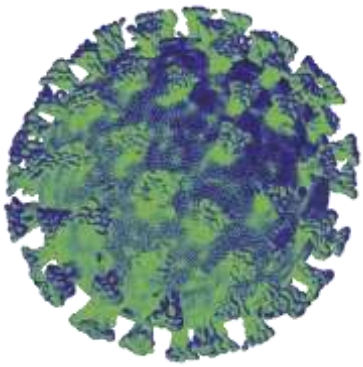
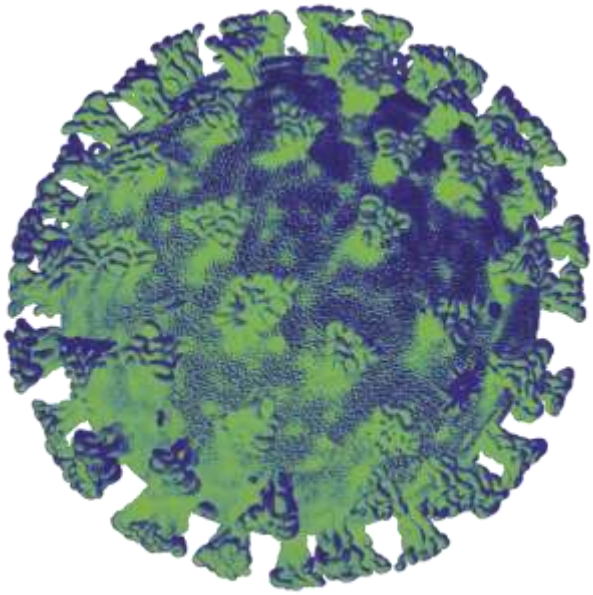
Llywodraeth Cymru
Welsh Government

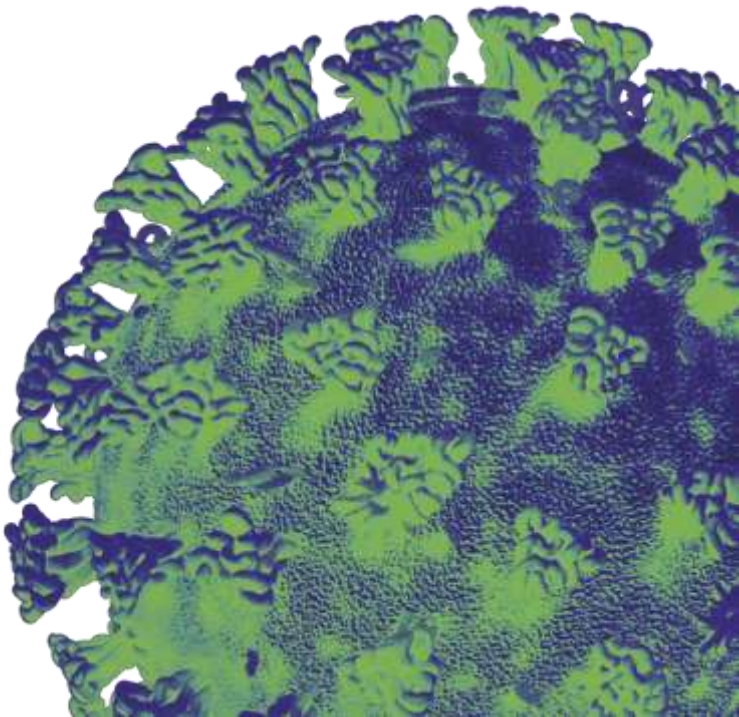
Technical Advisory Cell

Briefing: Seasonal effects on Covid 19 in S. America

10 July 2020







Briefing: Seasonal Effects on COVID-19 in South America – as of 25th June 2020
Health and Social Services COVID-19 Technical Advisory Cell (TAC)
Welsh Government Office for Science

Structure of Report

Findings:

Socio-economic.

- Poverty is associated with a strong prevalence and spread of the disease;
- The main hotspots in South American countries are associated with slums, ghettos, poor or very poor districts and social deprivation;
- Lack of, or a very poor, welfare state or poor and non-existent isolation financial support (furlough funding) forces the poor to continue to work when infectious, thus exposing other people in similar situations to the disease;
- Social deprivation is associated with over-crowed and densely populated districts or regions in large and medium cities (in the worst cases they are described as ‘slums’);
- The over-crowded, deprived areas have little access to open spaces, clean and unpolluted living conditions, with many households (up to 30%) without running water;

- The populations in these areas are generally less healthy due to diseases and illnesses of deprivation (obesity, diabetes, high incidence of smoking and alcohol abuse, drugs, crime and violence of all sorts);
- Employed people tend to have insecure and poorly paid work in often poor working conditions.
- All of these factors contribute to the spread of and high mortality from COVID-19, thus encouraging hotspots and clusters of infections.
- Both relative and absolute deprivation are important concepts. Despite much lower GDP, some south and Central American countries have quite high life expectancies, due in part to lower levels of non-communicable diseases.

Winter and wider environmental conditions:

- Evidence suggests that winter conditions in some countries (Argentina and Chile) add to the above because of diminished natural light and sunlight levels (where UV light is a factor in killing the virus).
- Cold and/or wet winter conditions encourage populations to remain in-doors rather than going outside.
- Winter conditions may reduce individuals' ability to fight off infections of all types, thus making them more susceptible to this virus.

Socio-political

- Unlocking procedures have started in most countries before proper control of the disease has been established. The possible exception to this is Argentina which, until recently, has had good control but this is beginning to breakdown in some districts of the capital Buenos Aires.
- Social unrest and demonstrations has been a symptomatic issue of deprivation in Chile and Peru and has been for a considerable time prior to the CV-19 pandemic. This has been driven by socio inequalities, poor working conditions, low pay and insecure employment and general disparities in social expectations, achievements and mobility as well as crime and violence.
- Trust in governments is low in Chile, Brazil, Peru and some other countries in South America and while Argentina has fared much better than most countries, this may be being eroded by the recent rapid rise in infections.

Parallels to the UK

- The level of social deprivation and poor living conditions is nowhere near as bad as parts of South America.
- Despite the above statement, there is significant disparity in socio-economic well-being between many parts of the UK. See COVID-19 and Health Inequalities in Wales. PHW reports on inequalities in Wales show the most deprived having 6-7 years lower life expectancy than the most affluent fifth.
- The likelihood of similar conditions in the UK to those of parts of South America becoming hotspots of infection is high, for example in overcrowded, multiple-occupancy, poor physical living condition housing and domestic settings, particularly amongst groups who also cannot afford not to work.

- Close confinement working conditions for discrete populations, for example in the meat processing and chilled ready-meal food preparation industries may encourage disease hotspot and cluster formation.
- Poor weather conditions, i.e. dark, cold, wet and windy conditions will encourage populations to remain in-doors and where overcrowding or densely populated areas exist, the disease is more likely to spread and hot spots to be formed.
- The above points will be exacerbated by other issues as described in the report "COVID-19 and Health Inequalities".

Mitigation measures:

As winter is approached, in all enclosed environments (public buildings, offices, factories, work places), control of the disease will be helped by:

- Good and regular hand hygiene
- Face coverings and masks
- Social distancing (min 1 metre but preferably 2 metres)
- Strong natural lighting or UV lighting (either artificial 'daylight', or UV lighting)
- Good indoor ventilation
- Higher indoor humidity
- Higher indoor temperatures

In broader terms, control of the disease will be helped by:

- An effective test, trace and protect system;
- Social welfare support system which allows for confirmed or suspected cases to be adequately supported financially while they self-isolate, i.e. to discourage return to work before the completion of the 14 days isolation period.

Introduction:

Infectious disease experts say they cannot be sure if the coronavirus is seasonal as it is with many other viruses, i.e. that it is more prevalent in winter conditions, because it has not been around long enough for sufficient evidence to be gathered to support such a conclusion. However, respiratory diseases like colds and flu exhibit strong seasonal correlation with winter months having the highest incidence. Scientists are unsure of the exact causes of this seasonality, but it is suggested here that there may be three contributing factors:

- It is thought that cold air causes nasal and airway irritation that makes people more susceptible to infection, or other health conditions exacerbated by winter increases the risks of a more acute response to infection (relevant for underlying health and wellbeing);
- People's behaviours change in that they spend more time in close confinement in indoor spaces that may help the viruses to spread (relevant for social distancing);
- Winter conditions (cold, damp, dark) may help viruses survive for longer in the environment, either in the air or on surfaces (relevant for face masks/coverings, hand washing, surface cleaning, ventilation, natural daylight/sunlight).

Furthermore, these seasonal effects may run in parallel to, or be enhanced by, other factors such as the following:

- Political (in)stability, corruption, crime and violence, trust in authorities;
- Levels of state welfare support and healthcare systems;
- Levels of socioeconomic deprivation and poverty.

By monitoring the spread of the virus in the southern hemisphere, especially South America, intelligence on individual or combined effects of the above may be assessed as these countries progress through their winter (June – August). Comparisons and lessons learned may help the UK and other northern hemisphere countries prepare for winter well in advance of the approach of that season.

Several Latin American Countries (Argentina, Bolivia, Brazil, Chile, Paraguay, Peru and Uruguay) and South Africa were selected to see how the onset of winter is affecting the rates of infection against a backdrop of wider factors.

Approaches taken by Southern Hemisphere countries.

Most of the countries studied imposed lockdowns early on in the pandemic but nearly all never got the R value below 1, in contrast to countries in Europe. The informal economy (black market) has continued to operate during lockdown with little regulation or lockdown restrictions and this may be contributing to many of these countries are experiencing large spikes in infections as official lockdown restrictions are eased.

Early research from Australia and China indicate a decrease in humidity has more of a significant effect on transmission rate than a lower temperature. It is known that indoor transmission is higher for the coronavirus and winter causes more people to gather indoors in the winter months. The known ability for UV light to kill the virus outdoors will diminish during the shorter winter days as the duration and intensity of the light decreases.

Recent outbreaks in meat processing plants across the UK and Europe/US may indicate that in the colder, chilled environments of the factories the virus spreads more easily. The use of migrant workers and their use of dormitories may add to the spread in some cases. The biggest cluster in the US emerged at the Smithfield Pork plant in South Dakota in March. The UK has had clusters recently at factories in Anglesey, Wrexham and West Yorkshire. Germany has had its first outbreak since relaxing restrictions associated with a meat processing plant and authorities in North Rhine-Westphalia are bringing back local lockdown measures for the first time since lifting restrictions in May.

The Latin American countries socioeconomic and health care systems were compared to see if health inequalities play a role. Poverty may have forced people to ignore social distancing guidelines more so relative poverty was considered. A recent welsh government report for the Executive Directors Team looked at COVID-19 and Health Inequalities in Wales.

https://documents.hf.wales.gov.uk/id:A30459752/document/versions/latest

Access to water and sanitation was included as hand hygiene continues to be a WHO directive.

It is thought that monitoring the rate of infection in South America as it enters winter will give the northern hemisphere an indication of how the seasonal change may impact the spread of COVID-19. As with other seasonal viruses, it is expected that there may be an increase in people's susceptibility to infection as air temperature falls. The recent rise in daily cases in South America as they enter winter adds to this caution.

Weather and current case rates in Southern Hemisphere countries

To assess possible seasonal variations, a selection of Southern Hemisphere cities were chosen and compared to that of London. The table below illustrates the inter-seasonal changes in temperature and humidity. Please note that London appears unusual simply because the summer/winter cycle is 6 months out of phase between the northern and southern hemispheres.

Average temperature (0C) and Humidity (%) ranges

Country/City	January temp range Celsius	July temp range Celsius	January Humidity	July Humidity
Argentina/Buenos Aires	30-20 C	16-8 C	65%	79%
Chile/ Santiago	30-12 C	14-2 C	57%	84%
Brazil /San Paulo	27-21 C	22 - 8 C	80%	78%
Brazil/ Rio de Janeiro	30-23 C	25-18 C	80%	79%
Uruguay/ Montevideo	28- 19 C	15-7 C	68%	80%
Paraguay/ Asunción	34-23 C	24-13 C	70%	68%
Bolivia / Sucre	21-11 C	20-5 C	67%	39%
South Africa / Johannesburg	26-15 C	17 -2 C	70%	50%
UK/ London	8-2 C	23-14 C	82%	64%

Source NOAA's National Centres for Environmental Information (NCEI)
https://www.ncdc.noaa.gov/

The best comparators to the UK based on average yearly temperatures are South Africa, Uruguay, Chile, Argentina and Bolivia. San Paulo and Brazil are included due to their high daily case rates and political stance on the virus. The best humidity comparators to the UK are Uruguay, Argentina South Africa and Chile, being of higher southern latitude.

The total infection cases and total deaths were compared for the selected countries as illustrated in the table below.

WHO Coronavirus Disease (COVID-19) Dashboard last updated: 10:00 CEST, 21

June 2020 https://www.worldometers.info/coronavirus/#countries

Country/City	Cases	Deaths	Population	Case rate/per million	Death rate/ per million
Argentina/Buenos Aires	39570	979	45,195,774	875.5	21.7
Chile/ Santiago	236748	5355	19,116,201	12384.7	280.1
Brazil /San Paulo	1032913	43959	212,559,417	4859.4	206.8
Brazil/ Rio de Janeiro	1032913	43959	212,559,417	4859.4	206.8
Uruguay/ Montevideo	853	24	3,473,730	245.6	6.9
Paraguay/ Asunción	1362	13	7,132,538	191.0	1.8
Bolivia / Sucre	22476	715	11,673,021	1925.5	61.3
South Africa / Johannesburg	92681	1877	59,308,690	1562.7	31.6
Peru	247925	7660	32,971,854	7519.3	232.3
UK/ London	303114	42589	67,886,011	4465.0	627.4

The ‘per million’ figures (case rate and death rate) were calculated using population data from ‘worldometer’ as shown in the table below. https://www.worldometers.info/world-population/population-by-country/

Argentina	Chile	Brazil	Uruguay	Paraguay	Bolivia	South Africa	UK
45.2 million	19.1 million	212.6 million	3.5 million	7.1 million	11.7 million	59.3 million	67.9 million

Seasonality and the effect of light on disease transmission.

With winter arriving in the southern part of the region and hurricane season in the northern part of South America, the World Health Organization warned recently that these adverse weather conditions could lead to a new spike in infections in Latin

America and hinder its pandemic response and winter is just starting in the southern hemisphere - June to August.

It is not possible to determine whether the recent increase in cases in the region is analogous to the winter influenza spikes experienced in high latitude countries (where the effect of the seasons is more marked between summer and winter), or whether it is due ineffective or too early relaxation of control measures. It is likely to be a combination of both and several other factors considered further below.
With influenza season starting in the southern hemisphere, WHO has alerted countries to maintain vigilance for influenza and prepare for the upcoming influenza season during the COVID-19 pandemic.

Research from the Journal of Infectious Diseases[1] shows that UV light deactivates the virus. Ninety percent of infectious virus was inactivated in 6.8 minutes in simulated saliva and in 14.3 minutes in culture media when exposed to simulated sunlight representative of the summer solstice at 40°N latitude at sea level on a clear day. The artificial light mimicked natural daylight and was varied to reflect UVB irradiance levels for different times of day and year. The temperature and relative humidity were maintained within a narrow range for testing, specifically 20 ± 4°C and 19 ± 5%, respectively.

Significant inactivation also occurred, albeit at a slower rate, under lower simulated sunlight levels. UV levels drop along with daylight hours in winter in the northern hemisphere (Fig.1).

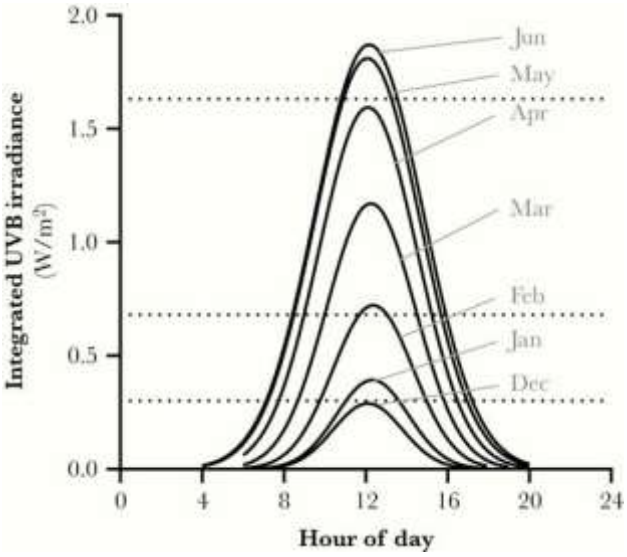


Figure 1. Illustration of daily light levels for different months of the year.

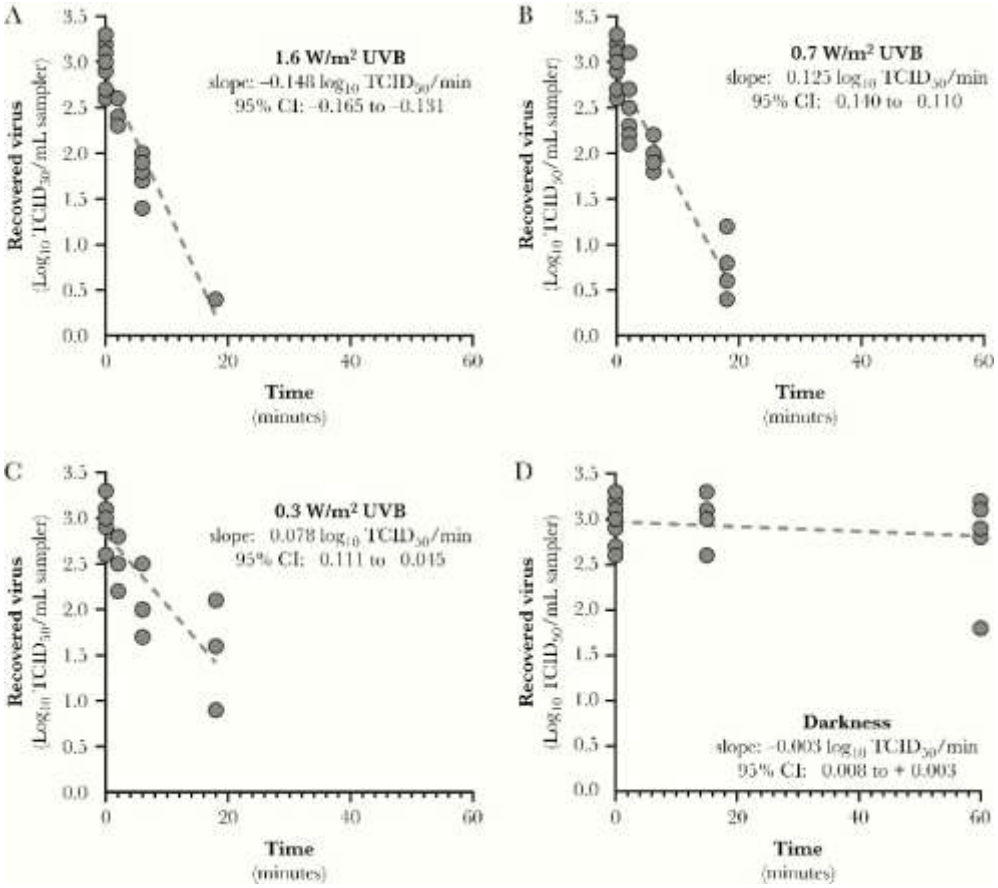


Figure 2 Comparison of strong, weak and no UVB (darkness) on virus deactivation

Previous studies with other viruses, including SARS-CoV-1, have demonstrated that survival in the environment is dependent on multiple factors, including temperature, humidity, sunlight, and the matrix in which the virus is suspended.

Furthermore, other studies[2] have demonstrated that SARS-CoV-2 is stable on surfaces for extended periods under indoor conditions. The study demonstrated that SARS-CoV-2 could persist for multiple days on nonporous surfaces under indoor conditions (23°C, 40% relative humidity), with a maximum half-life approaching 7 hours.

In general, germicidal UV radiation is understood to damage (mutate) the RNA and DNA nucleic acids in a virus, which prevents replication, leading to its deactivation. A previous study demonstrated that light in the UVA portion of the spectrum (315–400 nm) did not damage SARS-CoV-1 at doses similar to those used in the above study. Therefore, the integrated irradiance in the UVB portion of the spectrum (280–315 nm) was utilized to quantify exposure.

The results indicate that natural sunlight may be effective as a disinfectant for contaminated nonporous materials. This effect will lessen in winter. It is worth noting that normal silicate glass absorbs both UVC and UVB radiation, so appropriate specialized lighting would be required if a ‘daylight’ lighting control method was adopted. See appendix for a discussion of the use of artificial UV light.

There are limited data on the burden of disease posed by influenza in low- and middle-income countries. Furthermore, most estimates of influenza disease burden worldwide rely on passive sentinel surveillance at health clinics and hospitals that lack accurate population denominators. Research carried out 2 years ago in Peru indicated that 1 in 10 persons develops influenza each year in Peru, with the highest incidence in young children. Little is known about how changes in seasonal weather affect the new coronavirus. However, six infectious disease experts in Brazil said that past outbreaks in the country, including the 2009 H1N1 swine flu pandemic, point to colder temperatures exacerbating contagions.

A study by the University of Sao Paulo's Institute of Tropical Medicine on the 2009 swine flu outbreak confirmed the highest incidence of infections was in Brazil's three coldest and southernmost states. A 2006 study found that pneumonia and influenza deaths peak in Brazil's southern states during winter.

There are two studies that looked at COVID-19 and temperature/humidity. One looked at 725 cases around the Sydney area and assessed postcodes and weather data on estimated infection dates. This research in Veterinary Science has found a link between COVID-19 and lower humidity[3]. The research led by Professor Michael Ward, an epidemiologist in the Sydney School of Veterinary Science at the University of Sydney, and two researchers from their partner institution Fudan University School of Public Health in Shanghai, China, is the first peer-reviewed study of a relationship between climate and COVID-19 in the southern hemisphere.

Consideration of rainfall, temperature and relative humidity.

During periods of low relative humidity, the public health system should anticipate an increased number of COVID-19 cases. It appears lower humidity is the main driver here, rather than colder temperatures but more research is required. In winter, the combination of cooler temperatures and weaker UV intensity will also be a factor.
The research showed that a 1% drop in humidity increase infections by 6%. The lower humidity allows the virus to stay airborne longer.

The UK will experience similar seasonal conditions when winter arrives in the northern hemisphere. It is thought that most transmission occurs indoors, whereas most studies have analysed data on outdoor humidity, which can be quite different from indoor environments.

Infection rates in different southern hemisphere countries.

The graphs below show the recent daily infection rates and R values for Chile, Brazil, Peru, Argentina, Bolivia and South Africa. In all countries, the infection rates are rising or at best static indicating that their R values are above or very close to 1. The UK is illustrated for comparison.

Figure 3. Argentina

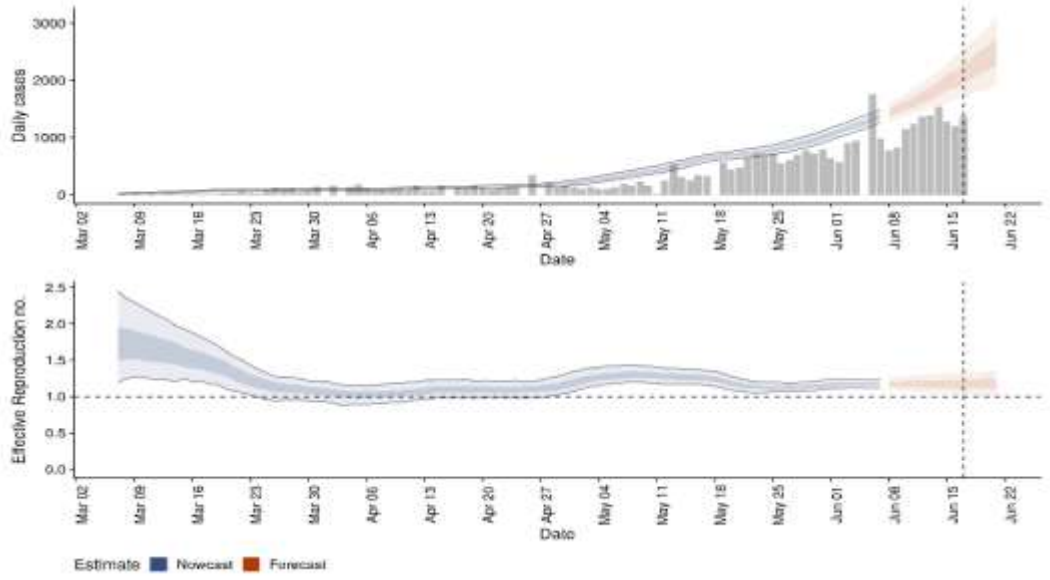


Figure 4. Bolivia

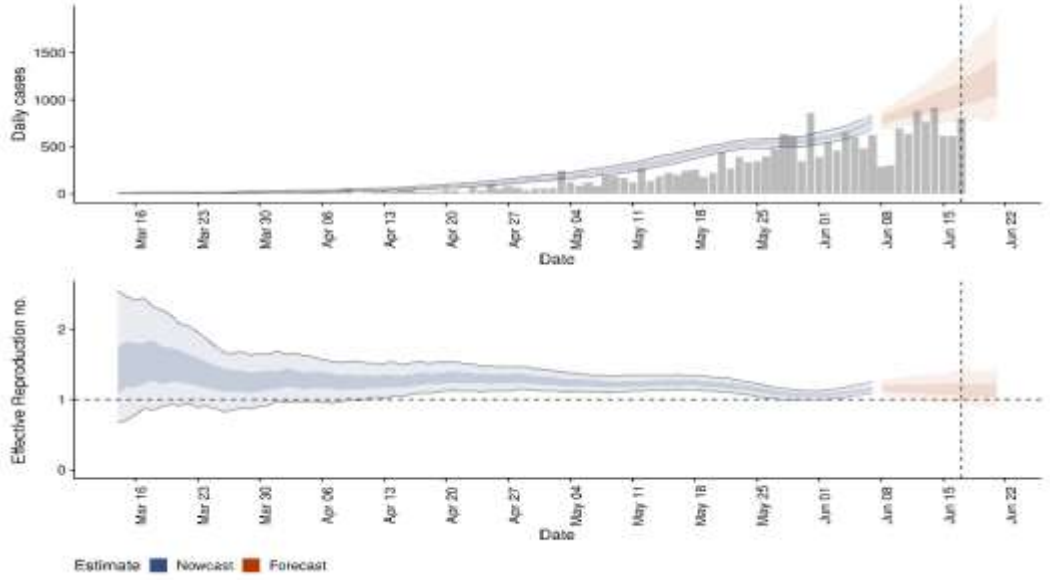


Figure 5. Brazil

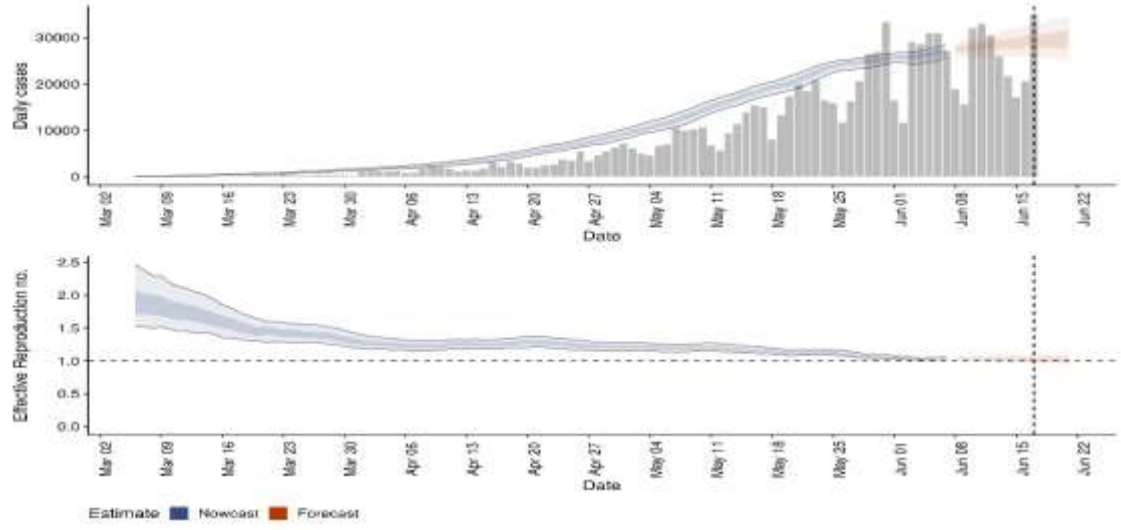


Figure 6. Chile

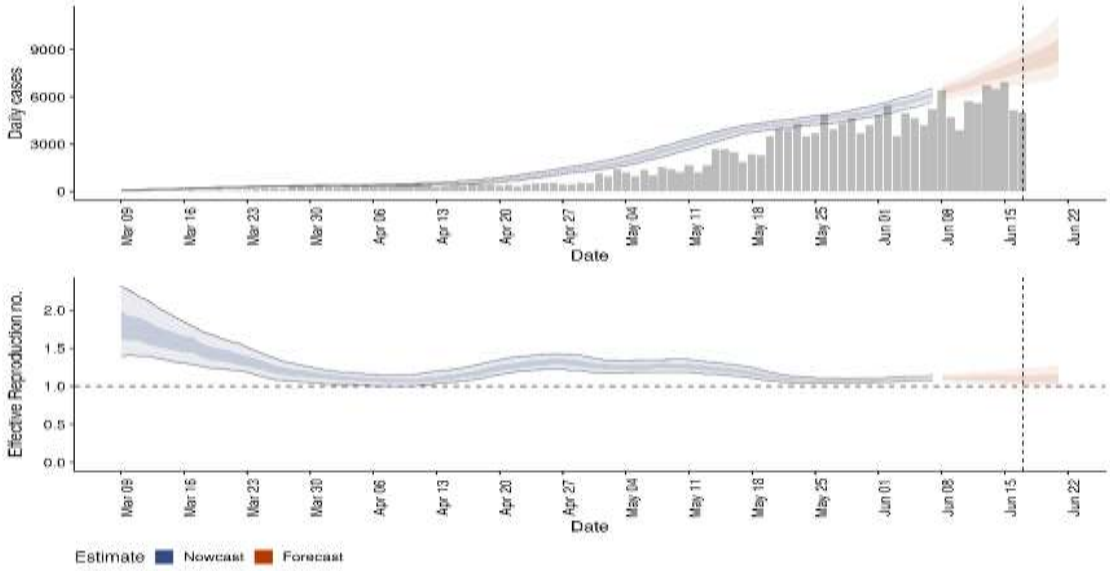


Figure 7. Peru

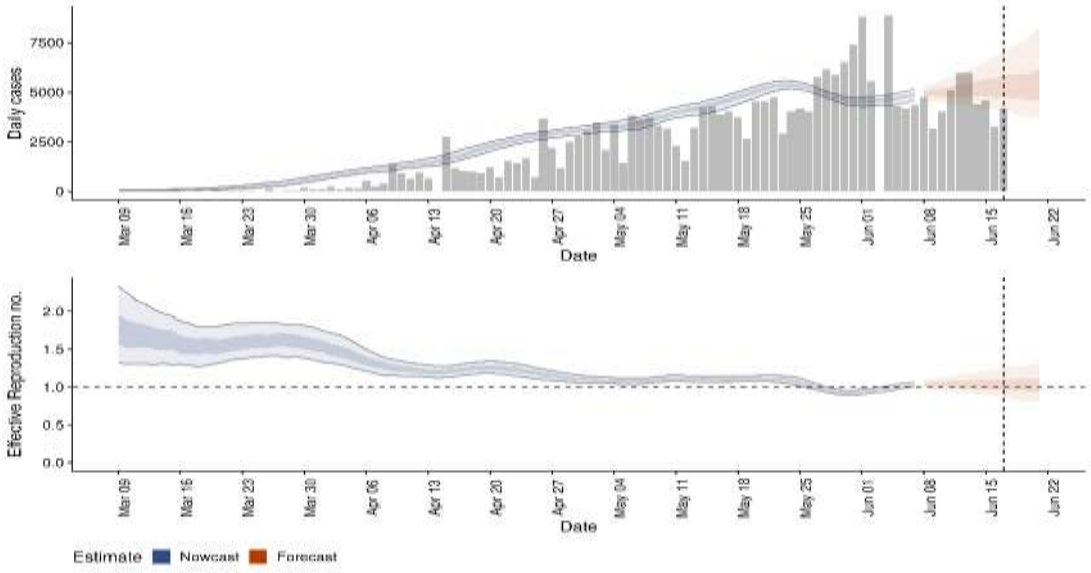


Figure 8. South Africa

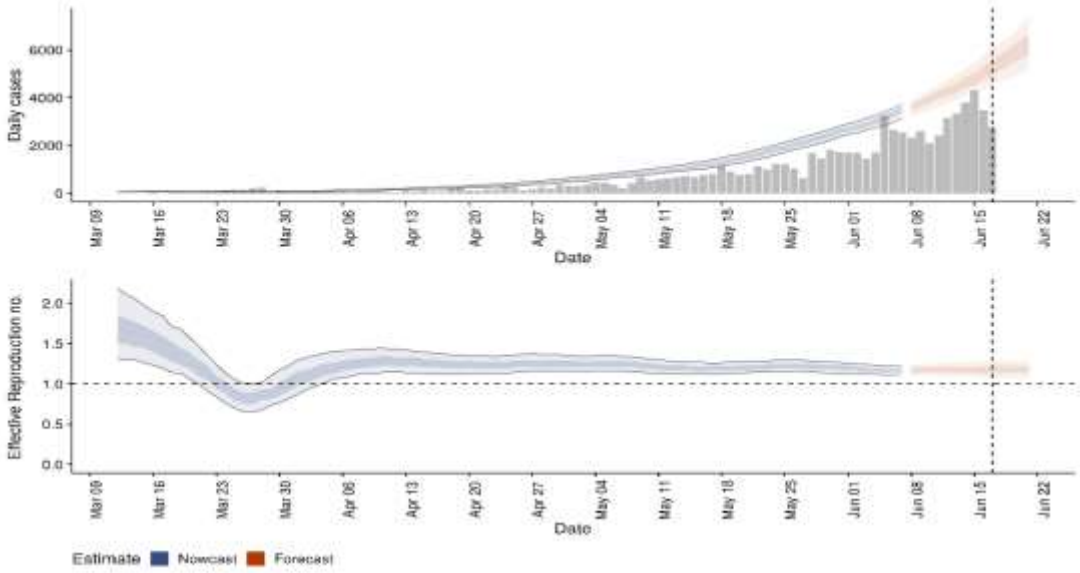
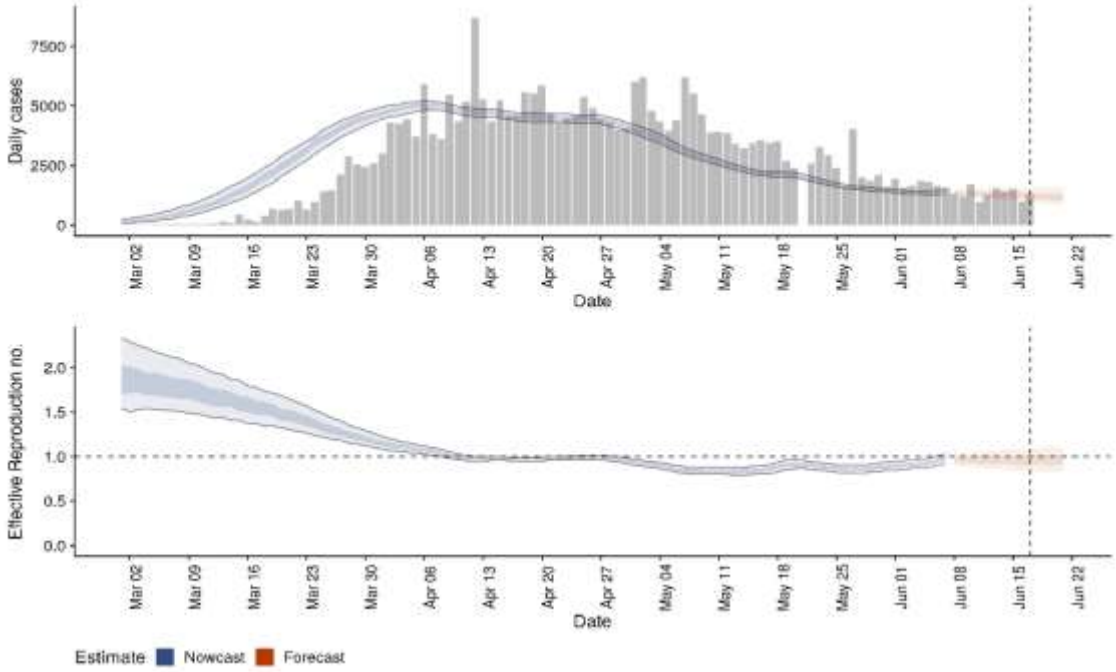

Daily cases
6000
4000
2000
0
Mar 09
Mar 16
Mar 23
Mar 30
Apr 06
Apr 13
Apr 20
Apr 27
May 04
May 11
May 18
May 25
Jun 01
Jun 08
Jun 15
Jun 22
Date
Effective Reproduction no.
2.0
1.5
1.0
0.5
0.0
Mar 09
Mar 16
Mar 23
Mar 30
Apr 06
Apr 13
Apr 20
Apr 27
May 04
May 11
May 18
May 25
Jun 01
Jun 08
Jun 15
Jun 22
Date
Estimate
Nowcast
Forecast

Figure 9. UK



Due to the small numbers of deaths, the Paraguay and Uruguay graphs were not included. National R values for selected countries or regional R values where available were used to compare rates of infection over time.

The R number range for the UK was 0.7-0.9 as of 19 June 2020 and was 0.7-1.0 as of 22 May 2020. Currently all the other countries R numbers are above 1 in June (see Figs 3-9). Brazil has an effective reproduction Value R of 1.1 with all regions with data showing increases in daily cases. Chile has nearly doubled its official death toll in a single day after changing the way it counted fatalities. By including deaths that were probably caused by COVID-19, Chile's death count jumped to over 7,000.
In the early part of the pandemic, R value comparison research[3] was undertaken by comparing Europe (Italy & Spain) with selected Latin American countries; this helped give estimates for the Effective Reproductive value (Rt) for Latin America in the initial stages of the pandemic.

At the time of the initial outbreak all Latin American countries (Brazil, Ecuador, Chile, Colombia, Panama, Mexico, and Peru) in the study had Rt greater than 2. Countries instigated measures to reduce their infection rates and these reduced infection rates but not below 1, i.e. they stemmed in the increase in growth, but did little reduce daily infection rates. More recently, increases in daily case rates in Argentina, Chile, Brazil and Peru have seen Rt rise above 1.

Brazil is an epicentre for COVID-19 in Latin America and research[4] from early May showed that following non-pharmaceutical interventions such as school closures and decreases in population mobility reduced the reproduction value substantially from between 3-4 at the outbreak to close, but is still above, 1. Therefore, the pandemic is still not under control in most of South America, unlike Europe and parts of Asia where similar measure have been more effective.

As with most countries, the infection has not spread evenly across Brazil with wide variations between different parts, suggesting that the epidemic is at a far more advanced stage in some parts of Brazil than in others.
In several countries, significant uncertainty exists in relation to the quality of their surveillance systems. Little is known of the issues around under reporting of deaths and assumptions have had to be made which reduces the reliability and quality of the data. Though governments in the region had ample time to impose lockdowns, and many did in the early stages of the pandemic, they have often been weak or poorly implemented. The shut-down of the formal economy by governments was not mirrored in the 'informal economy' (or black market) which has continued largely unchecked. In addition, social assistance for laid-off workers (furlough or welfare benefits) has been patchy or non-existent so adherence to lockdowns has been less effective.

Argentina was not as affected as other countries in the region but the Buenos Aires area has been hit badly, recording 95% of all the cases in the country. Like the other regional countries, June has shown a large increase in cases and deaths. New cases in Mid May were between 200-300 per day and by mid-June new cases were between 1400-1500 per day leading to a similar increase in deaths.

Covid deaths in Chile were low until early May, i.e. under 10 per day, but on June 17 it has risen to over 200 per day and continues to rise (3,615 deaths in total); this recent spike has caused the country's health Minister to resign. As measured by new cases per million population, Chile (250), Peru (150) Brazil (100) are emerging as hotspots.

The recent increases in South American countries is partly down to relaxing lockdown measures too early, i.e. well before proper control of the pandemics had been achieved.

Effectiveness of Mobility Control Measures

The governments in Latin America introduced measures to mitigate the spread of COVID-19 based primarily on world health organization recommendations but their implementation, adherence and relaxation have differed.

Results show that Rt has dropped dramatically following the implementation of public health interventions, with mobility declining by 29% on average across Brazil and Rt declining by 54% on average. However, in none of the states did results suggest that the measures implemented to date have brought Rt below 1. By contrast, in previously published work examining Italy[5] where stringent measures including societal lockdowns have been implemented, mobility had reduced by 53% compared to baseline[7], reducing Rt by 85% and bringing it significantly below 1.

Similar results from Chile show that mobility was reduced by 40% but this was insufficient compared to the reduction of 70% which was required to push Rt below 1. The lack of adherence to the initial control measures could be a contributing factor to the current rise in new daily cases across the region.

Although this report does not look at Peru for climate reasons it death toll graph is included as it too is seeing a similar increase even though it ordered one of Latin America's first and strictest lockdowns.
President Martín Vizcarra of Peru followed the best advice when the coronavirus arrived in Peru. He rolled out one of the region's biggest economic aid packages to help citizens

stay home. He shared detailed health data with the public, rushed to add hospital beds and ventilators and increased testing. Yet instead of being lauded as a model of disease control, Peru has become one of the world's worst coronavirus hot spots, its hospitals overwhelmed and its people fleeing the cities.
Lockdown did not work in Peru because staying at home was not an option in a country where many people have no savings leading to many ignoring the rules.
Hand washing did not work in a country where only one in three poor households has access to running water. In May, the death rate in Peru from all causes was twice as high as the average of recent years.

Testing rates have increased over time but numbers are currently as illustrated in the table below (tests per million). It is evident that all the countries have a much smaller testing capability than the UK.

Argentina	Brazil	Bolivia	Chile	Peru	South Africa	UK
5,547	11,032	4,522	47,260	3,689	20,716	106,956

Political decisions

Differing political choices between the selected countries may have impacted the control measures. Brazil, the epicentre of the pandemic in the region, has been accused of downplaying the virus. Recently (5th June), the Federal Health Ministry closed the webpage showing daily, weekly and monthly figures on infections and deaths in Brazilian states. President Jair Bolsonaro threatened to pull Brazil out of the World Health Organization. On the June 18th Brazil's controversial Education Minister Abraham Weintraub resigned, due primarily to his comments about the Supreme Court who are investigating him over tweets where he blamed China for the pandemic.

In Chile intense criticism of its management of the pandemic has resulted in the health minister resigning on the 13th June after their highest number of deaths in 24hrs. Chile also began to unlock in April before the pandemic was under control. The vast majority of Chile's 185,000 cases were recorded after the government prematurely espoused a gradual return to normality in April. Chile also experimented with the idea of an immunity passport before backtracking. The messaging from the government encouraged people to go back to normal, despite the infection rate heading upwards. The government has had a fluid strategy of lockdowns in which quarantines were imposed and then lifted in a 'strategic' manner across the capital Santiago. This policy was unsuccessful because commuter travel between unrestricted regions continued to proliferate the spread of the virus and relative poverty in the effected suburbs forced people to continue working, i.e. the informal economy largely ignored the control measures; the uncontrolled and unregulated 'informal' economy is an issue over all of Latin America.

How countries report COVID-19 deaths also varies across the region and obtaining more accurate death figures for comparison with worldwide levels is problematic. Globally the excess deaths figures estimate an extra 130,000 extra deaths on top of the published COVID-19 figures (440,000)[8]. Some will be unrecorded COVID-19 victims, but others may be the result of the strain on healthcare systems and a variety of other factors. For example, the UK excess deaths from March 7th to June 5th has been 43% higher than average with 64,500 more people dying than usual, which is a significantly higher number than the number of people dying from COVID-19. Chile (March 23rd –May 31st)

had 16% excess deaths. The number of deaths in six cities* in Brazil (March 1st –May 31st) has been 38% higher than average but in South Africa (March 25th – June 2nd) the number of deaths was 9% lower than average.

Argentina whose leadership's response has had widespread public approval appeared to be bucking the trend of neighbouring countries but it too is now seeing an increase despite the more cautious decisions made by the government. It entered nation-wide lockdown early on March 19th and has extended the lockdown on several occasions. It was lifted on May 10th but currently due to a recent surge it has a regional lockdown around Buenos Aires and is using temporary isolation centres to feed and care for the poor. Please see the guardian newspaper article on this topic in the appendix. On June 17th Argentina's president Alberto Fernández went into voluntary isolation due to a surge in cases amongst the political elite.

Socio-economic aspects.

Relative poverty in South America may be a contributing factor in the variation of severity of the pandemic. Chile was suffering with social unrest in the year leading up to the pandemic partly due to its failure to provide a social welfare safety net. This helped drive the protests and now these same people cannot afford to stay off work (30% of Chile's workforce in the informal sector) and this is despite Chile having the highest GDP per capita in South America.

There are few areas of Chilean society where the country's inequalities are as apparent as in healthcare, where private hospitals contrast sharply with an underfunded public health system. Chile has the second-lowest number of hospital beds per capita among the OECD countries.

When estimating the level of poverty in a country, the World Bank[9] uses three poverty levels based in daily income, i.e. $1.90, $3.20 and $5.50 per day.

The table below illustrates the percentage of the populations in the different levels of poverty for several countries. These World Bank figures are for 2017 or 2018.

Income per day	Argentina	Brazil	Bolivia	Chile	Peru	South Africa	UK
$1.90	1.0%	4.4%	4.5%	0.3%	3.4%	18.9%	0.2%
$3.20	3.0%	9.2%	10.6%	0.7%	9.8%	37.6%	0.2%
$5.50	9.6%	19.9%	23.1%	0.7%	23.9%	57.1%	0.7%

https://worldpoverty.io/map

It is very evident that the UK and Chile have by far the lowest level of poverty of all the countries considered, i.e. by at least an order of magnitude. Moreover, the UK has the 6th largest economy in the world with a world GDP share of 3.26% whereas Chile has the 41st largest world economy at 0.34% of world GDP. In economic terms, the UK is vastly more able to weather the pandemic than any of the South American countries, including Brazil which is the 8th largest economy at 2.54% of the world's economy, despite having three times the population of the UK.
(Source: https://www.worldometers.info/gdp/gdp-by-country/)

The less well developed health care and social welfare systems, along with a lack of a furlough type system, has forced poorer citizens in South America to ignore lockdown restrictions.

Access to clean water and sanitation is likely to have affected the guidance on hand hygiene[10]. Access to clean water supplies and sanitation services (WASH services) was recognized explicitly as universal human right by the UN in 2010. Research from March 2020 below looked at the relationship between income, urbanicity, race, and the cost of water and sanitation services.
For water supply Argentina, Chile, and Costa Rica had the highest proportion of access and the lowest inequality factors. Regarding sanitation, Chile had the highest level of access but exhibited a higher inequality factor than Uruguay, the country with the most equitable access. This points to a mixed story across the region with inequalities affecting certain population segments.

Health Policies and Systems in Latin America[11]

Inequality in health care may also contribute to an increased infection rate in sectors of the populations. Two different and opposed models of reform have been implemented in Latin America since the 1990s: the Universal Health Coverage (UHC) model and the Single Universal Health System model.

The essential characteristic of Latin American UHC is that health care has been governed by the introduction of competition that depends, in turn, on the payer/provider split, free choice, and pre-priced health service plans. The Single Universal Health System model is a model inspired by the principles of social justice and egalitarian, universal social rights. Characteristically funded by tax revenues, it makes provision of health services to the whole population a responsibility of the State and a universal citizens' entitlement independent of individual ability to pay contributions.

Health inequalities vary across the region. For example in Chile, which shows very high equality in child health, the degree of adult inequality is about the same as for Mexico and the United States of America, but this is misleading because the comparative equality with the USA arises because part of the population has an unusually high life expectancy. Inequalities in life expectancy persist and are strongly associated with socioeconomic class, even in countries with quite good health systems.

Held up by the UN as a model health care system for poorer countries, Brazil's universal system is used by 70% of the population. With 2 doctors per 1,000 people, the ratio of physicians is not far behind many European countries and performance-wise, the health care system is ranked as 125th in the world by the World Health Organization (WHO World Health Report published in 2000[12]).

Argentina has a good health service but the quality of facilities varies across the country. The public health care system, which provides both inpatient and outpatient care, free of charge to citizens, it is used by about 50% of the population. The country has a high doctor to population ratio, with nearly 4 per 1,000 inhabitants, putting it in line with Germany and Italy. It is ranked 75th by the World Health Organization, but the country as a whole spends 4.8% of its GDP on health, the lowest rate in South America.

It is evident that the countries in South America have varying quality healthcare systems and access to them by the populations. Compared to European countries, the health care systems are considerably underfunded but nevertheless give at least a minimum standard of care.

Cultural aspects

Religion is very important to people in Latin America. Some lessons from across the globe show that weekly worship attendance is most common where life expectancy is shortest; furthermore, greater income inequality is tied to greater importance of religion.

There have been several examples from across the world relating to outbreaks centred on religious activity or mass gatherings in megachurches. The table below shows relative observance in the selected countries to the dominant religions within each country. As the UK relaxes lockdown, targeted measures may need to be considered for places of worship.

Measure	Argentina	Bolivia	Brazil	Chile	Peru	S. Africa	UK
Affiliate	89%	96%	92%	84%	96%	93%	77%
Attend weekly	20%	42%	45%	19%	36%	55%	8%
Pray daily	40%	56%	61%	39%	51%	52%	6%
Rated as important	43%	71%	72%	41%	73%	75%	10%

PEW Research Centre June 13, 2018[13]

It is thought that some social traditions of embracing and kissing within large multigenerational households also contributes to transmission of the virus, simply because of lack of any social distancing. This is a key reason why the family ‘bubble’ system is so important for limiting contact.

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Appendix: Ultraviolet Light Effects on the Virus

Ultraviolet Light (UV) is electromagnetic radiation of shorter wavelengths than blue and violet visible light. Usually, it is divided into three bands, UVA, UVB and UVB as follows:

UV-A, also known as near-UV or black light, has a wavelength in the range of from 315 nm to 400 nm.

UV-B, also known as medium wave UV light, has a wavelength in the range from 280 nm to 315 nm. UV-B is the wavelength that kills the virus in natural sunlight but also causes sunburn.

UV-C, also known as short wave UV light, has a wavelength in the range of from 200 nm to 280 nm. V-C is blocked by ozone in the upper atmosphere and has a stronger germicidal effect, but is very damaging to exposed skin.

Regarding long-term effects, UVB is likely to be the main cause of photo ageing. UV is harmful to humans so cannot be used to combat the virus in covered spaces in winter. Therefore, germicidal UV lamps have been proposed both to irradiate contaminated surfaces and to irradiate the air in a room.

UVC lamps must be operated in strictly controlled environments only, i.e. within light-tight enclosures within, for example, air-conditioning systems, to avoid the possibility of exposure to occupant's skin or eyes. Ideally, the UV treatment of air or surfaces should take place away from humans. UVB is safer to use around humans but less effective against germs and bacteria.

Solar UV radiation at ground level is primarily made up of UVA, with some UVB but no UVC, and varies with the season, latitude, and time of day. The following factors effect natural UV light, sun height, latitude, cloud cover, altitude, ozone and ground reflection.

The widespread use of high-output UVB lamps to control the virus in enclosed public spaces is not recommended because of the risk to humans.

There could be a use of UVB or UVC lamps in strictly controlled conditions for sanitizing surfaces but great caution would be required in their use.

A passive UV B/C lamp could be used within an enclosed air-conditioning system for sterilising the conditioned air.

There is evidence that 'Natural daylight' lamps can reduce the life expectancy of the virus and, therefore, could have a role in suppressing the virus in enclosed, occupied spaces.

Case Study; an outbreak in a poor district of Buenos Aires, Argentina

The following is an article on Argentina "ghetto lockdown" from the Guardian newspaper - May 27th 2020. It is a snapshot of the recent difficulties experienced in one poor district of Buenos Aires which has been isolated by the authorities following a big outbreak in the area.

https://www.theguardian.com/world/2020/may/27/argentina-cordons-off-coronavirus-slum-ghettoes-for-poor-people

Security forces in Argentina have cordoned off one of the country's poorest slums, preventing inhabitants from entering or leaving the neighbourhood after a surge of coronavirus cases.

Police officers erected barriers at the entrance to Villa Azul on the outskirts of Buenos Aires on Monday after widespread testing was launched in poorer districts.

By Wednesday, 174 of 301 tests carried out in Villa Azul had come back positive, and officials expressed concern that if the 4,000 or so inhabitants of the neighbourhood were allowed to move freely, they could spread the virus to other areas nearby.

"This is worse than a nuclear explosion," said Sergio Berni, the Security Minister for

Buenos Aires, on Wednesday. "At least you can measure radioactivity in real time. With this [virus], it's 14 days late."

But the move was criticized by local activists and even members of Argentina's left-wing government. "It looks like we are creating ghettoes for poor people," said a Junior Minister for Social Development, Daniel Menéndez.

Daniel Gollán, Health Minister of Buenos Aires province, dismissed the charge. "We are working with the neighbourhood organisations, first to cut off the chain of contagion, and second to prevent people from leaving or entering because there is a much larger neighbourhood just next door."

So far, no deaths have been reported in Villa Azul, Gollán said.

Intensive testing is also being carried out in Villa Itatí, an equally destitute area nearby, which is home to about 15,000 people.

Mayra Mendoza, the mayor of Quilmes, the district including Villa Azul, said: "It's like a family: if one member tests positive, all the other members become close contacts. That is why we isolated the residents of Villa Azul, considering them close contacts of those who have been infected."

"If this had happened in a gated community, we would have isolated it as well," the mayor said.

As in other slum neighbourhoods or villas, most inhabitants of Villa Azul live in makeshift homes without public services, and the enforced isolation has left the population entirely dependent on deliveries of essential items by the army.

Valeria Mansilla, a 35-year-old mother of two who lives in Villa Azul, told TN television: "Tuesday was a terrible day – very stressful – because they brought water and bottled gas [for heating] but only for part of the neighbourhood. They brought us powdered milk but we don't have water."

Teams of sanitary workers in white full-body protective gear have been going door to door in Villa Azul, testing, and carrying food delivered by army units.

Argentina's villas often suffer from cramped living conditions and a lack of proper sewerage or running water, making it difficult for inhabitants to self-isolate or maintain proper hygiene.

"The first thing the pandemic has taught us, is that we live in an unfair country – and no one has the excuse of saying they didn't know because we've all seen it," said the country's president, Alberto Fernández, in a speech about the situation in the country's slums.

So far, most of Argentina's 23 provinces have fared relatively well during the pandemic, reporting low numbers of new cases, thanks to a tough government lockdown implemented early in the pandemic.

But the Buenos Aires Metropolitan Area – which counts as a separate administrative district and includes nearly 2,000 villas – has seen a worrisome spike, and has accounted for 90% of the country's new cases in recent weeks.

Argentina has 13,228 confirmed coronavirus cases and 490 deaths so far, with 600 new cases and 19 deaths reported on Tuesday – a sharp rise from early May when the number of daily new cases was in the low hundreds.

Security minister Berni said that the coronavirus situation in Buenos Aires slums would only get worse. "This is like the Titanic, we've got an iceberg ahead and we can chose to hit it head-on or from the side – but the crash is inevitable."