis housing ▲ Repurposing existing buildings for new uses ▼ Property prices/rents ▲ Safety, with metropolitan wide access to on-line health & other services
Mobility & Accessibility (Refer SDG11 Target 11.2)	▲ Overcrowded public transport (demand) ▲ Major projects including Melbourne Metro in construction ▲ Traffic congestion ▲ Bicycle culture	▼ International & national travel ▼ Reduced commuting, public transport trips & CBD pedestrians ▲ Local walking, cycling, home deliveries	▲ Private vehicle trips ▼ Commuting ▲ Bike paths ▲ Safer, cleaner public transport, touchless operations ▼ Investment in public transport
Land Use Efficiency (Refer SDG11 Target 11.3)	▲ Rapid expansion urban footprint ▲ Inner city café culture & online retail ▲ Medium density housing ▼ High-rise apartments ▼ High Street retail	▲ Temporary on-street bike paths ▼ Visits to retail, cafés & entertainment venues ▲ Construction hours ▲ CBD parking fines temporarily halted ▲ On-line retailing	▲ Reallocation of road space to wider footpaths & bike lanes ▲ Outdoor dining, retail pop-ups & markets ▲ Medium density housing aids 20-min n/hoods ▲ On-line services & retail
Cultural & Natural Heritage (Refer SDG11 Target 11.4)	■ Australia's cultural & sporting capital ▲ Support Aboriginal reconciliation	▼ Visits to public buildings, libraries, galleries, public space ▲ On-line/virtual tours	▲ Virtual tours ▲ Technology supports social distancing & crowd management

TABLE 42.1
Continued - Inner Melbourne Liveability, Trends in Response to COVD-19

Legend: ▲ Positive upward; ▼ Positive downward; ■ Neutral; ▲ Negative upward; ▼ Negative downward

Category	Pre-COVID-19 Trends	2020 Response/Trends	2022+ Response/Trends
Human Health & Wellbeing (Refer SDG11 Target 11.5)	■ Liveability ▼ Youth mental health ▲ Health impacts of drug & alcohol, intimate partner violence ▲ Isolation &loneliness	▼ Jobs ▲ Employment benefits ▲ Working from home ▲ Restrictions on sports & entertainment ▲ Drug & alcohol use, intimate partner violence & isolation	▲ Workplace flexibility, home/office allows more leisure time/less commuting ▲ Technology to support social connections & physical distancing ▲ Mental, physical & immunological health & desire for social connection
Healthy Environment (Refer SDG11 Target 11.6)	▲ Value of green buildings & interest in well buildings ▼ Policy coordination	▼ Public health rules, physical distancing ▲ Increased on-street cleaning, cleaner air	▲ Urban resilience & 20-min neighbourhood ▲ Healthy buildings, better ventilation & materials
Sustainable public open spaces (Refer SDG11 Target 11.7)	▲ Demand for public space to support higher density housing ▲ Pressure on existing public spaces through high levels of usage ▲ Urban forest strategies	▼ Playgrounds & exercise equipment ▼ Use of parks & public open spaces, restricted street furniture ▲ Social distancing & short stay less than 15-minute visitation	▲ High quality, safe inclusive public space ▲ Digital tools to manage & for placemaking ▲ More trees planted ▲ Adaptable use of space at different times
City planning & urban policy (Refer SDG11 Targets 11.a, 11.b & 11.c)	▼ Planning system capacity to manage rapid urban growth ▼ Capacity to deliver infrastructure, transport, health, education	▲ Future city taskforces prepare action plans ▲ Whole of government approach ▲ Prioritised resilience projects ▲ Stimulus projects	▲ Focus on city planning (resilience/pandemics) ▲ SDGs framework for sustainability ▲ Community capacity building

Melbourne has experienced significant downturns in its visitor economy, international education sector and its services economy due to the pandemic, exacerbated by Victoria's second wave of COVID-19 and hard lockdown measures introduced in August 2020. The economic adversity forecast, and currently affecting Australia has hit hardest in Victoria and most severely in the state's capital city. Since mid-March 2020 when the pandemic emerged in Australia until late August 2020 payroll jobs fell 4.2 per cent nationally, in Victoria this figure was 7.9 per cent [12] resulting in significant hardship for many households. To date Victoria's response to COVID-19 has been based on health advice and statistical modelling adopting a policy of aggressive suppression to avoid restrictions being continuously lifted and reinstated.

The conditional phased easing of restrictions outlined in Victoria's 'Roadmap to Reopening',

September 2020, outlines public policy settings that balance human health priorities with the staged reopening of the state's economy. In addition to financial support for business and individuals, approvals for construction projects and delivery of national and state government services have been fast-tracked. Underpinning business and streamlining service delivery has also occurred at a local government level including plans for localised urban interventions and public realm improvements to revitalise city centres. In Melbourne streets, footpaths and parking bays are being converted for use as outdoor dining areas seating patrons at a safe distance as part of a staged return of people and strategies to revitalise the city.

Valuable lessons have had to been learnt quickly about how to plan, organise, and administer our city and safeguard citizens during a global pandemic. This awareness is important now and in the future as policies and action plans are developed to promote urban resilience to protect and improve human health and well-being. With Victoria now in economic recession, the outcomes of the serve lockdown will test the resilience and liveability of Melbourne as its capital. Just as Melbourne has responded to crises and economic downturns in the past, its social and physical infrastructure combined with the patience, optimism and creativity of its citizens, means it is well placed for a future that accepts and embraces reactivation and on-going adaptation.

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43

Spatial Modelling Concepts for Controlling COVID-19 Risk in Saudi Arabia

Hassan M. Khormi

Location and time are important in controlling diseases. This chapter aims to explain how the Saudi authorities implement GIS concepts in controlling the spatial risks of COVID-19. In Saudi Arabia, the impact of COVID-19 is still limited, as the total number of infections did not exceed 74,795 confirmed cases until 25 May 2020, of which 45,668 (61% out of the total cases) have recovered. This chapter shows regions with high risk and very low risks as well as spatial disease distribution in SA regions. Ar Riyad (17,656 cases), which includes the capital city of SA, Makkah (29,436), Almadinah (9,751), and Ash Sharqiyah (14,012) are the most impacted regions as they recorded most of the cases with 70,855 (95%) out of the all confirmed cases. Those spatial information must be presented on a different spatial scale, such as city, district, sub-district and house level. Many mobile-based map applications are developed by the Ministries of Health and Interior to, for example, provide insights about disease distributions, help people to find transport during the times of isolation, and show the locations of services, hospitals, etc. These applications are meant to help monitor the impact of the outbreak, manage it, communicate with the security and health services, and help allocate resources, which will help society and institutions to respond effectively.

43.1 Introduction

The incidence of COVID-19 started when the virus moved from animal to human populations [1]. The main mode of transmission is from the respiratory tract via droplets or indirectly via fomites and, to a lesser extent, via aerosols. This disease is considered by the World Health Organization (WHO) to be one of the most important and impactful globally. It has been recognized as the most prevalent viral disease in all places around the world [2]. Associations between the incidences and environmental, meteorological and socioeconomic conditions are not yet clearly understood [3]. That makes it difficult to model its risk spatially using GIS. The transmission patterns of the diseases are sensitive to social factors, such as population density, habits, practices, as well as customs and traditions giving rise to occasions and gatherings. This chapter aims to explain how the Saudi authorities implement GIS concepts in controlling the spatial risks of COVID-19. It also shows the current spatial distribution of the disease in Saudi Arabia (SA), with most infected groups according to their nationality, sex and age. Three key factors stand out when looking at COVID-19: human, space (location) and time. When a person gets infected, there is a person involved, and this determines the diseases one gets infected with. Then there is the location, the position on the earth's surface where the event occurred. This position can be accurately located using GPS.

The location can be used to extract environmental conditions and meteorological variables of areas related certain human practices and people gathering. Time of infection gives valuable information about when the infected person is active and his historical movements. Together with location, time allows one to develop a spatio-temporal picture of the event, and this aspect is extensively used in public health modelling [4].

43.2 GIS-based Mapping and Modelling

When we map or model a disease, we take into consideration that everything is related to everything else but near things are more related than distant things [5]. In other words, a person infected with COVID-19 or environmental and climatological conditions closer to an impacted community or disease occurrence should be more conducive to the survival, reproduction and transmission of the virus than conditions further away. This suggests that a study of the geographical location of pathogens and vectors, host interaction, environmental and climatological variables and proximity to human or animal victims is paramount in understanding disease patterns. Spatial analysis answers questions such as what types of habitat that contain the virus, how far the virus's host travels, what populations live in zones of high or low occurrences and what other regions have conditions similar to those where the hosts are currently found and should so be denoted as high-risk areas.

The accessibility of geo-referenced COVID-19 data is of significance in mapping the disease and linking it to environmental or social risk factors. The geographical spreading and seasonal behavior of the disease, as well as its transmission and abundance, are controlled by environmental (such as land use, land cover, elevation) and climatological variables (such as temperature, rainfall, degree days and humidity). Visual displays of quantitative data, such as cases of infections, on cartographic maps for understanding causes has a long history. The best-known example is that of Dr. John Snow and the cholera deaths of London in the mid-nineteenth century [6]. The visualization of spatial epidemiological data on a background of environmental or climatological layer enables one to discern patterns and correlations. Early disease mapping methods were mainly used for communicable diseases to identify sources of infection, rates of spread and general environmental variables present at those sites [7].

43.3 The Current Spatial Distribution of COVID-19 in Saudi Arabia (SA)

In Saudi Arabia, the impact of COVID-19 is still limited, as the total number of infections did not exceed 74,795 confirmed cases until 25 May 2020, of which 45,668 (61% out of the total cases) have recovered. The numbers indicate that males were more at risk of contracting the disease than females. Since the infection started spreading in the country, between 70 and 80% out of the total recorded cases were male. This is due to the culture of mobility and interaction between men compared with women and the fact that women are more likely to apply the culture of guarding against disease risks and to adhere to regulations and laws targeted at curtailing diseases. But another important reason is that most cases in the Kingdom were recorded between employees of certain companies. So cases involving non-Saudis are around 55% to 65% of the total recorded since the beginning of March 2020.

The majority of company employees in Saudi Arabia are males and are mostly citizens of East and Southeast Asia, Pakistan, Bangladesh, and some Arab countries, such as Egypt and Sudan. Some companies, especially those that did not observe the precautionary measures or who delayed in applying them in their premises, were more likely to see infections among their workers. Also, the

educational and income levels of these employees are low, which required the health and municipal authorities to intervene and provide accommodation to achieve social distancing and create a better precautionary environment. The government decided to supply healthcare and COVID-19 testing for free to all non-Saudis. These steps have a significant impact on reducing the infection rate among workers.

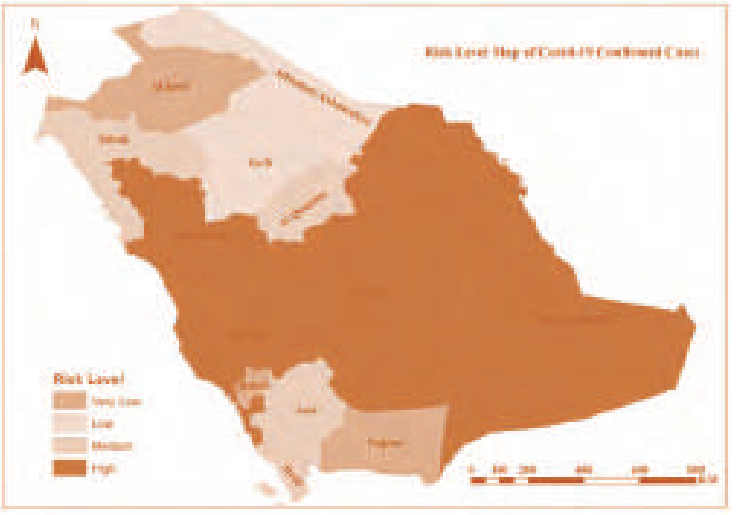

FIGURE 43.1
COVID-19 risk level and spatial distribution in SA regions (Data Source: Saudi Arabia Health Ministry)

Figure 43.1 shows regions with high risk and very low risks as well as spatial disease distribution in SA regions. Ar Riyad (17,656 cases), which includes the capital city of SA, Makkah (29,436), Almadinah (9,751), and Ash Sharqiyah (14,012) are the most impacted regions as they recorded most of the cases with 70,855 (95%) out of the all confirmed cases. The very low-risk areas are regions that recorded less than 150 cases. Those regions are Al Jawf (84 cases), Najran (147), and Al Baha (148). These numbers show the limited impact of COVID-19 across Saudi Arabia compared with other countries that registered similar numbers daily.

In SA, the deaths have not exceeded 400 since the emergence of the disease. The Makkah region obtained the highest rate of the deaths with 75%, followed by Almadinah (44 deaths), Ar Riyad (24), and Ash Sharqiyah (22). Most of the deaths were related to cases of people with underlying chronic medical conditions, such as diabetes, kidney failure, chronic lung disease, and deficient immune systems. Other regions recorded between zero and four cases of death. Once again, these figures show the minimal impact of the disease in Saudi Arabia compared with other countries around the world that recorded thousands of deaths in one day.

In general, the reason behind the limited negative impact of the disease in Saudi Arabia is the early measures taken by the authorities. That started with the formation of a higher committee headed by the Minister of Health and with the membership including a number of educational, research, service and security sector personnel to review international events related to the disease and assess the current conditions, make reference comparisons and gather experiences to address the disease, especially from countries that had already been ravaged by it.

At that time, the Saudi authorities began gradually isolating a number of the most affected neighbourhoods, then cities. Then they began closing international entry points and finally proceeded to completely isolating all Saudi regions. In all those steps and actions taken by the authorities, the geographical concepts were present, starting from determining the geographical location of the infected person, the relatives and friends of that person, the geographical locations of their movements, determining the boundaries of the closed neighbourhoods, setting a map to be

used by the public, and determining on the maps the ports to be used for entering and exiting the isolated areas.

There is high awareness as to the use of GIS in all aspects of disease surveillance and system control. The Saudi Health Ministry developed many mobile applications and a GIS platform for uploading and illustrating locations and data of, for example, confirmed, active and recovered cases based on small and large geographical scales to present the events on house (point) (Figure 43.2A), sub-district, district, county, region and country (Figure 43.2B).

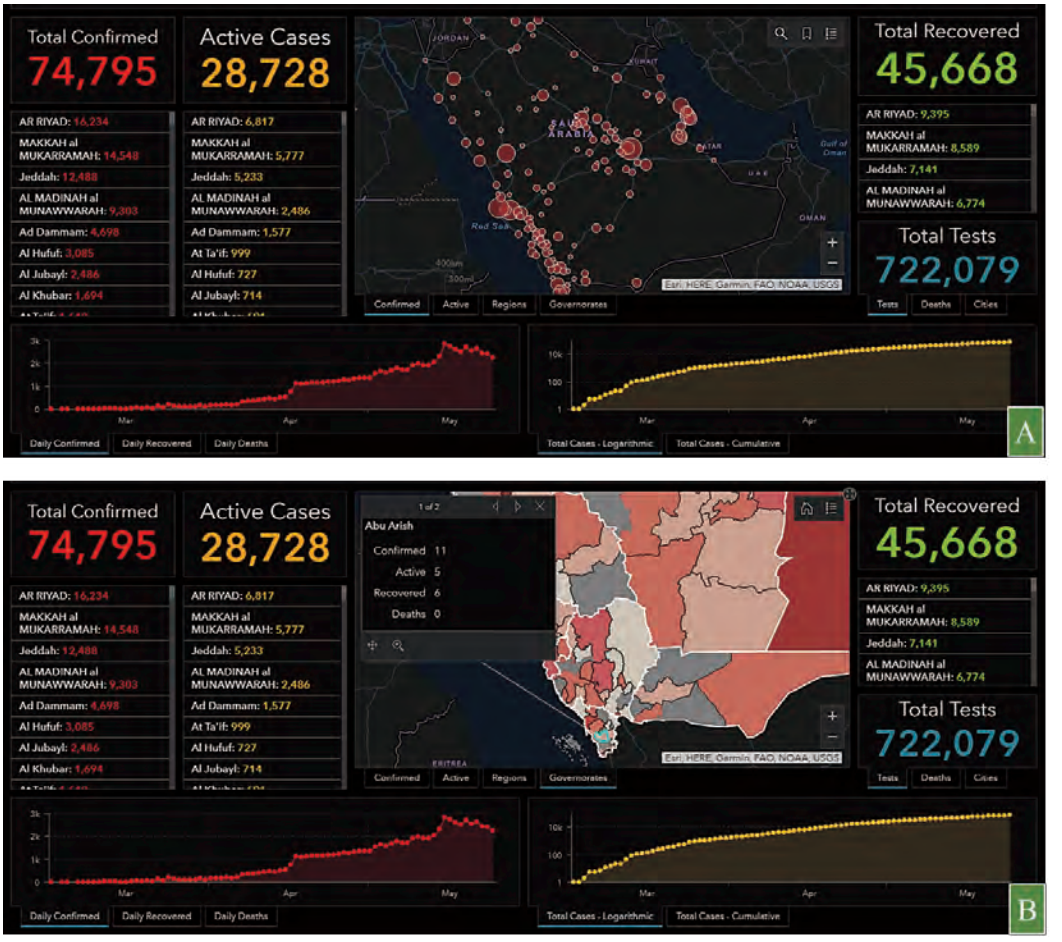

FIGURE 43.2
Interface of GIS platform developed by the Health Ministry to show daily spatial distribution and information of COVID-19 (https://covid19.moh.gov.sa/)

This GIS-based system can go far beyond the early studies on establishing correlates. So the main purpose can be enhanced to describe the geographical differences in disease occurrence for formulating aetiological hypotheses. Also, the system locates unusual high-risk hotspots to develop a preventive plan. Another purpose is to improve the reliability of disease risk models for allocating resources. Moreover, the system can undertake sophisticated spatial analyses of environmental features and disease rates, together with geostatistical analysis to statistically verify associations [8–10].

43.4 Conclusion

The spatial information must be presented on a different spatial scale, such as city, district, sub-district and house level. Many mobile-based map applications are developed by the Ministries of Health and Interior to, for example, provide insights about disease distributions, help people to find transport during the times of isolation, and show the locations of services, hospitals, etc. The main purpose of these applications is to help monitor the impact of the outbreak, manage it, communicate with the security and health services, and help allocate resources, which will help society and institutions to respond effectively. Accordingly, we summarize the aforementioned in this scientific paper to avoid the effects of the COVID-19 epidemic quickly. Immediate plans should be developed for the danger areas in your environment through several steps relying on GIS. The most important of these steps is to map the confirmed and active cases, deaths and retrieval operations to determine the whereabouts of the COVID-19 infections and to update the records continuously. Mapping the spatiotemporal distribution of the disease can reveal how the infection has spread over time and where you might want to target the interventions. Publishing a map of at-risk populations will provide information about how COVID-19 will unevenly affect some demographics, such as the elderly and those with chronic diseases as well as non-Saudi workers. Mapping social vulnerability, age and other factors also helps to monitor groups and areas at risk. It is important to map national capabilities and facility locations, such as a map of facilities, health providers, medical resources, equipment, goods and other services to understand and respond to the current and potential impacts of COVID-19. Interactive web maps, dashboard apps, story maps and historical tracking can be used to help quickly communicate with people about the national situation so everyone will be aware of all the procedures.

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44

COVID-19 in Spain and the Use of Geospatial Information

Carmen Femenia-Ribera and Gaspar Mora-Navarro

Spain declared a state of emergency on 14 March because of the serious situation due to COVID-19. Three months later there were more than 27,000 confirmed deaths due to the virus. During this period there were many initiatives using geospatial information to predict, follow, and detect infections, as well as control mobility. These measures were implemented by the central government, as well as regional governments and local councils. Most of these geospatial applications use open-access geospatial information that reuse public sector information and add value to this data. In this way, open data supports decision-making by the administration. Numerous thematic maps, spatial analyses, geoportals, websites, and mobile applications have recently appeared; and never have so many boundary maps have been published in the Spanish media. Geospatial information in Spain is likely to continue playing an important role as the pandemic evolves, and greater resilience is needed to address this and future challenges.

44.1 COVID-19 and the State of Emergency in Spain

Spain has been a member of the European Union since 1986 and is located in the southwest corner of Europe. The nation has an area of 505,944 km^2, 4,964 km of coastline, and a population of 46.5 million. Spain has the world's 15^{th} largest economy (2019) in terms of gross domestic product according to the International Monetary Fund, and is the world's second most popular nation for tourist visits (2018) according to the World Tourism Organization.

Spain has a central government, 17 regional governments, and 2 largely self-governing cities on the Mediterranean coast in Africa. The nation is also divided into 50 provinces and there are 8,125 local councils.

For geographical information, the main national organisation is the National Geographic Institute (IGN) ("Instituto Geográfico Nacional, IGN," [1]). All of the national territory is mapped in digital format. Spain also has orthophotographs of the entire nation as part of the Aerial Photography National Plan (PNOA) ("Plan Nacional de Ortofotografía Aérea, PNOA," [2]). The Spanish Spatial Data Infrastructure (IDEE) ("Infraestructura de Datos Espaciales de España, IDEE," [3]) centralises the geographical information of the regional governments and local administrations in line with the European INSPIRE Directive. The regions also have their own cartographical institutes. Cadastral maps are made freely available through the Electronic Office of Cadastre (SEC) ("Sede Electrónica del Catastro, SEC," [4]) of the Directorate General for Cadastre (DGC) ("Dirección General del Catastro, DGC," [5]), as part of open data policies, and policies for the reuse of Spanish public sector information.

Spain was the country most affected by Covid-19 after China and Italy. The virus started to be noticed early in February, with the first cases in the Canary Islands towards the end of January. A state of emergency was declared on 14 March. At that moment, the central government assumed all relevant powers and residents were quarantined in their homes. On 14 March the number of infected people was 5,753, and there were already 136 deaths, according to the health ministry. Just three months later, on 14 June, the total number of notified cases was 244,109 and there had been 27,136 deaths. Madrid and Barcelona were the worst affected cities. Forty new cases of infections were notified on the last day of nationwide quarantine (14/6/2020) with 25 deaths in that week. At that moment, the virus was considered controlled in Spain, with only small localised infections remaining. The highest point of the infection curve was at the end of March and the beginning of April. On 1 April there were 930 deaths ("Enfermedad por nuevo coronavirus, COVID-19," [6]).

The state of emergency lasted just over three months (from 14 March to 21 June). At the end of the state of emergency, the central government returned powers to the regional governments. During this period, a four-stage plan for a transition to a new normality was introduced. Each stage lasted about two weeks. During these stages mobility was controlled to avoid the spread of the virus, and the borders between counties, regions, provinces, and local councils become very important – together with the associated geographical information ("Estado de alarma y Nueva normalidad. Medidas crisis sanitaria COVID-19," [7]).

44.2 Geospatial Information Use

Geospatial information has been fundamental from the first signals of infection. The regions sent daily numbers for infections, deaths, and recoveries for each province. That information could be seen on choropleth maps.

This type of map was also frequently used in the transition to a new normality, where the stage for each province was indicated. Each stage depended on the provincial sanitary conditions, and each stage meant different mobility restrictions. At the beginning, the areas of control were the individual hospital authority areas, but this idea was abandoned because it was too difficult for the police to control inter-regional mobility as the exact hospital areas boundaries were not well known.

The Spanish provinces were then used as the basic units for controlling mobility. However, the municipality boundaries were also used in stage 0 (started on 2 May). In stage 0, mobility was only allowed inside each municipality. People were allowed a daily walk within a one-kilometre radius from their homes. Numerous mobile applications showed a circle with a one-kilometre radius centred on the user's home. These applications were launched by both public and private organisations [8].

Many tools appeared that used geographical information to control mobility after quarantine, as well as track the contacts of infected people. These applications included mobile applications, geoportals, thematic maps (choropleths, point, heat maps, and so on); and were used at national, regional, and local levels. Many of these applications employed free and official open access digital map data.

Due to the seriousness of the pandemic, and the enormous importance of spatial data infrastructures in the management of the crisis, it was considered necessary to allow access for all resources that could be useful in fighting the pandemic. At a national level, there is a collection of open resources on Covid-19 in the IDEE website. In this collection, there is an index list of data published by international, national, and local administrations ("Infraestructura de Datos Espaciales de España, IDEE. Recursos abiertos sobre la COVID-19," [3]).

This information is mainly organised by regions. The geoportal of the Spanish Terrestrial Transport General Directorate shows maps of tourist accommodation, restaurants, shops, rest areas, and take-away restaurants near to main roads – all of which have been obliged to remain open. These maps facilitated the location of supplies for workforces and enabled the main national services to remain supplied ("Punto de Información de servicios de restauración," [9]). The Ministry for Ecological Transition and Demographic Challenge also published a map with open petrol stations.

Figure 44.1 shows an example of a regional COVID-19 geoportal. The geoportal monitors the pandemic situation in the region of Valencia. The geoportal has been developed by the Valencian Cartographic Institute (ICV) ("Institut Cartogràfic Valencià, ICV," [10]), using ESRI technology and open data from the regional health authority [11]. It shows the spatial distribution of the pandemic and information is updated daily. It was started on 11 April and initially showed the 24 sanitary boundaries within the region. Municipal boundaries were not initially included to avoid stigmatising any towns or cities. This information was later included when the pandemic came under more control.

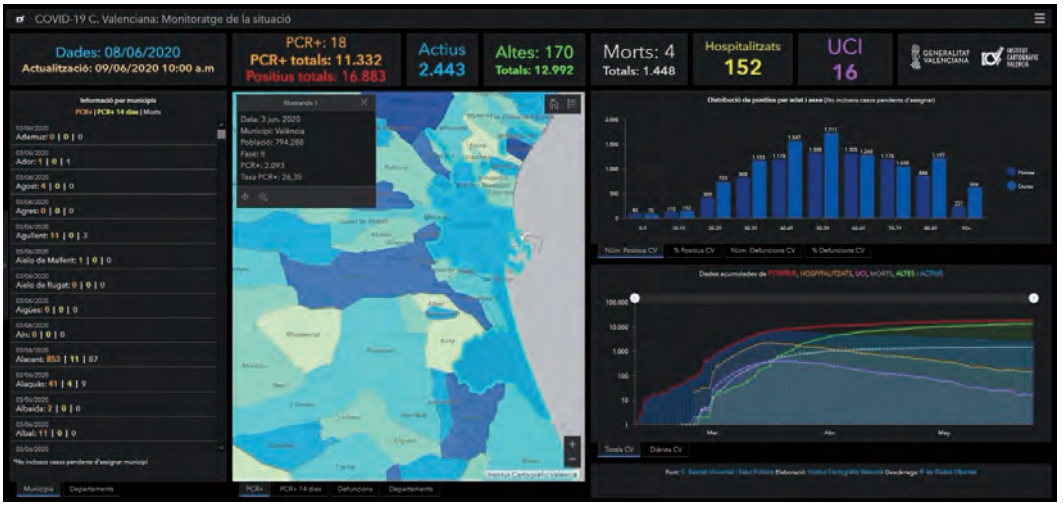

FIGURE 44.1
Geoportal to Monitor the Pandemic in the Valencia Region. Source: [11]

Some cadastral offices worked with regional governments to map the location of strategic facilities such as public sport centres or schools.

Eurostat (the Statistical Office of the European Union) performed a spatial analysis to detect risk areas, using population data, combined with the European healthcare services dataset [12], transport networks, and cadastre addresses.

Universities performed spatial analyses to calculate, for example, the most vulnerable provinces (using the population density, risk population indices, and especially the layer of interest points, like hospitals, pharmacies, and supermarkets). Universities also made a predictive analyses.

There have also been many relevant mobile applications developed in both the private and public sectors, as well as by universities. Most of these applications use GNSS and the objective is mainly to help people to avoid crowds. The usefulness of these applications is conditioned by the number of users who install them and share their locations. Councils have developed applications to control access to public spaces and facilities, as well as beaches and pools. Some use drones and image analysis to automatically count people in open spaces. The main goal is to ensure the safety of tourists who mostly come to Spain looking for sunshine and sand. Private companies are developing these types of application and selling them to public administrations.

Telecommunication companies exceptionally made their customer mobility data available to the central government to control infections, despite the geolocation of user mobiles phones colliding with privacy policies. Currently there is an ongoing discussion about privacy rights in the Data Protection European Commission.

44.3 Conclusions

- Never before have so many boundaries maps been published in the Spanish media.
- Free and open access to geospatial data enables the development of many applications in private as well in public sectors – emphasising the value of geospatial data.
- Many ministries manage spatial information: including industry, health, transport, mobility, and ecological transition.
- Standardised geospatial information in the European framework enables spatial analysis using big data.
- User geolocation obtained from smartphones causes privacy problems that must be examined and clarified.
- Thematic maps, spatial analysis, geoportals, big data, GNSS, and drones are words linked to geospatial information that have frequently appeared in the media during this crisis.
- Geospatial data enables predictive analysis, tracking infected people, and statistical studies that support decision making by public administrations.
- Geospatial information in Spain is likely to continue playing an important role as the pandemic evolves.
- Updated and quality geospatial information is necessary to improve community resilience and respond to possible outbreaks and future crises.

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45

Lessons Learned from COVIDSafe: Understanding Conditions for Successful Implementation of Track and Trace Technologies

Nathaniel Carpenter and Anna Dabrowski

Digital track and trace works not just because of cutting edge technology, but because of public trust – a key condition for its utility. We have seen that trust is fundamental to other government COVID-19 tracking programs. This should be cultivated in Australia with engagement of experts and academics to provide a clear public message.

45.1 Introduction

As a consequence of the current COVID-19 pandemic, many national governments have retroactively deployed digital track and trace systems to support ongoing community health monitoring. In some contexts, contact tracing technologies have met with great success in monitoring the spread of the novel coronavirus, while in other spaces, there has been failure in regards to both implementation and uptake. This chapter focuses on the implementation of COVIDSafe, a track and trace technology designed for the Australian context. Building upon lessons learned from the successful implementation of contact tracing mechanisms in Asia, we argue that the success of contact tracing mechanisms depends not only on the quality of tracing technology, but on the cultural conditions of government and community that surround their enactment.

45.2 Do track and Trace Mechanisms Work?

Contact tracing technologies can provide communities with a method to contain the spread of communicable diseases by quickly identifying and notifying people who have come into contact with infected individuals [1]. Exposed individuals could then be informed, tested, and isolated, which would break the chain of further transmission. However, breaking the chain only works if individuals both use and trust the system while also adhering to self-isolating advice. It is also important to remember that track and trace mechanisms do not actually render individuals safe from the novel coronavirus. Although contact tracing should (in theory) support community awareness and protection, contact tracing alone does not offer inoculation like a vaccination might [2].

Effective uses of contact tracing tend to be found in East Asia, such as China, South Korea, Taiwan, Singapore and to a lesser extent, Japan [3, 4]. Yet the reason for the success of track and trace technologies in Asian nations may be cultural, as opposed to technological. In addition to developing technologies to monitor the population, many Asian nations have previous experience with epidemics such as MERS and SARS. Trust in government underpins civic duty and collectivist cultures, which often embrace compliance with government infection control mechanisms. Contact tracing applications in countries like South Korea are also mandated and invasive, yet extremely popular, and discussed widely by community members. In contrast, most western democracies have had little experience with modern infection control tracing techniques [5–7] which include adopting technology, implementing infrastructure, and streamlined data sharing agreements; let alone public awareness campaigns on contact tracing.

45.3 The Failures of COVIDSafe: Technology or User?

Despite the name, COVIDSafe has not succeeded in protecting the Australia public from COVID-19. However, the failures of this contact tracing mechanism can be attributed to several key factors that extend beyond the technological [8–10]. A lack of trust in government, coupled with a rushed response to developing the tool, has certainly led to a lack of public investment in the implementation of COVIDSafe. Mixed messages around the efficacy and safety of the tool has led to a belief of limited benefit, and individualistic culture has undermined Australia's efforts to implement their own track and trace mechanism successfully.

Inexperience in secure enactment of track and trace technology has also marred public perception of the efficacy of COVIDSafe. Australia lacks the experience of its Asian counterparts: even in May 2020, well after the novel coronavirus had developed into a pandemic, infrastructure was still not in place for the Australian government to act on notifications of infected individuals and their contacts. One major concern relates to data security [9]. In the case of COVIDSafe, if a user tests positive for COVID-19 and consents to their data being uploaded, the information is then held by the federal government on an Amazon Web Services server in Australia. Data from the app is stored on a user's device and transmitted in an encrypted form to the cloud-based server. Cloud based storage poses risks at the best of times [11]; unfortunately, Australia also has a long history of compromised data usage. Concerns around privacy render many members of the Australian public reticent to utilise basic health storage technologies, such as MyHealthRecord [12], let alone invasive track and trace technologies. Like financial data, spatial data is sensitive, identifiable information able to compromise an individual's identity and safety.

Although COVIDSafe does not access positioning information, it does ask for permission to collect information about accessing the phone network, which can be used as a form of location tracking. COVIDSafe uses Bluetooth to record anyone who is within range of the signal [10]. This concept does allow people to remain spatially anonymous; however, since most individuals' routines are fairly stable and most people have a physical contact group which tends to remain the same, it would not be difficult to infer locations and associations. Importantly, based on previous data security breaches [13], the Australian public is aware of vulnerability in data collection systems, and their ability to be exploited. Privacy implications remain murky. Evidence from the Australian public highlights issues with platforms and device error [9], often resulting in users uninstalling COVIDSafe. Another major issue is that individuals must upload their information through a rather complicated process; perhaps this is why individuals who test positive to COVID-19 fail to report.

45.4 Enhancing Implementation Through Education

There are many ways to enhance the utility of track and trace mechanisms, and success should not only be seen as culturally determined. For while South Korea and China have successfully employed contact tracing mechanisms [14], there have also been low levels of success in track and trace technologies in certain neighbouring contexts, such as Singapore. However, without public support of digitally enabled track-and-trace technologies, the purported digital inoculation will fall short of intended goals [15], be it low number of users such as seen in countries such as Singapore [16], or in an overall reduction in transmission rates [17].

Although it is crucial to improve user uptake, increasing awareness through broader education is also important, particularly to overcome a lack of community understanding as to the limits of contact tracing technology (see [18]). Awareness campaigns that raise knowledge and understanding are important tools for promoting change in social behaviours and norms; however, an important consideration is understanding the cultural context [19]. Raising awareness of track and trace processes is crucial, but assurances of data security and transparency are also necessary steps to building trust and overcoming public cynicism as to the utility of contact tracing tools. However, if governments fail to take into consideration that a country like Australia promotes a culture of self over community, it is unlikely that track and trace systems can ever succeed.

45.5 Lessons from Australia: Enhancing Contact Tracing

There are many reasons why track and trace mechanisms fail. In this chapter, we have reflected on the lessons learned from Australia, as evidenced in the example of Australia's COVIDSafe tool. While community hesitation and a lack of willingness to download the application can be attributed to an absence of trust towards the government, the manner of implementation is also of concern. A lack of public education and trust has failed to generate a meaningful awareness of what COVIDSafe can (and cannot do) in terms of providing protection for the Australian population. As a consequence, in order for COVIDSafe (or future track and trace technologies) to be successful, it is crucial for government efforts to focus on enhancing the capabilities of tracing technologies and providing an awareness which addresses community concerns. Increasing knowledge is the first step to behavioural change [15], however, being responsive and building trust will also help the Australian government to navigate the risks posed by this pandemic, and the next.

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46

Sustainable Transport as a Key Pillar to Community Resilience During the COVID-19 Pandemic

Arturo Ardila-Gomez

As cities gradually exit COVID-19 quarantines, some are suggesting that public transport might increase contagion risk and that private cars should be considered the only safe alternative. This view, however, is based on perception rather than facts. Moreover, promoting widespread car use could actually impede recovery and come with a host of negative side effects, especially for the poor. This chapter uses the Three Cs framework—avoid closed and crowded spaces, and closed contact situations and in particular their overlap—to understand how sustainable transport can be resilient to the pandemic. To minimize the three Cs while preserving the economy the ideal is to have people work from home which applies only to workers who tele-commute. Yet for first responders, blue-collar, and informal workers getting to work is essential for generating income. Sustainable transport can provide efficient, dependable mobility that connects people to opportunities and be COVID-safe during this pandemic.

46.1 Introduction

As cities gradually exit COVID-19 quarantines and reopen their economies, some observers are suggesting that public transport might increase contagion risk [1] and that private cars [2] should be considered the only safe alternative. However, this stance is based on perception rather than facts. In addition, promoting widespread car use could actually impede recovery and come with a host of negative side effects, especially for the poor.

In this observation chapter I explain why sustainable transport — public transport, walking, and biking — must become an integral part of our response to the pandemic, and how we can make this happen in a safe, resilient way.

46.1.1 We Need to Keep People and Economies Moving

The International Labor Organization estimates that a whopping 1.6 billion people are at risk of losing their livelihoods [3]. Many of them are informal workers who do not have access to unemployment benefits or any other kind of social safety nets. Some 39 million people have already lost their jobs in the United States [4]. There is growing concern that many jobs lost to the pandemic will vanish forever [5], raising some significant questions about the future of the labor market, particularly in cities.

Furthermore, the ILO estimates that, globally, “more than 436 million enterprises [3] face high

risks of serious disruption." Related, up to 580 million people could fall into poverty [6], as estimated by the United Nations University. There is also a high probability that the health crisis may contribute to a hunger pandemic [7] could push another 130 million people to the brink of starvation.

These numbers show how quarantine and shelter-at-home can hurt millions of people, particularly the poor. Now, imagine if these losses were permanent and the urban labor market collapsed. Poverty would skyrocket, middle classes would shrink, and tax revenue would plummet. To avoid this scenario, countries are anxious to reignite their economies while minimizing contagion risk, which remains a major preoccupation worldwide. Transport will be a key piece of the equation: we must find ways to connect people to jobs, and to connect them as safely and sustainably as possible. For example, 60 percent of the world's employed population work in the informal market [8]. Informally employed people typically must travel outside their homes to generate income [9].

46.2 Sustainable Transport and the Call for a Green Recovery

As the world grapples with the pandemic and its economic fallout, we cannot forget about the climate crisis that has been looming over the last few decades. While the measures to lower the spread of the virus have temporarily reduced greenhouse gas emissions [10], atmospheric carbon dioxide levels are the highest in human history [11]. Just in 2020, northern Siberia–above the Arctic Circle—experienced record-high temperatures [12] that can melt the permafrost and release even more GHG (greenhouse gas) into the atmosphere.

Clearly, decisionmakers at all levels must work toward a green recovery model that will help address the ongoing health, economic, and climate emergencies simultaneously. Moving toward sustainable transport will be a key part of that process: the transport sector already accounts for a quarter of energy-related emissions, and that number is poised to grow [13] much higher over the next decade. Low-carbon transport can significantly reduce overall emissions, and, concurrently, will help us build more competitive, more inclusive communities –and be COVID-safe. Transport is also key for community resilience, understood as the "measure of the sustained ability of a community to utilize available to respond, withstand, and recover from adverse situations," (RAND Corporation. N.d.) Sustainable transport is more resilient because it embeds redundancy: many buses provide service, bicycles and pedestrians can circumvent many obstacles. If the solution to the pandemic is to provide every adult in the planet with a car, then resiliency will go down because of the resulting gridlock. Worse, a planet with six billion cars will be very warm due to the huge cradle to grave and well to wheels emissions, regardless of the engine technology.

46.2.1 The Three Cs: Avoid Closed, Crowded, Close-Contact Situations

What exactly should sustainable transport look like in the context of COVID-19? What are the transport modes and solutions we should prioritize? And, importantly, how should we adapt existing systems to minimize health risks?

To answer this, I refer to the Three Cs framework: Closed spaces, Crowded spaces, and Close contact situations. According to the framework, the three Cs can drastically increase the risk of spreading the coronavirus, in particular where they overlap [14]. Japan developed this framework to help it contain the pandemic—quite successfully [15].

46.2.2 Managing Transport Demand Through Home-Based Work

The best way to minimize the three Cs while preserving the economy is to have people work from home—a situation that applies mostly to workers with access to digital technology. These workers—myself included—can hold virtual meetings, continue to read, and reply to emails, and can even make coffee and cook food at home. For a COVID-safe restart of economic activities, whoever can work from home should continue to do so: this will reduce transport demand and

allow people who do need to travel to achieve proper physical distancing inside buses or metros, particularly during peak hours [16].

Whether home-based work is temporary or permanent is something that only the future will tell. But it is safe to say that the pandemic will have a lasting and dramatic impact on the way we manage office space [17]. However, it is important to note that not all workers are coping well with home-based work, as indicated by the troubling increase in domestic violence ([18] and [19]), stress [20], and depression [21].

46.3 Providing Safe Mobility to Those Who Need It

Yet home-based work is possible not only because of technology, but also because of the countless formal and informal workers who leave their homes every morning to keep supply chains running, deliver packages, and restock the shelves of our local markets. Add first responders who must also travel to work in order to keep us safe and healthy.

For those essential workers, the ability to get around is as important as ever—without a way to reach their jobs, most of them would likely lose their income and have no way to put food on the table. In the next sections, I analyze how we can use sustainable transport to provide safe, green, and efficient mobility for those who need it most, both during and after the pandemic. We will focus on public transport first, and then explore the potential of cycling and walking.

46.3.1 Safe Operation of Public Transport During a Pandemic

Many of those who must continue commuting rely on public transport systems, which are uniquely positioned to carry large volumes of passengers through urban areas. Even during a pandemic, public transport remains the backbone of sustainable mobility and essential to economic recovery.

There is growing evidence that public transport riders do not face higher infection risk than anyone else [22, 23]. While Hong Kong relies heavily on mass transit, it has registered few cases even as its mass transit system continues to operate [24]. Japan is also highly dependent on transit, yet researchers "did not trace any [infection] clusters to Japan's notoriously packed commuter trains... Riders are usually alone and not talking to other passengers. And lately, they are all wearing masks," [25]. A study in France found that of the 150 infection clusters that appeared after reopening the economy, none could be traced back to public transport [26]. Several authors rapidly and convincingly debunked attempts to blame the subway in New Your City for spreading the virus [27, 28]. For example, Manhattan had the highest density of subway lines but the lowest incidence of COVID-19 cases [29]. In contrast, areas with higher car use had higher contagion rates—some researchers found that it was cars that seeded the epidemic [30].

For the sake of public health, economic recovery, and environmental sustainability, we must keep the momentum going to preserve the appeal of public transport. As long as the virus is here, transport providers must adapt their operations to minimize the overlap of the three Cs: Closed and Crowded spaces, and Close contact situations. We need COVID-safe transit systems for staff and passengers.

Many transport systems have adopted stricter cleaning protocols with anti-viral chemicals or simply with soap and water because the virus "is no match for plain old soap [31]." Still, touching a surface such as a handle or a bar is not believed to be the primary way for the virus to spread [32]. Proper ventilation is critical ([23] and [33]). Transport companies should instruct their drivers to open windows systematically or keep the air-conditioning on. In Japan, for example, trains operate with the windows open to ensure proper ventilation [34]. However, the air conditioning cannot be in recirculation mode because air must circulate within the space [35] to prevent contagion.

As person-to-person [32] is the primary transmission means, then public transport users must do their part. They must not touch their faces [36], wear masks [37]—one of the most effective ways to prevent transmission [38]—and wash their hands with soap and water before and after using public transport [32].

Notice that this advice applies to everyone, not just public transport riders [32]. Indeed, car drivers should also wash their hands before and after using their private cars. The same goes for cyclists, who can sneeze or cough while riding their bike.

The proper physical distancing between riders is another critical requirement. The World Health Organization recommends people stay at least 1 meter [39] to minimize transmission risk. Masks could help reduce this distance [40] and are effective at preventing the spread of germs in public transport [41]. Still, there is a need to reduce occupancy rates and avoid crowding on transit vehicles. Public transport and particularly mass transit cannot operate initially at high occupancy rates due to regulations to reduce the risk of contagion. To make this possible, countries around the world have temporarily capped transit capacity: Colombia, for instance, announced that public transport can use only 35% of its capacity [42], while the UK (United Kingdom) set an even lower limit of just 10% [43]. Governments can increase these caps as the epidemic evolves [44], and scientists [45] gain knowledge on key epidemiological parameters [46]. Indeed, by September 2020 as the pandemic diminished, the Colombian government increased the maximum occupancy of mass transit to 50% by requiring improved ventilation and cleaning protocols [47].

46.3.1.1 Adapting Infrastructure and Resources

If cities are to decrease passenger density on public transport vehicles, they need to keep frequent service, which requires predictable speeds and traffic conditions. Easy to say but challenging to implement—especially in developing countries, where residents own fewer cars, but, paradoxically, tend to experience higher congestion levels [48]. The solution: "pop-up bus lanes" or bus priority lanes –implemented of course with proper road safety considerations [49] and proper traffic management measures. The New York Metropolitan Transit Authority, for example, has requested 97 km of new bus lanes in response to the pandemic [50].

But despite the best efforts of professionals across the sector, there is no denying that the COVID-19 crisis has dealt a massive blow to public transport. Demand nosedived almost overnight [51], leading to considerable financial distress for formal and informal public transport operators. The issue is complicated. The bottom line is that, if governments offer subsidies, they must set proper incentives to avoid service reductions and get operators committed to long-term improvements [52].

The current situation could have a profound impact on the way cities approach their transport policy [53], even once the virus subsides. The measures described in this chapter may have been taken hastily in the face of a global public health emergency. Nonetheless, these measures already challenge many deeply-rooted assumptions about urban transport [54]. Think of the space that private cars are supposedly entitled to in comparison to mass transit. Something as simple as a pop-up bus lane lets us envision what a transit-friendly city could look like: a greener, more inclusive place where the road belongs to everyone [55]. People at all income levels could get around quickly and efficiently.

Bolstering public transport will be instrumental if we are serious about putting sustainable mobility at the heart of the "new normal." Communities will be more resilient also because of the redundancy embedded in public transport and the efficient use of scarce resources such as road space. And even though the pandemic has dealt a significant blow to the sector, the lockdowns have also created unexpected opportunities to rethink sustainable transit vs. private cars.

46.3.2 Biking

Decisionmakers have quickly realized that bicycles could be a COVID-safe transport for residents to get around. Besides being an open-air form of transport, cycling also makes it easy to enforce physical distancing thanks to each bike's physical footprint and the additional gap that cyclists need to leave between each other to avoid collisions. Notice how bicycles naturally avoid the three Cs that increase the risk of infection, especially when they overlap: closed spaces, crowded spaces, and close-contact situations.

As a result, many cities in both developed and developing countries have been deploying pop-up bike lanes over the last few months, from Paris and London to Berlin, Milan [56], Bogotá, Mexico

City, Lima [57], and Wuhan. As part of this trend, new design guidelines help local governments implement simple changes to road infrastructure or signage, allowing for the creation of bike lanes at a low cost and in as little as ten days [58].

Although designed as a temporary solution, there is reason to believe that some bike lanes could become permanent. Public opinion is undoubtedly moving in the right direction: 56% of Londoners "want pavements to be permanently widened to make space for walking and 57% want to see new cycle lanes created and existing ones broadened" [59]. Further, with the right infrastructure, cycling can carry impressive volumes of passengers. In 2019, 583 km of permanent bike lanes in Bogotá absorbed 800,000 rides per day—about 6% of all trips, including walking and motorized [60].

46.3.3 Walking

Last but not least, walking is and will be a crucial pillar of urban mobility in developing countries [61], particularly for women [62] and the poor. People walk to access public transport, to shop, or even to commute to work. Walking brings many advantages to cities and their residents. Promoting pedestrian-friendly streets can make travel safer [63], reduce air pollution, improve public space, and create a more inclusive environment for all users [55], including children and people with disabilities.

Because they demand physical activity by users, public transit and active modes like walking or biking are also associated with tangible health benefits such as "lower Body Mass Index, lower waist circumference, less obesity, higher vitamin D, lower cholesterol and lower hepatic inflammation" [64].

The pandemic has made walking even more appealing because it is COVID-safe [65]. Pedestrians on a sidewalk can typically avoid the three Cs that increase the risk of infection. Sidewalks are open spaces. Pedestrians can usually avoid crowding and keep a safe distance of at least 1 meter. Moreover, pedestrians rarely engage strangers walking by, let alone closely. If needed, wearing masks can provide additional protection.

Yet pedestrians face significant challenges, including less-than-perfect infrastructure and competition with other transport modes. In developing countries, for instance, cars frequently park on the sidewalks, making it more challenging for pedestrians—as well as people on wheelchairs and children on strollers—to keep a safe distance.

Cities can take many concrete steps to enforce parking rules and, more generally, to expand the amount of space available to pedestrians. Some are converting road space into "pop-up sidewalks" for the benefit of pedestrians and bicycles [66]. Other cities are even creating "al fresco streets [54]" to allow retail and restaurants to set up shop outdoors. Al fresco streets are an innovative way to avoid the Three Cs and enjoy life in a safe, responsible manner.

These "road diets" [63] will hopefully continue after the pandemic so people everywhere can enjoy the advantages of walking. Road diets work if accompanied by solid traffic management so that car volumes do not lead to gridlock. Many cities are already taking this step and looking at long-term solutions to accommodate pedestrians [53].

46.3.4 A Window of Opportunity for Sustainable Transport

The pandemic has forced cities across the globe to take emergency measures that have created a window of opportunity to: Avoid unnecessary travel, Shift toward sustainable transport, and Improve transport infrastructure and services. This "Avoid-Shift-Improve" paradigm [67] is precisely what sustainable transport advocates like myself have been preaching over the last few decades to transform urban mobility. While many decisionmakers used to balk at this approach, the COVID-19 crisis has dramatically changed the transport conversation: people are now clearly seeing the value of sustainable transport, and the idea of reallocating space or resources toward public transit, cycling, and walking has become a lot more acceptable.

The challenge is to keep the momentum going to ensure cities do not move right back to auto-centric development as soon as the virus starts to subside. The transition to sustainable transport could significantly contribute to a green recovery [68] revive urban economies, and create 15 million jobs worldwide [69].

46.4 Conclusions

Sustainable transport—public transit, walking, and biking—can provide efficient, dependable mobility that connects people to opportunities [70] and be COVID-safe during this pandemic. Transport is indeed what sustains the agglomeration effects [71] that make urban economies so attractive and make the urban labor market work [70]. Sustainable transport is also paramount for achieving community resilience.

But relying on private cars alone will achieve negative results, partly because cars cannot absorb the large volumes of people transiting through busy urban centers every day. Private vehicles will weaken community resilience. Calls for one person per car to be COVID-safe will lead to gridlock and a very warm planet. Sustainable transport is highly relevant in developed and developing countries as this open letter for the European Union states: "As unemployment and lay-offs are expected to rise in the coming months, and family income will be under stress, walking, cycling and public transport will be the most affordable and equitable transport options, and they will be more necessary than ever" [72].

The window of opportunity for sustainable transport has opened. Public transport, biking and walking can create the conditions for a more robust, inclusive, and resilient recovery. Sustainable transport increases community resilience because of the more efficient use of resources, the redundancy embedded in public transport and the ease to navigate obstacles by buses, bicycles and pedestrians. Importantly, these sustainable transport options could also drastically reduce the greenhouse gas footprint of urban mobility—a key priority considering that, despite the temporary dip in emissions [10] induced by the pandemic, atmospheric carbon dioxide levels are at their highest in human history [11]. Promoters of sustainable transport need to become champions to implement sustainable transport and achieve a green recovery while also building a key pillar to community resilience.

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Part V

The Future Direction

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47

Preparing for the Next Pandemic: Geospatial Information for Enhanced Community Resilience

Greg Foliente, Daniel Paez and Abbas Rajabifard

This chapter presents a high-level synthesis of the knowledge and perspectives shared in the chapter contributions in the book. We suggest strategies to apply the geospatial and techno-social lessons learned to date. We also present proposals to develop new capabilities to build resilience in local communities and reproduce them worldwide, especially in preparation for the next pandemic or global crisis.

47.1 Introduction

Throughout human history, pandemics have caused major societal upheavals and impacts. While there have been a few global pandemic threats in the last twenty years, the emergence of SARS-CoV-2 in late 2019 and throughout 2020 and 2021 (i.e. the COVID-19 pandemic) has been one of the most significant disasters in the last 100 years. The extent of its impact to individuals, people groups, nations and the world will not be fully known for many years. Already, COVID-19 has set-back the UN's Sustainable Development Goals (SDGs) [1].

Even as we present and reflect on the technical and techno-social applications of geospatial information and the broader lessons in response to COVID-19 from around the world in the diverse chapter contributions in this book, the evolving global environmental and climate changes coupled with the increasing globalised settings in economics and trade, population growth, migration and movements, the potential for the next pandemic occurring in the not-so-distant future is not a far-fetched idea. We may not only have to deal with the continuing threat of the SARS-CoV-2 lingering on – despite the availability of a number of vaccines – but also with new equally if not more fatal viruses.

In this concluding chapter, we seek to bring together the knowledge and perspectives shared in the different chapters in the book. Our objective – beyond identifying common themes, differences or trends – is to synthesise and suggest a way forward to apply the geospatial knowledge shared and the techno-social lessons learned to date in this book into building community resilience worldwide, especially in preparation for the next pandemic. A well-considered and robust set of strategic and operational capabilities need to be in place long before the outset of a pandemic. We certainly will learn a lot more in the next few years about what worked and what did not work in the public health and wellbeing management of COVID-19. More data and research will surely follow, but this is still an opportune time to pause and take stock.

The rest of this chapter is organised in three parts. First, we summarise the key lessons learnt to date from the COVID-19 pandemic for the geospatial and allied industries from the chapter contributions in this book. Then we discuss some key considerations about an ideal or desired

future. Finally, we present an overview of the core strategies that we can embark on today so that we can strengthen our capabilities against, and build community resilience in, future pandemics.

47.2 Key Lessons from COVID-19

"What we learn from history is that people don't learn from history."
American investor and philanthropist Warren Buffet (1930-).

The first affirmation to make is the critical importance of geospatial information, and the supporting technologies that underpin them and the software applications and web platforms that make them useful for a variety of stakeholders and decision-makers in managing COVID-19, as first outlined in Chapter 1. These are evident across the diverse contributions in this book. A wide range of geospatial and digital technologies has been featured, including remote sensing, drones and mobile applications. Countries in the Americas, Europe, Africa, Asia and Oceania are using maps and GIS dashboards as the key graphical interface to display data around COVID-19 infections, and to disseminate information. This will likely continue in planning and managing the logistics of vaccine distribution and guiding the recovery phase from COVID-19 and other disasters. But as noted by Kraak in Chapter 34, there are effective and ineffective ways of presenting data. Much more consideration needs be given to this.

Data and understanding what they mean (and what they do not say) are the foundations for sound decision making. This topic has many dimensions. Beyond geospatial information, many types of data needed to be sourced and analysed in a dynamic way, often in fast-changing situations. One of the early difficulties with COVID-19 was the scope of uncertainties in knowledge about its epidemiology. But the unprecedented scientific local and global collaboration amongst medical and public health researchers and with those in a wide range of disciplines across the physical and social sciences, including geospatial experts, system modellers, computing and data scientists and social scientists, have produced unprecedented COVID-19 related research. This book is an example of this cross-disciplinary effort.

The need for open data empowering open science has been raised by several authors. Both scientific research and the authorities' decision-making have been either aided or hindered by the availability of, or access to, data of appropriate quality and resolution. The latter is not just a challenge for small developing countries (e.g. in the Pacific Island Countries and Territories, Chapter 26) but also in developed countries (e.g. in the UK, Chapter 18). All types of information – quantitative and qualitative – and those obtained by surveys (e.g. Chapters 27 and 28) and social media feeds (Chapter 11) are especially important. These approaches allow understanding and monitoring of community resilience, engaging the public and understanding their attitudes, behaviours and actions.

Data need to be organised and managed via harmonised terms and definitions, and spatial data infrastructures (SDI) both at the local and national level, in land and in water (Chapter 9). The success of rapid tool developments to support the COVID-19 public health measures in Korea (Chapter 24), for example, has been partly credited to its national SDI. As noted in Chapter 1, the UN-GGIM's efforts to advance an Integrated Geospatial Information Framework (IGIF) across the globe are critical. Issues around core reference data, interoperability, common geographies, integration of statistics and geography, privacy and confidentiality and cybersecurity need to be addressed. Experiences during the pandemic, depicted in many parts of this book, tell us that when complex decisions are needed, there is no time to sign data custodian agreements or to integrate geospatial databases. In a number of case studies in this book, geospatial information effectively supported decision-making when the SDI was operational and not just conceived in a technical report.

Beyond data and technology, the critical role of leadership and governance cannot be overemphasised. In the web portal of endcoronavirus.org, the gallery of countries "winning" or "beating" COVID-19 includes both developed and developing countries, those that are

technology-rich and those without much technology. In some ways, this affirms the importance of the first two of the three core themes of the UN-GGIM IGIF's strategic pathways: Governance, People and Technology. When informed by science and evidence, political leaders can manage COVID-19 using adaptive public health measures. Since the start of the pandemic, there have been multiple reports on how in many instances, government and institutions did not act in the multiple warnings around the need for stronger pandemic resilience at the local and regional levels. The lack of attention by some leaders to risks brought forward by the scientific community has not yielded the desired results.

It is hard to determine if the lack of attention to science was due to scientists not communicating results effectively or political leaders and authorities making decisions based on ideology. Either way, the lesson learnt is that community resilience building should be based on sound science and built on trust between the community and the authorities [2]. The more the authorities rely on science and evidence, the more chances the community will likely support the public health measures (Chapter 27). Cooperation, collaboration and trust across society are needed; in the end, human behaviour was key to the success of COVID-19 public health measures.

The COVID-19 pandemic has demonstrated that in a highly interconnected social, economic and natural environments, a highly contagious virus can become a global pandemic in no time. And from a safety perspective, nobody is out of the woods until everyone is out. It would not matter how strong a particular country is in its response to the pandemic. It requires its neighbours and the rest of the nations to be building resilience before normality can be returned to the natural, social and economic settings. New Zealand, Australia, Singapore and some other countries have had relatively effective responses to the pandemic with limited infections and a reduced number of deaths compared to the world's average. However, full epidemiological, social and economic recovery in these countries will not occur until the world achieves a lasting solution. Without a global solution, the risk of multiple re-infection waves will continue. Therefore, we have learnt from COVID-19 that community resilience is not an isolated concept for a particular community or group of people. Global crises such as climate change and the COVID-19 pandemic demand community and societal resilience that is built from broad stakeholder cooperation at the local, regional and national levels.

Still along the lines of high interconnectivity, cities – as a dense centre of human settlements and socio-economic activities – emerged as natural hot spots for COVID-19. Adapting from sustainability research, it can also be stated that, "Pandemics will be lost or won in cities". There are many considerations in managing the pandemic in urban centres (e.g. see Chapters 10, 17, 18, 28, 42 and 46), but we can only be successful beating a pandemic if we beat it in our urban centres.

Finally, COVID-19 has sped-up the digitalisation and online transformation of work and education, and in the process also highlighted societal inequalities. The most vulnerable groups of people and regions have been asymmetrically impacted not just health-wise, but also socially and economically [1]. Often, as in the case of people in informal settlements (e.g. Chapters 8 and 15), very little information is available about them even before the pandemic, making it difficult to monitor and support their situation during the pandemic. Recovery efforts, including economic stimulus measures, provide opportunity to re-set the social, economic and environmental conditions of the majority of a nation's populations, and thus make a major advance on many fronts across the SDGs. This requires strategic vision, leadership, political will and effective governance. Data and technology, in general, are just enablers.

Having come full circle, we acknowledge that there are many more lessons not listed in this chapter, and reaffirm the critical role of geospatial information and technologies in managing a pandemic. In the next section, we explore our desired future before the next pandemic and global crisis.

47.3 The Road Ahead: The Only Certainty in the Future is Change

"Prediction is very difficult, especially about the future."
Danish writer, artist and humourist Robert Storm Petersen (1882-1949).

In this section, we cast our future vision and aspirations on the basis of the observations and lessons discussed in the previous section. In other words, we will attempt to describe a desired future where the lessons are assumed to have been learnt and applied. As we do, it is worth noting that the authorities and our society, more broadly, need to face a future pandemic while facing other concurrent hazards and stresses. For example, in 2020 and 2021, we had to deal with the overlapping challenges and impacts of climate change and COVID-19; these included the wildfires and hurricanes in the US, and the tropical cyclones and flooding in the Asia-Pacific. Thus, we need to recognise also that this could be the new norm moving forward.

Following the structure of the previous section, we imagine a future where a multi-scale SDI is in place in most countries around the world. The maturity and adoption levels may be uneven across different countries but the core definitions and reference data are harmonised, with high interoperability and linkages with other data infrastructures and platforms. A diverse range and type of data contents can come from established and new sources – including those from new technologies and from the crowd – with trusted provenance and quality indicator and that protects individual and corporate privacy. The geospatial information of most data is preserved. The infrastructure and the contents are supported by sensible data governance regimes and appropriate cybersecurity measures. The supporting physical infrastructure is robust, in the face of an extreme event, and highly resilient in case of disruption. In other words, it is able to be made operational again swiftly; that is, a fail-safe system. Political appetite and societal expectations regarding cybersecurity risks and privacy – that vary from one country to another – could be a significant factor here. Putting these issues aside, the ultimate aim is to eventually realise the concept of a Digital Earth (Chapter 32).

With a solid data infrastructure in place and in operation, when the next global crisis occurs, new information can be readily managed and made widely available. New mobile and digital applications and solutions can be developed rapidly to meet the specific needs of a future crisis, allowing data to be used more effectively for a coordinated response and decision-making by different stakeholders, including the public. Information management protocols guide these stakeholders in an environment of information glut and where "infodemic" is widespread.

And so, as highlighted in the previous section, the most consequential factor remains the human factor, or the people's capabilities and ability to make sound decisions. This is a future that is challenging to describe because this is value-laden. What is a "sound decision" and who is even able to make this judgment? How do we shape critical thinking and innovation? What are acceptable and unacceptable moral values? Who decides? We can only generally hope that most people will aim for the "greater good".

Despite the above dilemma, identifying the critical role of human factors is important. From a top-down perspective, these are usually identified as vision, leadership and governance. From a bottom-up perspective, the complex nature of human behaviours and actions can lead to highly unpredictable emergent outcomes, which is a truly complex system. In an ideal future, we certainly hope that these behaviours are better understood and harnessed, again for the greater good, especially in times of crises.

In other words, we are describing herein a future where the UN-GGIM's aspirations for IGIF are in place in many countries around the world. In these aspirations, the performance settings for governance, technology and people are continually improving based on new knowledge and lessons from field experiences, including pandemics and other crises. In this future, the geospatial sector and allied industries and disciplines, collaborate widely and effectively to serve the needs of society and, in times of crisis, adapt our efforts to enable different stakeholders to manage the crisis and communities to bounce back better.

47.4 Strategies to Face the Next Crisis and Build Community Resilience

"The best way to predict the future is to invent it."
American computer scientist and pioneer Alan Kay (1940-).

The gap between lessons learned to date (present state) and our aspirations (future state) is how to get to the latter. Herein, we organise the strategies to fill this gap over time according to the general knowledge development and maturity curve in Figure 47.1. The main curve in this figure follows a Sigmoid (or simply, "S") curve. The concept being that new knowledge (early in time, left of the curve) grows and matures over time according to this curve, until such time that it is fully adopted and widely applied in industry or practice.

Knowledge topics in any area or discipline can be placed in this curve, according to its maturity. At the lowest levels of maturity are the topics that will typically be undertaken as PhD thesis projects in universities. Those at the middle may require a combination of research and development. Over time, some of these topics would have been developed into demonstration prototypes, field-tested and eventually deployed. Some of the knowledge may be adopted as industry guidelines, standards or regulations.

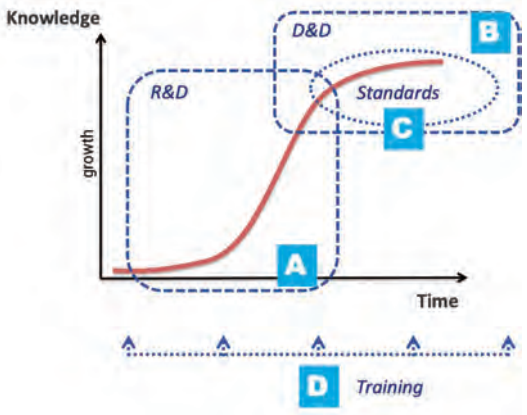

FIGURE 47.1
Knowledge development and maturity curve and the four strategic pathways to improved geospatial information capability in the future: (A) Research and development, (B) Demonstration and deployment, (C) Frameworks, standards and regulations, and (D) Training and human resource development.

The core strategies are, thus, organised as shown in Figure 47.1 and elaborated below.

A. Research and development

It was evident in this book and in the general COVID-19 literature that lack of knowledge, or epistemic uncertainty, hampered the early efforts to assess risks and manage the pandemic. Although the bulk of the research that needed to be undertaken about the virus and its epidemiology fall into the hands of experts in the medical and public health disciplines, it is clear now that interdisciplinary and transdisciplinary research collaborations have been significantly valuable. In other cases, questions raised by researchers from one discipline have led to collaborations and have enriched the understanding of key issues. For example, research by N.N. Taleb and his associates [3] on pandemic risk management based on the probability distribution's tail properties raised many salient points and helped identify common errors and fallacies when using point forecasts

for fat- tailed variables like pandemic deaths. Together with the research gaps identified by various contributors in this book – across disciplines – it now seems that there are many more areas that demand deep research or serious research and development (R&D) efforts, especially where geospatial and temporal information are critical.

With even more data and improved insights about COVID-19 and its spread, impacts and control coming to fore in the next year or two, undertaking more quality research will consolidate and expand our knowledge further. Of special note, where geospatial information needs to have more prominent roles, for example, are in: network epidemiology, pandemic risk management, including perception vs. actual risk, community wellbeing, social attitudes and human behaviours and response (e.g., from public health measures to vaccines), economic and SDG impacts and recovery scenarios, balance of privacy and cybersecurity, amongst others. Some research will be about more fundamental science questions while others will be more applied. Research on addressing the methodological gaps in the use and analysis of qualitative and quantitative data, and developing new integrated approaches that take into account the spatio-temporal patterns in studying the impacts of the pandemic on urban residents' wellbeing, for example, will be worthwhile. Furthermore, R&D that support the full development of a Digital Earth, SDIs and interoperability standards, and strengthen data provenance and governance are needed.

B. Demonstration and deployment

For topics that are near the top of the knowledge S-curve in Figure 47.1, they need to be prototyped and/or their applications demonstrated. These efforts should have the goal of moving beyond proof of concepts and towards broader practical adoption and applications. In the past, pilots have not consolidated into operational applications in crisis response. For example, during the beginning of the COVID-19 pandemic, there was the idea that our tracking systems would be ideal to limit contact between healthy and infected people and help health authorities conduct better contact tracing and quarantine people. In a preliminary review of mobile phone applications used during the pandemic, we found that the role of geospatial technologies was very limited. We did not have proven technologies that could track individuals on a large scale. There were pilots but when they have been implemented on a rush during the pandemic, a limited contribution was provided.

Society will increasingly demand from the geospatial industry operational tools that can be embedded within community resilience systems. Current concepts of digital twins and the use of drones are spatial technologies that could not pass the "pilot" phase unless there is transdisciplinary collaborations and cooperation among practitioners in key areas such as standards and regulations. For the future, we cannot be afforded to be an industry of pilots, but we need to move into an industry of solutions. To be successful, the challenges of scaling and capital funding for technology commercialisation and/or deployment need to be addressed.

C. Frameworks, standards and regulations

There is an urgent need to develop and implement established knowledge as part of SDI frameworks and standards, and to consider relevant results from strategies A and B above for inclusion in future updates of these standards (Figure 47.1). Over time, issues around core reference data, interoperability, common geographies, integration of statistics and geography, privacy and confidentiality and cybersecurity need to be addressed. International harmonisation is key because the long-term or ultimate goal is to build the Digital Earth, country by country. Collaboration amongst UN-GGIM, the Open Geospatial Consortium (OGC) and ISO, together with national standards bodies, is vital. Broad support from the geospatial sector is needed.

Whether these frameworks and standards are initially voluntary or mandatory (or part of a regulatory regime or policy scheme) will depend on a country by country basis.

D. Training and human resource development

Across the knowledge life-cycle and maturity curve in Figure 47.1, we need to develop and implement intentional and flexible training, education and mentoring programs for personnel with different levels of capability and responsibilities in the geospatial sector and allied industries. Here we note that this is not just the role of academic institutions and professional organisations (Chapter 12) but it should be a collective goal and responsibility. After all, we have previously noted that, beyond data and technology, the critical role of leadership (at all levels) and governance cannot be overemphasised. Thus, a well-rounded program that goes beyond the technical and that fosters critical thinking and enhances collaboration and communication skills will be ideal. When the next pandemic strikes, a workforce with these attributes will be able to manage it effectively.

In all of the above, the practical challenge for the geospatial and allied sectors is to develop and deploy local resilience-enabling solutions but with global cooperation and harmonisation also in mind. Stronger partnerships and collaboration, even more than those demonstrated in the COVID-19 experience, in addressing a future pandemic will likely lead to successful outcomes. When a society's stakeholders join forces to address an existential crisis, pandemic or not, the greater good is served.

COVID-19 is a clear call to humanity to remind us to care beyond ourselves and about the need to work together to balance our interaction with the natural environment and to act – to save our common future. In this call, many people lost their lives during the COVID-19 pandemic. Their death will not be in vain if we learnt the lessons, particularly around working cooperatively to solve global crises, with a long-term perspective and more equitable societal outcomes in mind.

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