KPMG

Australia's COVID-19 performance

Good luck, good management or a combination of both?

A quantitative analysis of the global variation in case fatality ratios.

21 April 2020

KPMG.com.au

Contents

Executive summary

- Australia's COVID-19 death rates are low by global standards.
- One reason for Australia's effective performance can be traced to our health system capability and preparedness, where we rank in the top 10 per cent of all countries. KPMG analysis found that this is strongly related to lower death rates. This is probably a function of both good management of our health system, as well as some good luck that we have the wealth to invest in our health care system.
- Where Australia is perhaps not so lucky is our population demographics: a relatively high proportion (10 per cent) of our population is aged 70 and above. In most other countries, this is associated with higher death rates.
- Australia's testing regime to date has focused on testing those at high risk of COVID-19 infection, rather than testing of the broader population. Globally, this narrower type of regime is associated with higher death rates, so as more testing becomes available, we could expect our case fatality ratio to fall further.
- Australia's efforts to successfully "flatten the curve" of positive COVID-19 cases have undoubtedly saved lives, and efforts to keep cases in check relative to our health system capacity is of critical importance to avoid a steep increase in the number of fatalities.
- While analyses tend to focus on ratios such as deaths to cases, or cases to beds, our result highlights that the absolute size of the problem also matters: countries with relatively large populations, including Australia, are particularly susceptible to high death rates when cases exceed health system capacity.
- The epidemiology of COVID-19, and global responses to it, are incredibly complex. The analysis presented here considered only broad, country-level factors based on available high-level data. The results should therefore be considered indicative only.

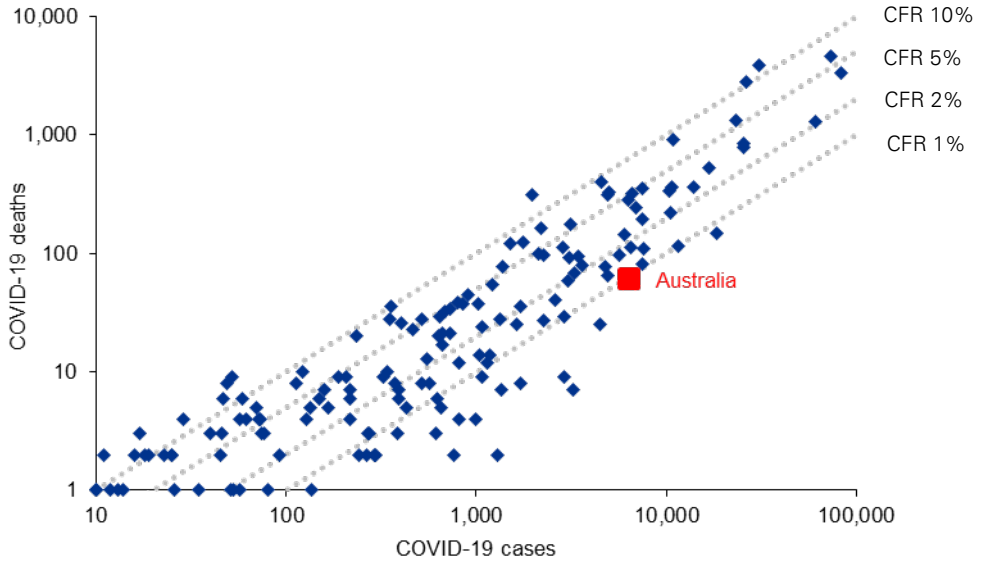
Introduction

Earlier this month the Morrison government released the Doherty Institute modelling that has informed its decisions to date[1]. The modelling highlighted the potential for COVID-19 cases to rise rapidly across Australia in the absence of policy responses such as social distancing. Of course, Australia has enacted social distancing and progressively locked down the country, and, as a result, has seen a sharp 'flattening of the curve' in the number of positive cases of COVID-19.

However there remains much uncertainty and many unknowns: for example, in releasing the modelling, the Prime Minister and the Chief Medical Officer did not know when or if a vaccine will be found; and could not say what the death rate will be[2]. One measure of the death rate is the case fatality ratio (CFR), which reports the number of COVID-related deaths relative to the number of COVID-19 cases. In Australia, the CFR is currently a fraction lower than 1 per cent (less than one death per 100 COVID-19 cases). This is an excellent result compared to most countries across the globe (see Figure 1); Italy, for example, has a CFR of 13 per cent (13 deaths for every 100 people infected with COVID-19)[3].

In this short report, KPMG Economics examine global COVID-19 deaths, cases and resulting CFRs to better understand the drivers of the variation, and the extent to which Australia's relatively good performance is a result of good luck, good management, or a combination of both.

Figure 1: Global variation in COVID-19 cases, deaths and case fatality ratio (CFR), April 14th 2020



Source: https://ourworldindata.org/coronavirus-data, April 14th 2020

1 https://www.health.gov.au/news/modelling-how-covid-19-could-affect-australia
2 https://www.theage.com.au/national/scott-morrison-is-starting-to-take-us-into-his-confidence-that-s-important-20200412-p54j3y.html
3 https://ourworldindata.org/coronavirus-data, April 14th 2020

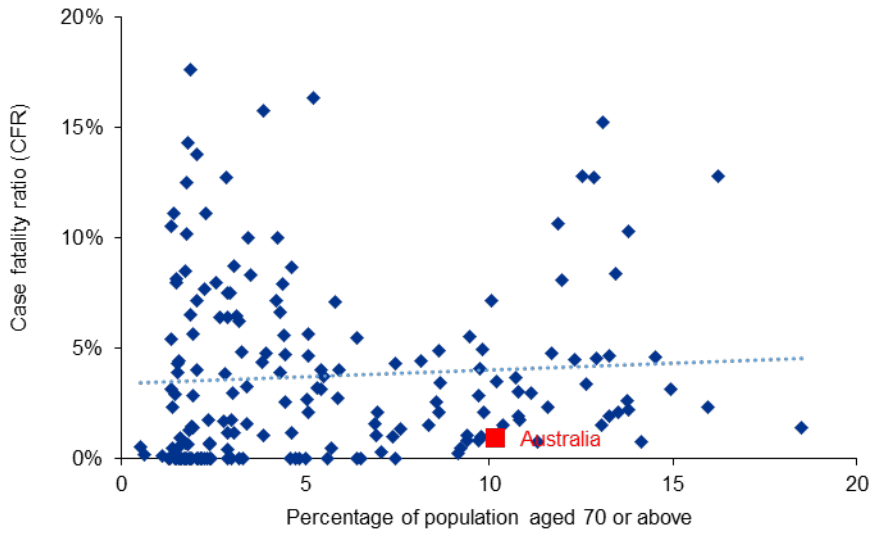
Potential reasons for variation in the CFR across the globe

On first glance, it might seem surprising that the CFR varies so much across the globe. After all, death doesn't usually discriminate. However there are many reasons that might explain the variation, including age and comorbidity of the population; the COVID-19 testing regime that has been adopted; and the capacity, capability and preparedness of each country's health care system.

Age and comorbidity

'All-cause' mortality rates in the general population vary by age and comorbidity. The same is true for COVID-19, only the effect is magnified[4]. We can therefore expect a higher CFR in countries with more elderly and comorbid populations. Around 10 per cent of Australia's population are aged 70 or above[5], which is almost double the global average[6], so we would expect this to push up our CFR. However when compared to other countries with similar age profiles, Australia tends to have a relatively low CFR (Figure 2). This may be due to our population health: our rates of smoking and CVD deaths are less than half the global average[7], although our prevalence of chronic respiratory illness is above the global average[8].

Figure 2: Case fatality ratio versus proportion of population aged 70 or above



Source: https://ourworldindata.org/coronavirus-data, April 14th 2020

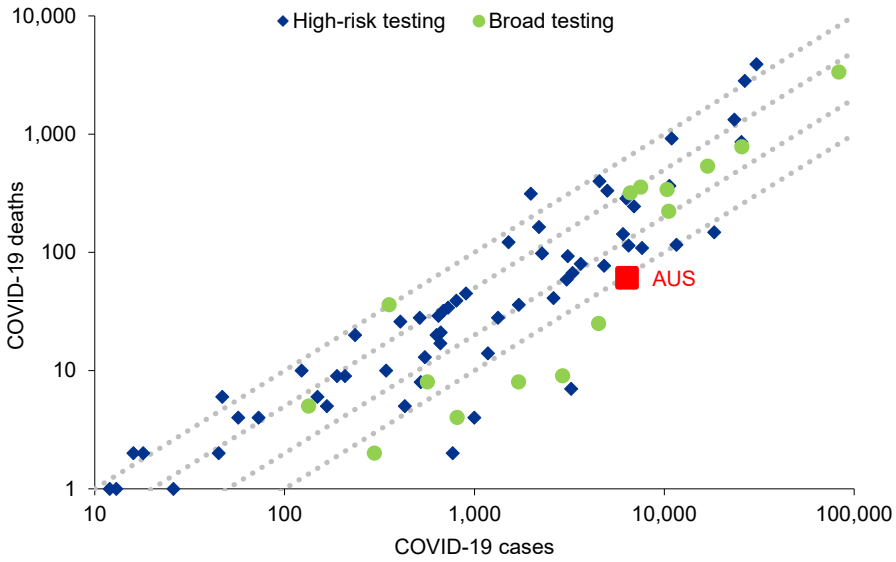
COVID-19 testing criteria

Different countries have applied different criteria to who is tested for COVID-19. In Australia, testing has been confined to 'at risk' people amongst the population (the elderly, those returning from overseas, or health care professionals), so that most confirmed cases are in the high risk category, although we note that this is just

[4] https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30243-7/fulltext
[5] https://ourworldindata.org/coronavirus-data, April 14th 2020
[6] https://ourworldindata.org/coronavirus-data, April 14th 2020
[7] https://ourworldindata.org/coronavirus-data, April 14th 2020
[8] http://ghdx.healthdata.org/gbd-results-tool

beginning to change[9]. Nonetheless, we would expect to see a higher CFR than for countries that have been testing a broader population, including lower risk people. The University of Oxford has a government response tracker that categorises the type of testing regime being adopted across countries, with the majority of countries following similar regimes to Australia, and only 14 per cent testing more broadly[10]. Figure 3 plots COVID-19 cases, deaths and CFRs for countries by testing regime, with high-risk testing regime countries (blue) versus countries with a broader based testing regime (green). Australia has a CFR lower than most other countries with a similar (high-risk) testing strategy.

Figure 3: Global variation in COVID-19 cases, deaths and case fatality ratio (CFR), by testing regime



Source: https://ourworldindata.org/coronavirus-data, April 14th 2020

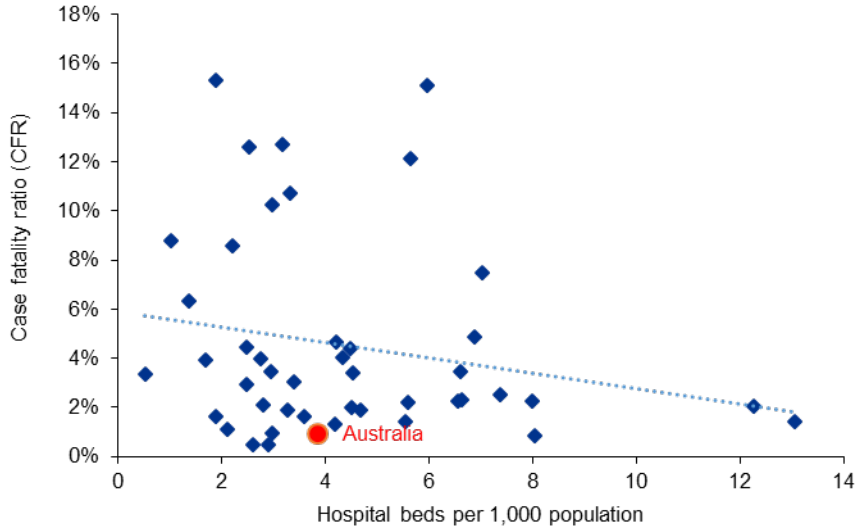
There can also be variability in how a COVID-19 death is defined. In some countries, such as Spain for example, authorities only report confirmed COVID-19 deaths; which means that only people who were tested positive for COVID-19 were counted in official figures[11]. In other countries, there may be a large share of deaths that are not yet reported in the official data[12]. Unfortunately, these sources of variability are difficult to systematically quantify across countries.

Health system capacity, capability and preparedness

The treatment of severe cases of COVID-19 requires trained medical staff and equipment such as respirators and intensive care units. Where these staff and equipment are available, and the health system is not overwhelmed, we can expect to see lower CFRs than in countries where there are insufficient resources to treat those in need[13]. Australia's health system capacity, as measured by hospital beds per 1,000 population, is about average (Figure 4).

[9] https://www.abc.net.au/news/2020-04-16/coronavirus-testing-expands-who-can-get-tested-and-where/12153004
[10] https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker
[11] https://english.elpais.com/spanish_news/2020-04-08/coronavirus-deaths-in-madrid-could-be-3000-above-official-figures.html
[12] https://www.abc.net.au/news/2020-04-16/uk-aged-care-home-hit-by-coronavirus-outbreak-covid19/12149024
[13] https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30627-9/fulltext

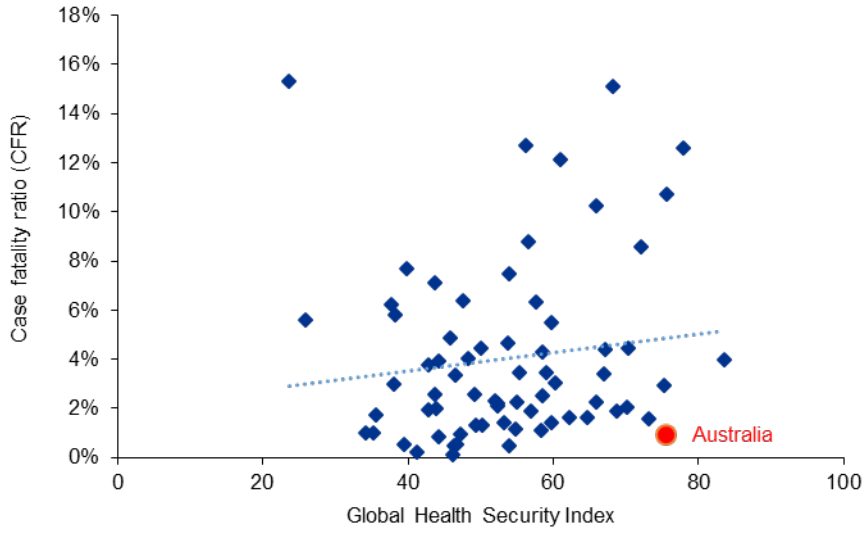
Figure 4: Case fatality ratio versus health system capacity



Source: https://ourworldindata.org/coronavirus-data, April 14th 2020

The Global Health Security Index (GHSI) has a range of metrics that measure the readiness and capability of a country's health system to endure pandemics such as COVID-19. Australia performs strongly in these metrics, although interestingly, the basic scatter plot suggests that a better score is associated with a higher (worse) CFR (Figure 5). However, once other factors are controlled for in an econometric model (next section), this relationship reverses and a higher score is associated with a lower (better) CFR.

Figure 5: Case fatality ratio versus the global health security index



Source: https://ourworldindata.org/coronavirus-data and https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker, April 14th 2020;

An econometric analysis of Australia's performance based on the observed global variation

KPMG tested a range of regression models to better understand how the above and other similar factors combine to influence Australia's COVID-19 deaths and CFR. An overview of the data, sources and methods used is provided in the appendix.

Regression results and interpretations are shown in Table 1. There is overlap and interactions between some variables; and variability in definitions and issues with the underlying data; as a result the analysis presented here is indicative only.

Table 1: Regression analysis log (deaths)

Metric	Coefficient	Marginal impact for Australia	Shapley contribution
Deaths (log)	Dependent variable		
Cases (log)	1.15***	A 10 percent increase in cases would be associated with a 11.5 percent increase in deaths	62.0%
Age >= 70 (log)	0.30	A 10 percent increase in population 70 or above would be associated with a 3 percent increase in deaths	6.3%
Testing regime			4.5%
1 = narrow (high risk)	Reference		
2 = medium	-0.52*	Moving from a high risk testing regime to a medium regime would be associated with a reduction in deaths by 40 per cent	
3 = broad	-0.67**	Moving from a high risk testing regime to a medium regime would be associated with a reduction in deaths by 50 per cent	
Large population & high case to bed ratio	0.92**	Moving into this category would be associated with a 250% increase in deaths	24.6%
Overall health system preparedness	-0.03**	A one point change in score would be associated with a 3.5 per cent change in deaths	2.6%
		Total Adjusted-R2	89.5%

*, ** and *** report statistical significance 1, 5 and 10 per cent respectively.

Demographics and comorbidities

Australia has over 10 per cent of the population aged 70 and above, but our CFR is more in line with a country with a younger demographic profile. Across the globe, an ageing population is positively related to the CFR, with a 10 per cent increase in the share of the population aged 70 and above adding about 3 per cent to the CFR.

However, demographics are not the only driver: if Australia had the same demographics as Italy (16 per cent share 70 and above), we could expect a CFR of around 3, whereas Italy's CFR is almost 13. Interestingly, none of the comorbidity metrics we tested (e.g. smoking, obesity, CVD, chronic respiratory illness) explained any of the variation in CFRs. We suspect this is due to the high correlation with other variables (e.g. demographics, GHSI).

Testing regimes

Countries that widely test across the population are reporting CFRs around half of those countries that test only high risk cohorts, consistent with Figure 3. This suggests that as testing in Australia becomes more widely available, Australia's CFR should drop even further.

Health system capacity, cases and population size

A clear threshold is observed in the data for countries with a relatively large population (greater than 10 million people): those with a relatively high ratio of COVID-19 cases to health system capacity are performing particularly poorly. As cases exceed health system capacity, the CFR increases dramatically, but the absolute size of the problem also matters. It is countries with relatively large populations that are more susceptible to high death rates. Based on this global analysis, cases reaching a critical level relative to our health system capacity would have been associated with an increase in Australia's CFR of 250 per cent.

Population density was also considered, but was not a statistically significant predictor of variation in death rates. We suspect that country-level population density may not capture some of the city-level density or country interconnectedness issues that could impact COVID-19 outcomes.

Health system capability and preparedness

Health system capability and preparedness are also strongly associated with CFRs. Australia's capability and preparedness ranks in the top 10 per cent of countries, and is a key driver of our excellent COVID-19 results to date. A rank in the middle of all countries would be associated with a doubling of our CFR. The health system capability metrics are highly correlated with GDP per capita however, so this could also be a result of wider factors associated with our wealth and living standards.

Cases

The above factors all influence the nuanced relationship between the number of COVID-19 cases and the number of COVID-19 deaths. However, it bears repeating that the strongest driver of COVID-19 deaths is simply the number of positive COVID-19 cases. Australia sits at less than 7,000 cases and 70 deaths; had that number reached 20,000 cases, we could have expected a fourfold increase in the number of deaths.

Table 2: Metrics and data sources

Data group	Metric description	Metric name	Date	Year	Source
Outcomes	deaths	deaths	14/04	2020	https://ourworldindata.org/coronavirus-data
	case fatality ratio (CFR)	cfr	14/04	2020	deaths/cases
Demographics	population	pop	N/A	2017	https://ourworldindata.org/coronavirus-data
	proportion aged 70 and above	age70	N/A	2015	https://ourworldindata.org/coronavirus-data
	population density	popdens	N/A	2018	https://data.worldbank.org/indicator/en.pop.dnst
Comorbidities	proportion male smoking	male_smoking	N/A	2016	https://ourworldindata.org/coronavirus-data
	proportion female smoking	female_smoking	N/A	2016	https://ourworldindata.org/coronavirus-data

	proportion male obese	male_obese	N/A		https://ourworldindata.org/coronavirus-data
	proportion female obese	female_obese	N/A		https://ourworldindata.org/coronavirus-data
	cvd deaths	cvd	N/A	2017	https://ourworldindata.org/coronavirus-data
	chronic respiratory illness prevalence per population	chr_resp_prev	N/A	2017	http://ghdx.healthdata.org/gbd-results-tool
	chronic respiratory illness 70+ prevalence per population	chr_resp_prev70	N/A	2017	http://ghdx.healthdata.org/gbd-results-tool
Testing	testing	testing	14/04	2020	https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker
	tests per 1,000	testspt	14/04	2020	https://ourworldindata.org/coronavirus-data
Capacity	beds per 1,000	bedspt	N/A	2015-2018	https://ourworldindata.org/coronavirus-data
	medical doctors per 1,000	medspt	N/A	2014-2017	https://ourworldindata.org/coronavirus-data
	beds	beds	N/A	2015-2018	beds per 1,000 X population
	medical doctors	meds	N/A	2014-2017	medical doctors per 1,000 X population
	cases	cases	14/04	2020	https://ourworldindata.org/coronavirus-data
	cases/beds	casespb	N/A	2015-2018	cases/beds
	cases/medical doctor	casespm	N/A	2014-2017	cases/medical doctor
	High population, high cases to bed ratio (factor variable)	popcbc1	14/04		1 if Population > 9,740,000 & cases/beds >0.21; 0 otherwise
Capability	GHS Scores	ghs	N/A	2019	https://www.ghsindex.org/
	Prevention of the emergence or release of pathogens	prev_path	N/A	2019	https://www.ghsindex.org/
	Early detection & reporting epidemics of potential international concern	detect_epid	N/A	2019	https://www.ghsindex.org/

	Rapid response to and mitigation of the spread of an epidemic	rapid_resp_epid	N/A	2019	https://www.ghsindex.org/
	Sufficient & robust health sector to treat the sick & protect health workers	robust_health	N/A	2019	https://www.ghsindex.org/
	Commitments to improving national capacity, financing and adherence to norms	nat_capacity	N/A	2019	https://www.ghsindex.org/
	Overall risk environment and country vulnerability to biological threats	overall_risk	N/A	2019	https://www.ghsindex.org/
GDP	GDP per capita	gdppc	N/A	2017	https://ourworldindata.org/coronavirus-data

Conclusion

Australia's COVID-19 death rates are low by global standards. This is particularly impressive given our relatively elderly population, and our strict testing regime to date, factors that tend to push up a country's CFR. One reason for Australia's effective performance can be traced to our health system capability and preparedness, where we rank in the top 10 per cent of all countries. Our analysis found that this is strongly related to lower death rates. Australia's efforts to successfully flatten the curve have also undoubtedly saved lives. Efforts to keep cases in check relative to our health system capacity is of critical importance to avoid a steep increase in the number of fatalities. While analyses tend to focus on ratios such as deaths to cases, our result highlights that the absolute size of the problem also matters: countries with relatively large populations, including Australia, are particularly susceptible to high death rates should case numbers creep up relative to health system capacity.

Appendix 1: Detailed methodology

Data

For each of the factors identified above, metrics or a range of metrics were developed. For example, for population demographics, we use the share of the population aged 70 and above; for comorbidities we use the share of population with a range of disease and risk factors, such as smoking, obesity and cardiovascular disease. For a country's testing regime, we use an indicator from the Oxford University government response tracker metric, and the number of tests per million population. For health system capacity, we use hospital beds and medical doctors per thousand population. Metrics with particularly skewed distributions are log transformed. The full list of metrics and sources is provided in Table 2 below. Data is sourced predominantly from Oxford University's World in Data (https://ourworldindata.org/coronavirus-data), as at 14th April 2020.

Methodology

KPMG developed a range of regression models to investigate the relationship between deaths, cases and the CFR. In general, the models regressed deaths or CFR against the range of explanatory variables provided in Table 2, e.g.

$$\ln \delta_t = \alpha + \beta_1 \ln \emptyset_t + \beta_i X_{i,t}$$

where δ_t = total COVID-19 deaths on day t

$\emptyset_t$ = total COVID-19 cases on day t

$X_{i,t}$ = predictor i on day t

Models were chosen based on their performance in explaining the observed variation (adjusted-R2) and the consistency with underlying known relationships (e.g. that the CFR is related to age[14]). Models were completed for data as of 14th April 2020. Panel models were also considered, to try to better capture the time-varying relationship between cases, capacity and the CFR, however there were issues with inconsistent and volatile data, and so simple point-in-time models were ultimately adopted. To test the robustness of this to changes over time, the models were also estimated at earlier dates (e.g. 1st April 2020 and 7th April 2020) to test if the broad relationships held.

One of the major issues with the analysis is the high degree of correlation between many of the potential explanatory predictors. Because of this, we performed a basic regression tree investigative analysis to uncover potential thresholds and interactions between variables. The population versus case to beds factor variable was a result of this analysis.

Limitations

There are a range of limitations that should be noted, including the use of broad, population data and a subjective categorical variable for testing regimes that contains significant heterogeneity within categories; omitted variable bias, particularly for respiratory comorbidity and issues around definitions of COVID-related deaths, as well as the omission of 'exogenous shocks' like cruise ships; point-in-time analysis; and selection bias of relatively rich countries where data was available. There are also likely to be complex interactions between factors that have not been accounted for. The results presented here should be considered as indicative only.

[14] https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30243-7/fulltext

Acknowledgement

KPMG Australia would like to acknowledge the authors of this report, from our Economics and Tax Centre, including:
— Dr Chris Schilling
— Dr Ashley Crouch
— Michael Cowling
— Dr Brendan Rynne

Contact us

Brendan Rynne
Partner, Chief Economist
+61 3 9288 5780
bjrynne@kpmg.com.au

Dr Chris Schilling
Senior Health Economist
cschilling1@kpmg.com.au

KPMG.com.au

March 2020.