Area-level geographic and socioeconomic factors and the local incidence of SARS-CoV-2 infections in Queensland between 2020 and 2022

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Abstract

Objective: Calculate the incidence of SARS-CoV-2 (COVID-19) infection notifications and the influence of area-level geographic and socioeconomic factors in Queensland using real-time data from the COVID-19 Real-time Information System for Preparedness and Epidemic Response (CRISPER) project.

Design and setting: Population-level ecological study and spatial mapping of the incidence of COVID-19 infection notifications in Queensland, by postcode, 2020–2022.

Main outcome measures: Proportions and distribution of COVID-19 infection notifications by year, age-group, socioeconomic disadvantage, and geospatial mapping. Incidence rate ratios (IRRs) were calculated.

Results: Between 28 January 2020 and 30 June 2022, a total of 609,569 cases of COVID-19 associated with a Queensland postcode were recorded. The highest proportion of cases occurred in 2022 (96.5%), and in the 20- to 24-year age category (IRR = 1.787). In non–Major City areas, there was also a higher incidence of COVID-19 cases in lower socioeconomic areas (IRR = 0.84) than in higher socioeconomic areas (IRR = 0.66).

Conclusions: Queensland experienced its highest proportion of COVID-19 cases once domestic and international borders opened. However, geographic and socioeconomic factors may have still contributed to a higher incidence of COVID-19 cases across some Queensland areas.

Implications for Public Health: Although Australia has moved from the emergency response phase of the COVID-19 pandemic, we need to ensure ongoing prevention strategies target groups and areas that we have identified with the highest incidence.

Key words: COVID-19, Queensland, epidemiology, spatial mapping, incidence

Introduction and background

Health inequality and socioeconomic deprivation can contribute to the burden of morbidity and mortality in pandemics and endemics.[1,2] This has shown to be no different in the 2019 pandemic of SARS-CoV-2 (hereinafter referred to as COVID-19). Following an initial outbreak in Wuhan, China, it was reported that as of March 19, 2020, a total of 5,939 cases were localised to 39 well-developed cities within the Hubei province, with almost half of the total cases in China being reported outside of regional city areas.[3] A 2021 rapid review of literature concluded that there is limited evidence regarding key socioeconomic determinants, such as occupation, education, and housing status, and the resulting incidence of COVID-19 infection on a global scale.[4] Furthermore, it has been emphasised that analysis of socioeconomic characteristics of patients with COVID-19 will be beneficial for future public health planning and implementation of prevention measures, guidelines, and interventions aimed at identifying vulnerable populations.[5]

Roder et al.[6] examined socioeconomic factors that may have contributed to the non-homogeneous incidence of SARS-CoV-2 infections across Victoria. In regional areas of Victoria, incidence of COVID-19 infection increased with mean household size [per person: incidence rate ratio (IRR) = 7.30; 95% confidence interval (CI) = 4.37–12.2], unemployment (per percentage point: IRR=1.50; 95% CI=1.33–1.69), and for whom rent (IRR=1.15; 95% CI=1.07–1.22) or mortgage repayments (IRR=1.22; 95% CI=1.15–1.28) exceeded 30% of household income. Furthermore, this study discusses how factors associated with lower socioeconomic status, such as poor housing conditions, age, and employment, interact together and contribute to

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transmission of COVID-19 through differing exposure and engagement with public health measures.[6] One such example of this is employment, whereby those in lower socioeconomic positions tend to engage in part-time or casual work and may face job insecurity and not be entitled to paid sick leave. This in turn may discourage individuals from reporting COVID-19 illness to avoiding mandatory isolation, in the form on non-paid time off work, thereby increasing community and household transmission. Similarly, a 2020 study in the United States of America found that among households with poor housing conditions, there was a 50% higher risk of COVID-19 incidence (IRR = 1.50, 95% CI = 1.38–1.62) and a 42% higher risk of mortality from COVID-19 infections [mortality rate ratio (MRR): 1.42, 95% CI = 1.25–1.61].[7] In Australia, there have been no studies that have spatially mapped COVID-19 cases geographically or by socioeconomic status to identify specific areas of high disease burden. We aimed to examine all notified cases of COVID-19 infections in Queensland by age and map the cases spatially by remoteness of living and socioeconomic status.

Methods

Data for COVID-19 cases in Queensland were obtained from the COVID-19 Real-time Information System for Preparedness and Epidemic Response (CRISPER) project.[8] This system collected integrated data from multiple sources in the one platform in spatially explicit real-time to capture the number of national COVID-19 cases, deaths, rapid antigen tests (RATs) and polymerase chain reaction (PCR) tests and contact tracing locations in Australia at a postcode level. For Queensland cases, CRISPER sourced publicly available data from Queensland Department of Health and the National Notifiable Diseases Surveillance System to include those who met the national case definition. In Australia, the case definition for a confirmed COVID-19 case requires laboratory definitive evidence in the form of either the detection of SARS-CoV-2 by nucleic amplification acid testing; or SARS-CoV-2 IgG seroconversion or a four-fold or greater increase in SARS-CoV-2 antibodies of any immunoglobulin subclass including ‘total’ assays in acute and convalescent sera, in the absence of vaccination. A probable COVID-19 case includes individuals who present laboratory-suggestive evidence in the form of detection of COVID-19 by the RAT.[9] It is important to note that due to the overwhelming number of cases experienced within certain time periods, the recommendation was made to consider using alternative testing technologies such as RATs for other priority groups to relieve pressure on the pathology system.[10] For this study, we have used data from both RAT and PCR test results as COVID-19 cases as RATs have been considered to have high specificity (99.9%, 95% CI = 99.5–100.0) to COVID-19 infections.[11] People who became COVID-19 positive whilst in hotel quarantine were counted as cases and were included in the results.

For this study, we obtained data between 28 Jan 2020 and 30 June 2022 (inclusive). For the year 2022, data were available for the first half of the year. Population estimates were calculated using the Australian Bureau of Statistics (ABS) 2021 Census Data,[12] and as 2022 was an incomplete year, rates per 1,000 Queensland population were adjusted to reflect this. Socio-Economic Indexes for Areas (SEIFA) indexes were taken from the 2016 ABS Census of Population and Housing: Socio-Economic Indexes for Areas, Australia.[13] The Index of Relative Socio-economic Disadvantage (SEIFA-IRSD) was chosen for analysis as this incorporated more variables to determine relative advantage and disadvantage.[13]

Accessibility/Remoteness Index of Australia (ARIA) data were also obtained from the 2016 ABS.[14] Data were cleaned and analysed using STATA-SE 17, and graphs were produced using Microsoft Excel. The mapping component was performed using ArcMap 10 version 10.7.1,[15] and shapefiles for Queensland were downloaded from the 2021 ABS.[16]

For the SEIFA analysis, the Queensland population was divided into Major City and non–Major City classes, which is consistent with the Australian Institute of Health and Welfare (AIHW) annual health reporting.[17] When analysing the health of population groups using the ARIA index, rural and remote populations are often combined with those living in inner and outer regional areas[17] to account for small population sizes. Within Australia, approximately 72% of the total population reside in a Major City, followed by 26% in the combined classes of Inner and Outer Regional areas, and only 2% reside in the combined Remote and Very Remote areas.[18]

Statistical analysis

Epidemic curves were created using daily aggregated Queensland case numbers and graphed as cases per week. The distribution of cases was calculated by age group. Postcode-level data were used to categorise cases into SEIFA and ARIA indexes, and these are presented as proportions for each decile. In general, cells with <5 cases are not reported in Queensland Government reports. To account for small cell sizes, the SEIFA deciles were combined to form quintiles, which is a common practice for analysing SEIFA indexes in epidemiological studies.[6] Postcodes corresponding to a major city were classified as “Major Cities” under the ARIA Index, whereas those corresponding to a non-major city were combined from the “Regional Outer, Regional Inner, Remote, and Very Remote” areas. Incident cases of COVID-19 were spatially mapped according to the individual postcode of residence to demonstrate a visual representation of the proportion of COVID-19 cases across Queensland.

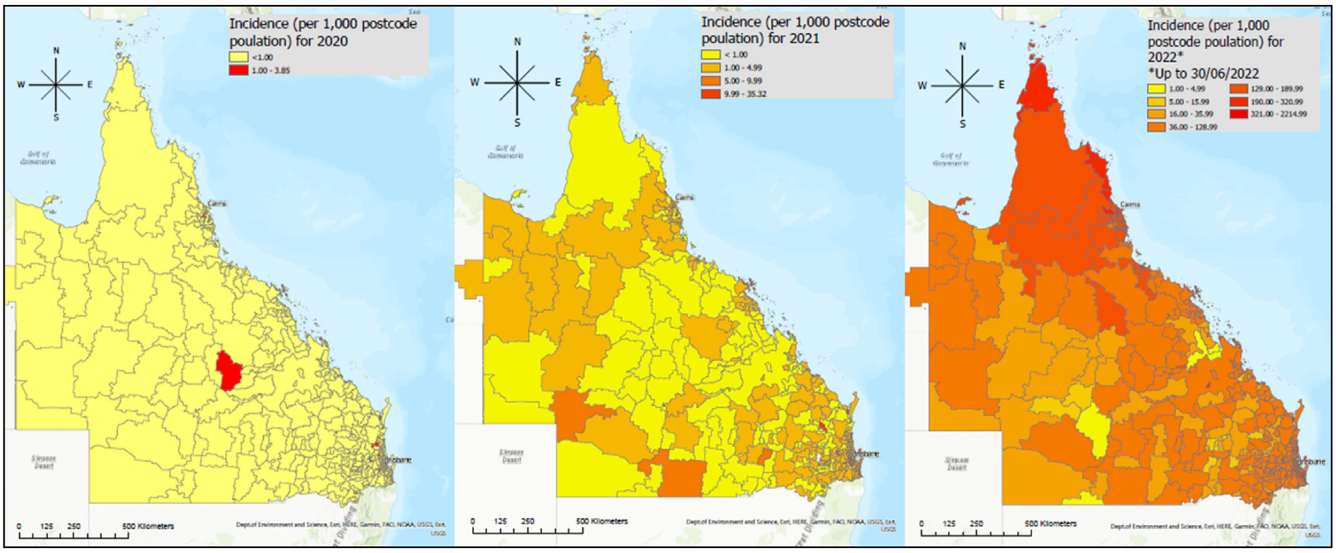
Results

Between 28 January 2021 and 30 June 2022, a total of 609,569 cases of COVID-19, associated with a Queensland postcode were recorded. In 2020, there were 1,297 cases reported and 19,151 cases in 2021. The remainder and majority of cases (n=583,727) occurred between 01 January 2022 and 30 June 2022. A further 23,735 cases were reported to have occurred in Queensland but were associated with an “unknown” postcode; four postcodes were recorded as having no COVID-19 cases (4051, 4384, 4493 and 4706), and these were excluded from the spatial mapping analysis. The highest incidence of cases per postcode population was reported for the postcode 4008, containing the suburbs of Brisbane/Pinkenba/Brisbane Airport. The distribution of COVID-19 cases by week of notification is shown in Figure 1.

Age distribution

Overall, the lowest incidence of cases occurred in the 70- to 74-year age group (IRR = 0.452; 95% CI = 0.444, 0.460) followed by the 75- to 79-year age group (IRR = 0.461; 95% CI = 0.451, 0.470). The highest proportion of cases occurred in the 20- to 24-year age group

Figure 1: Changes in distribution of incidence (per 1,000 population) of COVID-19 in Queensland by year.



(IRR = 1.787; 95% CI = 1.77, 1.802) followed by the 25- to 29-year age group (IRR = 1.55; 95% CI = 1.540, 1.566). When categorised by year, a similar pattern for the highest incidence was observed (Supplementary Figure 1).

Geographic characteristics

The incidence of COVID-19 cases in Queensland between 2020 and 2022 was not evenly distributed. There was a higher proportion of notifications in the major cities, with the highest incidence occurring in both the Far North and the South East regions. This was supported by the analysis of ARIA distributions. The highest incidence of COVID-19 notifications occurred in postcodes with an ARIA index correspondi ng to Inner Regional Areas (IRR = 1.222; 95% CI = 1.214, 1.230). This was followed by Major Cities (IRR = 1.161; 95% CI=1.155, 1.168) and the condensed classes of Remote and Very Remote areas (IRR = 0.88; 95% CI = 0.869, 0.902). The lowest occurrence of cases occurred in postcodes in Inner Regional areas (IRR = 0.668; 95% CI = 0.663, 0.673).

The distribution of COVID-19 cases changed substantially for each year of the pandemic (Figure 1). In 2020, there was a large cluster of cases in central Queensland in addition to those in the capital city of Brisbane. In 2021, there was a more uniform distribution of cases throughout Queensland with the highest proportion of cases occurring in the capital city of Brisbane. For the first half of 2022, there was a large proportion of cases in the Far North region of Queensland in addition to Brisbane and South East Queensland regional area.

Socioeconomic characteristics

There was an uneven distribution of COVID-19 cases across SEIFA-IRSD quintiles (Table 1). When notifications were differentiated as either Major City or non–Major City, there was a higher incidence of COVID-19 cases in residents living in the lower socioeconomic quintiles from Major City areas (SEIFA Quintile 2; IRR = 1.05; 95%CI = 1.04, 1.06) than in the higher socioeconomic quintile (SEIFA Quintile 5; IRR = 0.89; 95% CI = 0.88, 0.90). In non–Major City areas, there was also a higher incidence of COVID-19 cases in lower socioeconomic areas (SEIFA Quintile 1; IRR = 0.84; 95% CI = 0.84, 0.85) than in higher socioeconomic areas (SEIFA Quintile 5; IRR = 0.66; 95% CI = 0.64, 0.69).

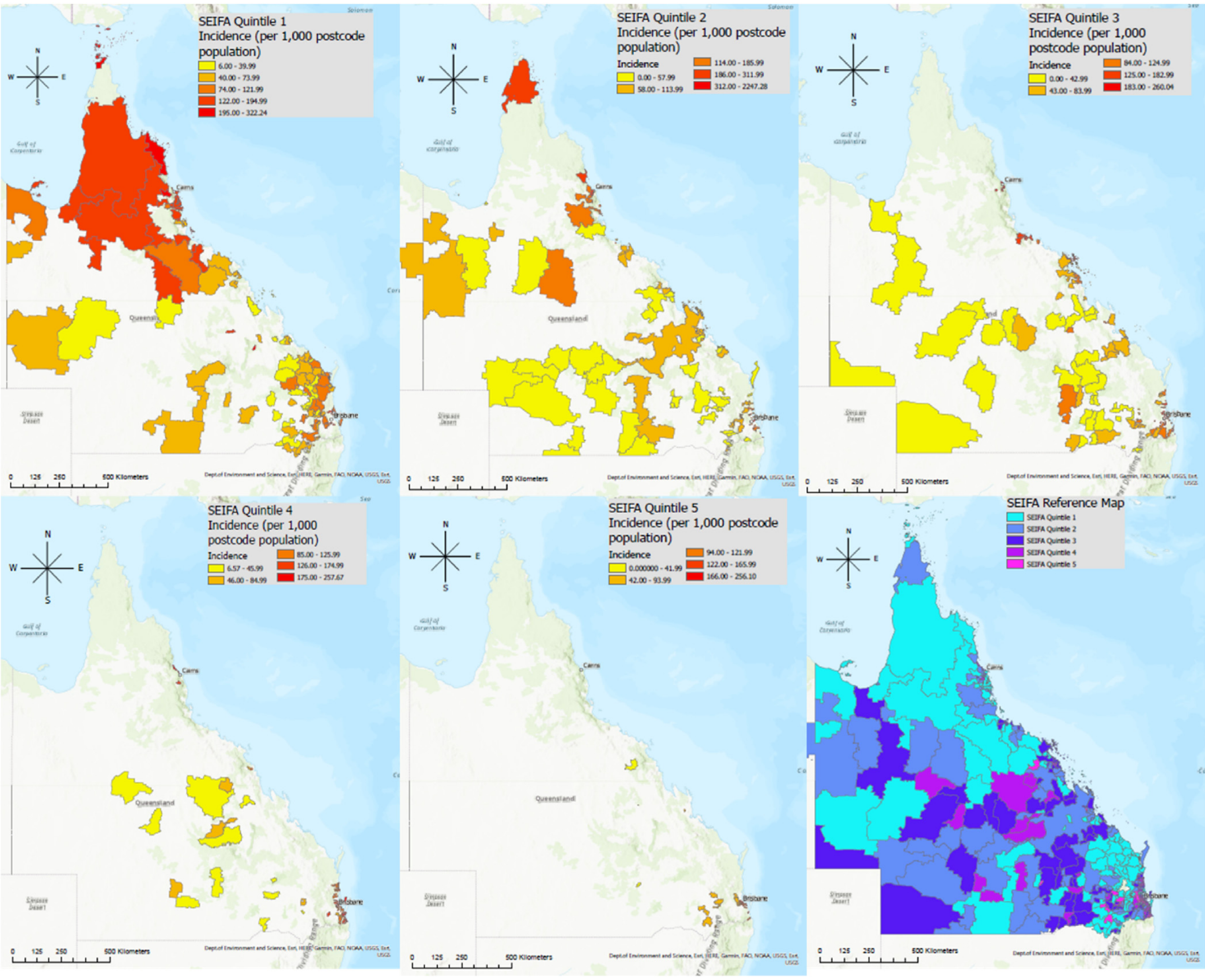
There was also variance in COVID-19 cases by SEIFA quintile when cases were mapped geographically (Figure 2). Those from the lowest quintile of advantage (SEIFA-IRSD quintile 1), had the highest proportion of cases throughout Queensland. In contrast, those from the highest advantage group (SEIFA-IRSD quintile 5) were more confined to South East Queensland and Brisbane.

Table 1: Incidence of COVID-19 by area and Socio-Economic Indexes for Areas quintile.

Category	SEIFA quantile	Incidence (per 100,000)	Incidence rate ratio (95% confidence interval)
Overall	1 (disadvantage)	11045.12	0.862 (0.856, 0.868)
	2	12189.42	0.972 (0.965, 0.979)
	3	12955.09	1.050 (1.044, 1.056)
	4	13088.00	1.064 (1.058, 1.071)
	5 (advantage)	12716.78	1.022 (1.015, 1.029)
Major Cities	1 (disadvantage)	13413.07	1.031 (1.021, 1.042)
	2	13666.39	1.054 (1.043, 1.065)
	3	13231.56	1.019 (1.011, 1.027)
	4	13344.72	1.038 (1.031, 1.045)
	5 (advantage)	11953.51	0.894 (0.887, 0.901)
Non–Major City	1 (disadvantage)	10125.15	0.848 (0.840, 0.857)
	2	13181.08	1.232 (1.220, 1.24)
	3	11121.15	0.969 (0.960, 0.979)
	4	12824.39	1.138 (1.118, 1.159)
	5 (advantage)	7663.26	0.668 (0.647, 0.690)

Abbreveations: SEIFA: Socio-Economic Indexes for Areas.

Figure 2: Changes in incidence (per 1,000 population) of COVID-19 between different Socio-Economic Indexes for Areas Index of Relative Socio-economic Disadvantage quintiles 01/01/2020–30/06/2022.



Discussion

Between 2020 and 2022, most COVID-19 cases occurred in the major cities of Queensland and among the 20- to 24-year age group. Our study is the first to map COVID-19 cases in Queensland by individual postcode and demonstrated a higher incidence of cases in Remote and Very Remote areas where there are larger populations of First Nations people and/or those with less access to health care. The mapping component of our study also highlighted the disparity in the number of cases between those living among areas of higher advantage compared to those living in areas of lower advantage.

These findings are reflective on a national scale, with a 2022 report by the AIHW describing incidence of COVID-19 being highest among those living in major cities compared to regional centres and for individuals aged between 20 and 39.[19] On a global scale, a US study of COVID-19 cases also found a significantly higher incidence of COVID-19 infection in adolescents and youth than in older adults.[20] While the higher incidence of COVID-19 cases in the Major City region of Brisbane and South East Queensland is consistent with the patterns observed in other Australian jurisdictions, the higher incidence of cases in Far North Queensland is concerning, given the vulnerability of the population in that region.[21] A 2019 report by the Northern Queensland Primary Health Network found that 26.6% of the population falls within the lowest (most disadvantaged) quintile of the SEIFA.[22] The report also highlighted a higher prevalence of the population engaged in health behaviours that have been linked to poorer outcomes when infected with COVID-19 such as daily smoking (13.8%), daily alcohol drinking (27.1%), overweight or obesity (61.6% of the population), and high prevalence of preventable premature death (266 deaths per 100,000 population).[22] In addition, another study found that overcrowded housing was a key contributing factor to the increased burden of respiratory disease in the Northern Queensland region.[23]

A 2022 case report evaluating the public health policies used in Australia during the pandemic suggests that the government's response, combined with the health system organisation, resulted in better management of the pandemic than in countries that did not enact such responses.[24] Numerous studies analysing cases of COVID-

19 in Australia in 2020 and early 2021 found that effective elimination was largely maintained using lockdown and quarantine measures.[25–29] This is reflected in the findings of the low number of cases of COVID-19 in Queensland during 2020.[30] It is important to note that prior to 13th of December 2022, the Queensland borders were closed to both international and interstate travellers.[31] However, this finding may also be due to the high levels of vaccination coverage that was achieved in Queensland during the early stages of the COVID-19 vaccine roll-out in 2021.[32]

A 2022 report published by the Australian National University Centre for Epidemiology and Population Health outlined the clear discrepancy in uptake of the COVID-19 vaccine across different socioeconomic populations in Australia.[33] Key findings from this report showed that males, First Nations people, and people who speak a language other than English at home were less likely to be vaccinated for COVID-19 than others.[33] Previously, many studies have shown that the willingness to receive a COVID-19 vaccination was lower in socioeconomically disadvantaged groups such as those with lower levels of education,[34–37] persons identifying as a First Nations person,[35,38] non–English speaking background people,[36,39] refugees,[40] and those living outside a capital city area.[41] Our data have confirmed a higher incidence of COVID-19 cases in the areas where these groups are less likely to be vaccinated; therefore, mobilising and prioritising strategies to increase vaccination in these areas is warranted.

Limitations

As our data included all notified positive cases who were in hotel quarantine following their return from overseas, the high proportion of cases recorded for Brisbane may have been influenced by these cases and was not a reflection of community transmission. A limitation to using COVID-19 case data is the inconsistency in both testing and reporting of cases. Our data showed a sharp climb in the number of people utilising the home RAT in 2022. While there are no official data on the number of under-reported RAT results in Australia, leading epidemiologists have suggested that the true number of infections circulating in the community would likely be potentially five-times higher than the sum of RAT and PCR tests.[42] Further supporting this point, a small-scale survey of 117 households on the Gold Coast, Queensland, found that 20 of those participants tested positive for COVID-19, and of these, only 16 presented with any symptoms.[43] Although a small sample, only two of those who tested positive were aware that they had COVID-19.[43]

As we did not have access to postcodelevel–associated outcome data from COVID-19 notifications, we were therefore unable to determine the severity of infections such as hospitalisation, ICU cases, and/or deaths and SEIFA/ARIA indices. A 2022 national report by the AIHW[19] suggested that a higher rate of deaths occurred in persons from lower socioeconomic backgrounds and in older age groups. However, we highlight that Queensland has accounted for only 10.6% of all COVID-19-related deaths in Australia, with the majority attributed to other jurisdictions [New South Wales (NSW) 38% and Victoria 45.7%].[19] In addition, a cohort study by Liu et al.[44] found that those who were in higher advantage SEIFA deciles in NSW, had an age-adjusted hazard risk ratio of 0.55 (95% CI = 0.37–0.81) when compared to those in the less advantaged areas. Therefore, our findings of RAT incidence may have been an under-representation of the true number of Queensland COVID-19 cases, especially in lower socioeconomic areas.

Conclusion

This study highlights that postcode-level geographic and socioeconomic factors may have contributed to the non-homogenous incidence of COVID-19 cases across Queensland between 2020 and 2022. Queensland experienced its highest proportion of COVID-19 cases once domestic and international borders opened; however, geographic and socioeconomic factors may have still contributed to a higher incidence of COVID-19 cases across some Queensland areas. This study contributes novel spatial mapping data that has highlighted key areas of vulnerability among the Queensland population, which can now be used to inform future policy development during the ongoing pandemic of COVID-19 and prepare for similar pandemics in future. Although Australia has moved from the emergency response phase of the COVID-19 pandemic, we need to ensure ongoing prevention strategies for target groups and areas that we have identified with the highest incidence.

Ethics approvals

The CRISPER project was approved by the Australian National University Human Research Ethics Committee (HREC) as a negligible risk project, HREC approval number: 2021/HE000897. In addition, this project was approved by the University of Queensland HREC approval number: 2021/HE000897.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Appendix A Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.anzjph.2023.100094.