

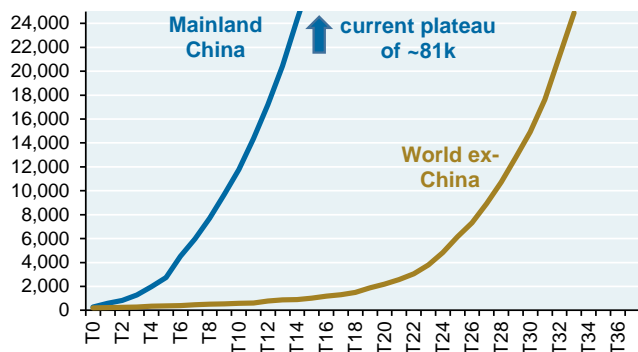


The pandemic gap: the critical distinction between “infected” and “sick”; understanding mortality rates; context around the Spanish flu in a pre-antibiotic world

A lot of data is being made available on the coronavirus, but most of it requires careful analysis before drawing conclusions. Here's what is clear: the rate of reported infections outside China is now accelerating at a similar rate to what was happening a month and a half ago in China itself. In response, many parts of the world have adopted control measures such as quarantine/lockdown, school closures, etc.

Coronavirus T days after respective region's outbreak

Cumulative number of cases



Source: WHO. March 8, 2020. T0: China = Jan 21, Outside China = Feb 4.

Recent coronavirus measures:

- Italy: 16 mm people quarantined, lockdown of northern region of Lombardia and 14 other provinces; museums closed, weddings/funerals suspended; bars close by 6 pm; live stream of Pope's Sunday prayer for the first time
- France: closes 120 schools
- UK: rationing of food/household items (Tesco)
- US: restricts travels to and from S Korea and Italy
- Saudi Arabia closes Holy cities of Mecca and Medina
- San Fran: banned events for 2 weeks
- Cancelled classes: Seattle Northshore district, University of Washington, select NYC private schools
- Cancelled events: Adobe, Facebook, Google, IBM, Microsoft, IMF/World Bank, Geneva Motor Show, etc.

That's where the clear part ends. The complex thing about pandemics is that early mortality rate estimates tend to decline over time. Why? Here are four simple measures that matter in the context of a pandemic:

- (a) the population of a given geographical area
- (b) the total number of infected individuals, including both asymptomatic people and people that get sick
- (c) the total number of people that are infected, get sick and self-report
- (d) the total number of people that die

During the haze of a pandemic, the best estimates that entities like the World Health Organization often derive are based on (a), (c) and (d), and even things like (d) are complicated by pandemics affecting older individuals with pre-existing conditions. **They do not know (b) upfront**, and sometimes it is never known, or only known with the passage of time. Take the Swine Flu (H1N1/2009) as an example. Early estimates in the fall of 2009 from the WHO¹ pegged the H1N1 mortality rate at 1.0%-1.3%, since they were dividing (d) by (c). Four years later, a study from the WHO and the Imperial College of London² estimated H1N1 mortality as a function of total infections, including both the asymptomatic and the sick. **Their revised H1N1 mortality rate using (b) as a denominator: just 0.02%.**

So, **please** treat estimated infection rates and mortality rates with care, since they can mean very different things. Marc Lipsitch from Harvard has estimated that 40% - 70% of the world's population could become infected³. Lipsitch himself makes it clear that this number is an example of (b) and not (c) and that there is an enormous **gap** between the two, so please do not multiply population by 40%-70% and then multiply by a mortality rate assumption. **The vast majority of infected people will likely not become sick, and around 80% of people who get sick develop mild infections rather than severe ones.**

¹ WHO Situation Report, Pandemic (H1N1) 2009, Update 76, November 22, 2009.

² "Estimating age-specific cumulative incidence for 2009 influenza pandemic", Kerkhove et al, Influenza and Other Respiratory Viruses, January 21, 2013.

³ "Cooperating to combat coronavirus", Harvard Magazine, March 3, 2020.



To get a sense for the possible spread of COVID-19, let’s look at China now that its trajectory of reported cases is in decline⁴. The table shows (a), (c) and (d), since (b) and all statistics derived from it are unknown.

Outside Wuhan/Hubei, China mortality and infection rates are much lower, even in poor provinces that neighbor Hubei itself. As illustrated on the next page, China’s ex-Hubei mortality rates are not that different from seasonal flu mortality rates for individuals over 65 in developed countries like the US.

COVID-19: Population, infections, fatalities and derived statistics in select Chinese provinces
Columns B, C and D are reported based on cumulative figures to-date (March 8)

Disease	Region	A Population	B Infected (asymptomatic + sick)	C Infected (sick only)	D Deaths	D/C Death rate of the sick	C/A Infection rate to population, sick only	D/B Death rate, all infected	B/A Total infections to population
COVID-19	Wuhan	11,000,000	Unknown	49,871	2,370	4.75%	0.45%	Unknown	Unknown
COVID-19	Hubei	59,170,000	Unknown	67,707	2,986	4.41%	0.11%	Unknown	Unknown
COVID-19	Guangdong	113,460,000	Unknown	1,352	7	0.52%	0.00%	Unknown	Unknown
COVID-19	Henan	96,050,000	Unknown	1,272	22	1.73%	0.00%	Unknown	Unknown
COVID-19	Zhejiang	57,370,000	Unknown	1,215	1	0.08%	0.00%	Unknown	Unknown
COVID-19	Hunan	68,990,000	Unknown	1,018	4	0.39%	0.00%	Unknown	Unknown
COVID-19	Anhui	63,240,000	Unknown	990	6	0.61%	0.00%	Unknown	Unknown
COVID-19	Jiangxi	46,480,000	Unknown	935	1	0.11%	0.00%	Unknown	Unknown
COVID-19	Shandong	100,470,000	Unknown	758	6	0.79%	0.00%	Unknown	Unknown
COVID-19	Jiangsu	80,510,000	Unknown	631	-	0.00%	0.00%	Unknown	Unknown
COVID-19	Chongqing	31,020,000	Unknown	576	6	1.04%	0.00%	Unknown	Unknown
COVID-19	Sichuan	83,410,000	Unknown	539	3	0.56%	0.00%	Unknown	Unknown
COVID-19	Heilongjiang	37,730,000	Unknown	481	13	2.70%	0.00%	Unknown	Unknown
COVID-19	Beijing	21,540,000	Unknown	428	8	1.87%	0.00%	Unknown	Unknown
COVID-19	Shanghai	24,240,000	Unknown	342	3	0.88%	0.00%	Unknown	Unknown
COVID-19	Hebei	75,560,000	Unknown	318	6	1.89%	0.00%	Unknown	Unknown
COVID-19	Fujian	39,410,000	Unknown	296	1	0.34%	0.00%	Unknown	Unknown

What might reported UK government central estimates of 100,000 deaths imply? Something very different than what’s reportedly happening in China itself

Estimate 1: 38% of population infected; 40% of infected people get sick; 1% mortality rate as % of sick population									
COVID-19	UK	66,440,000	25,000,000	10,000,000	100,000	1.00%	15.05%	0.400%	38%
Estimate 2: 23% of population infected; 10% of infected people get sick; 4.4% mortality rate as % of sick population									
COVID-19	UK	66,440,000	22,000,000	2,258,960	100,000	4.43%	3.40%	0.455%	33%

Sources: World Health Organization Coronavirus Situation Reports, Health Commission of Hubei Province, Sunday Times, JPMAM. 2020

That’s what makes the UK’s reported estimate of 100,000 deaths very puzzling⁵. To arrive at such an outcome, we had to assume that 38% of the entire UK population is infected (i.e., similar to the 1918 Spanish flu), *and* that 40% of infected people get sick and then experience 1% mortality; or we had to assume that only 10% of infected people get sick but then experience 4.4% mortality that’s equal to the epicenter of the virus outbreak in Wuhan. Even after accounting for Chinese infection/death underreporting and the difficulty Western countries might have replicating what China has done (the largest lockdown/quarantine in the history of the world, accomplished via AI, big data and different privacy rules⁶), both of our modeled UK outcomes would be **magnitudes worse** than what’s occurring in China and South Korea. This is another pandemic gap that we are still trying to understand and reconcile.

Why are Hubei mortality rates so much higher? Likely answer: a collapse in Hubei’s healthcare infrastructure given a flood of infections. This prevented Hubei doctors from providing round-the-clock care that other cities provided to keep patients alive until their immune systems could fight the disease.

⁴ Column C shows total infections to-date and does not reflect recoveries. Provinces such as Anhui, Jiangsu, Fujian, Qinghai and Tibet have now been declared as infection-free by the Chinese government.

⁵ “Coronavirus: Boris Johnson keeps calm but Whitehall plans for worst”, Sunday Times, March 8, 2020

⁶ “China suppressed Covid-19 with AI and big data” (via smartphones), Asia Times, March 3, 2020

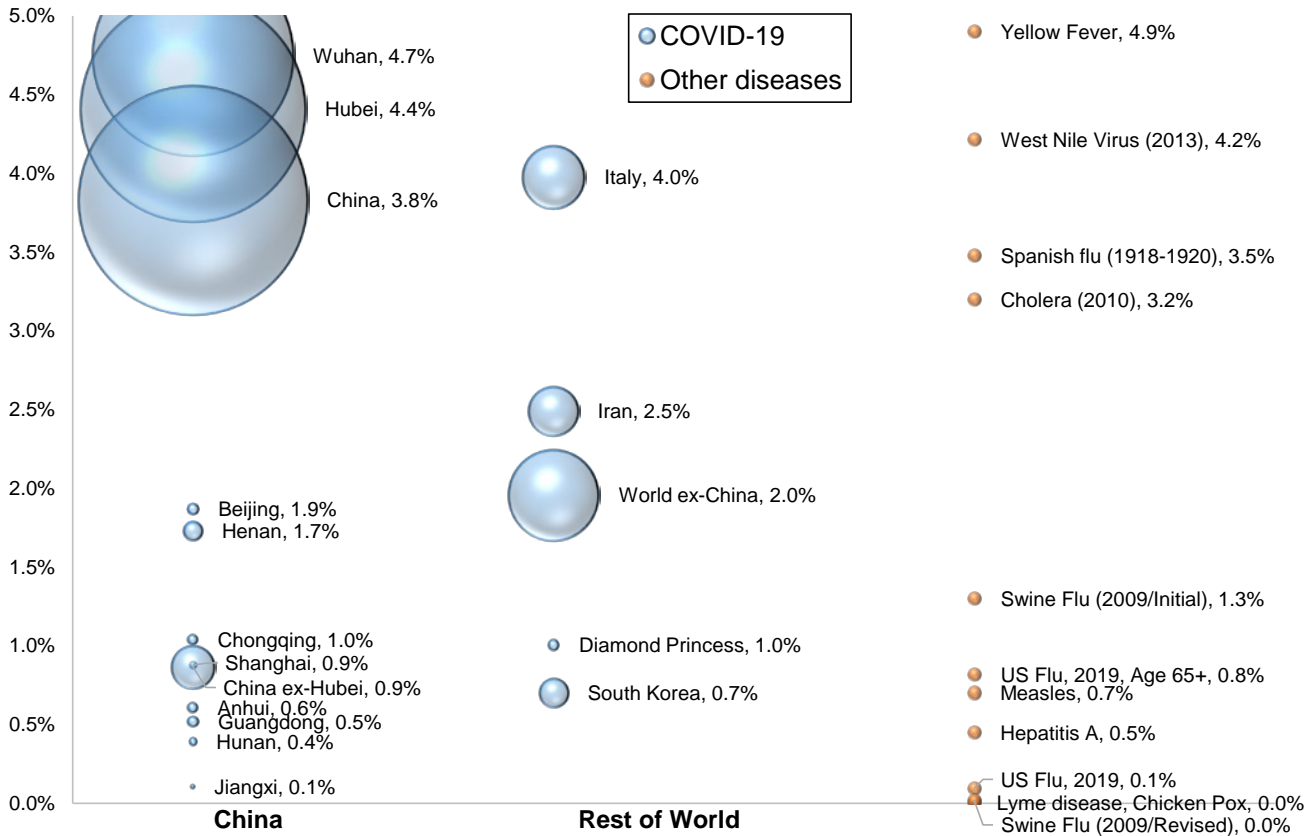


FOR INSTITUTIONAL/WHOLESALE/PROFESSIONAL CLIENTS AND QUALIFIED INVESTORS ONLY – NOT FOR RETAIL USE OR DISTRIBUTION

Mortality rates for COVID-19 so far. With that context, it should be clearer how difficult it is to compare mortality rates in the heat of a pandemic given uncertainties on numerators/denominators. That said, even an uncertain exercise can reveal important trends. As shown below, mortality rates in Hubei are heavily influencing both China and global measures. Outside Hubei province, China mortality rates are much lower. Italy’s mortality is high right now; we will have to wait and see if it declines once self-reported infections increase in the weeks ahead. South Korea has conducted the most widespread testing and its mortality rate may be closer to the “deaths to true infections” ratio discussed on the first page. Iran is in the early stages as well, and has a very weak healthcare system further compromised by sanctions and a steady brain drain of medical personnel⁷.

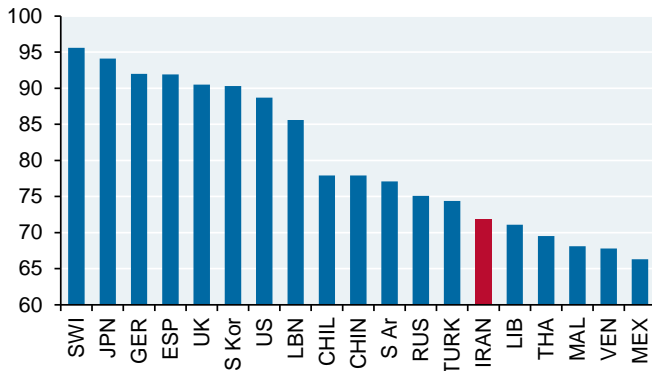
Mortality rates: COVID-19 vs other diseases, and the impact of Wuhan/Hubei

Mortality rate; bubble size indicates relative number of fatalities for COVID-19 only



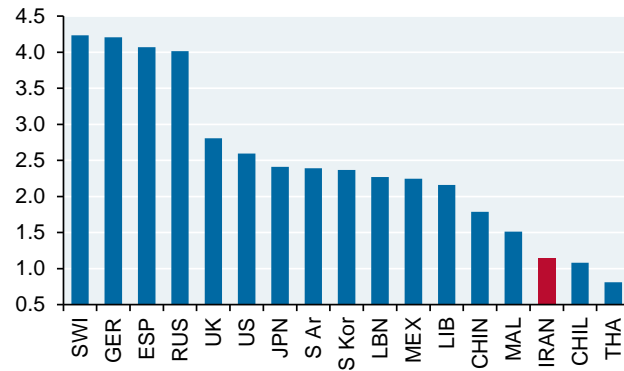
Mortality rates shown for all countries with at least 1,000 infections to date. Sources: CDC, China National Health Commission, Center for Health Protection (HK), Global Health Data Exchange, World Health Organization, Netherlands Institute for Health Services Research, Imperial College of London, Mayo Clinic, JPMAM. 2020.

Healthcare Access and Quality Index



Source: Institute for Health Metrics and Evaluation. 2016.

Physicians per 1,000 people



Source: The World Bank. 2020.

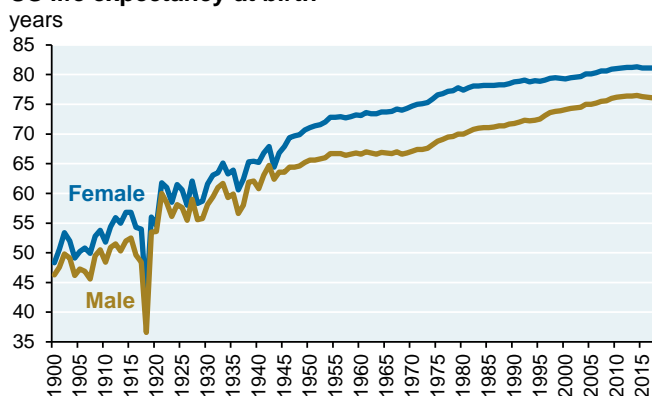
⁷ "Iran Faces Serious Shortage Of Doctors Due To Emigration", Radio Farda, Iran In-Depth, June 30, 2019



The Spanish Flu (1918-1920) in context, and why it’s a poor proxy for COVID-19

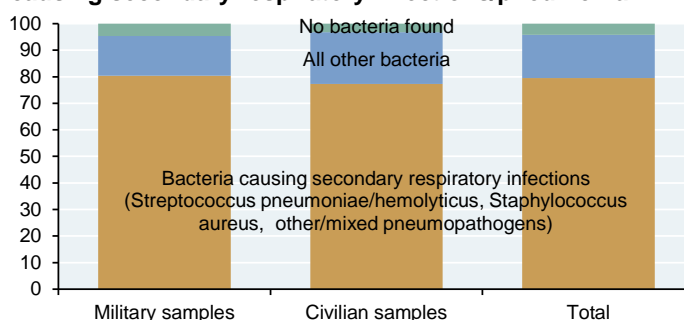
- **No vaccine was ever developed to combat the Spanish Flu.** In contrast, a SARS vaccine was developed in response to the 2002 outbreak but was never used since public health measures (closing workplaces, people working at home, etc) got the disease under control by May 2003 before the vaccine was ready⁸. Since that time, Harvard scientists have found the antibody which blocks SARS and MERS from entering human cells⁹, which were used to develop antibody therapies (which are different from vaccines, which are the treatment of choice and much cheaper to produce). The new COVID-19 virus shares 86% genetic similarity with SARS, so scientists aren’t starting from ground zero
- **There were no antibiotics in 1918** to treat secondary bacterial infections associated with influenza. From a paper marking the 100th anniversary of Spanish Flu: “in 1918, most severe influenza-associated pneumonias were associated with **secondary bacterial infections**... high pandemic case fatality during the fall 1918 pandemic resulted primarily from increased frequency, and not increased severity, of secondary bacterial pneumonias, especially in young adults”¹⁰ (see chart). Furthermore, without secondary bacterial pneumonia, “experts generally believed that most patients would have recovered”. The first antibiotic was discovered in 1929 but mass antibiotic production did not occur until the 1940’s
- The US CDC reports that lab experiments with recombinant influenza viruses containing genes from the 1918 virus suggest that the 1918 and 1918-like viruses would **be as sensitive as other virus strains** to FDA-approved anti-influenza drugs rimantadine and oseltamivir
- **As further indication of a world without antibiotics and other healthcare innovations such as anti-virals, ICU-level hospital care, ventilators, etc**, the US life expectancy for men and women ranged from 50-55 years before the onset of the Spanish Flu¹¹ in 1918

US life expectancy at birth



Source: US CDC; Andrew Noymer, Public Health Dep’t, UC Irvine. 2020.

Spanish Flu (1918): % of cultures containing bacteria causing secondary respiratory infections/pneumonia



Source: "Predominant Role of Bacterial Pneumonia as a Cause of Death in Pandemic Influenza," National Institute of Allergy and Infectious Diseases, Morens et al, 2008

⁸ China began clinical trials of a SARS vaccine in November 2003, while in the US, the first human SARS trials began in December 2004, conducted by the National Institute of Allergy and Infectious Diseases

⁹ Harvard professor Wayne Marasco identified a single antibody out of a 27-billion antibody library that blocked the SARS virus from entering human cells. Marasco is actively testing new antibodies in search of one that will have the same effect on SARS-CoV-2 (COVID-19)

¹⁰ "The 1918 influenza pandemic: 100 years of questions answered and unanswered", Taubenberger et al, Viral Pathogenesis and Evolution Section, Laboratory of Infectious Diseases, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Science Translational Medicine, July 2019

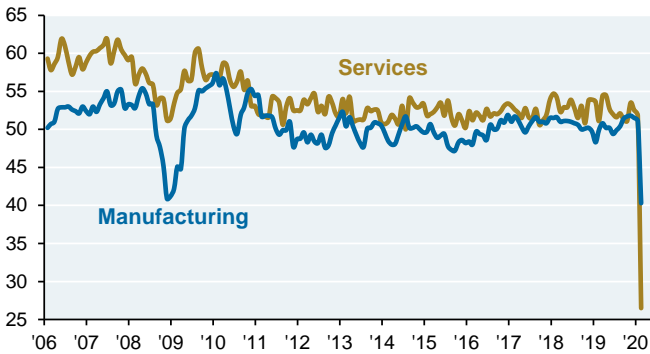
¹¹ Male life expectancy at birth was ~25 during the Roman Era; rose to ~33 by the Middle Ages; and hovered between 30 and 40 until the late 1800’s. Starting in the 1920’s, the innovations cited above ushered in the most remarkable improvement in life expectancies in the history of the world



Appendix charts: quarantine, SARS vs COVID, high frequency indicators in China, OECD tourism

- China’s quarantine/lockdown is the largest in the history of the world, as per a paper on comparing COVID-19 and SARS transmission trends¹². Evidence of this is shown in the first chart: China’s manufacturing and service sector declines are larger than in 2008. The second chart shows a small recovery in activity from the lows. We have reasons to believe that the electricity numbers overstate actual activity
- In 2003, SARS was eventually contained by surveillance, isolation of patients, strict enforcement of quarantine of all contacts, and in some areas community-level quarantine. By interrupting human-to-human transmission, SARS was eradicated. Isolation was effective for SARS because peak infectiousness occurred **after** patients were already very ill with respiratory symptoms and could be easily identified. Although asymptomatic patients were reported for SARS, **no known transmission occurred from these patients**
- The new virus SARS-CoV-2 (which causes the COVID-19 disease) has 86% similarity with the 2002 SARS-CoV virus, and both have median incubation times of ~5 days and basic reproductive numbers of ~2.2. The first paper linked below estimates the mean serial interval of COVID-19 at 7.5 days (the time it takes for an infected person to become contagious to others), similar to the SARS virus. **However**, a separate paper from the International Journal of Infectious Diseases¹³ may explain why SARS-CoV-2 is spreading more rapidly: the authors estimate the SARS-CoV-2 serial interval at just 4.5 days, which is less than its incubation period (i.e., when symptoms occur). **That means that asymptomatic individuals could be contagious before they know they have the virus.** If that’s the case, that’s quite different than SARS, since isolation of severely ill COVID-19 patients at the time they show up at health-care facilities would be too late

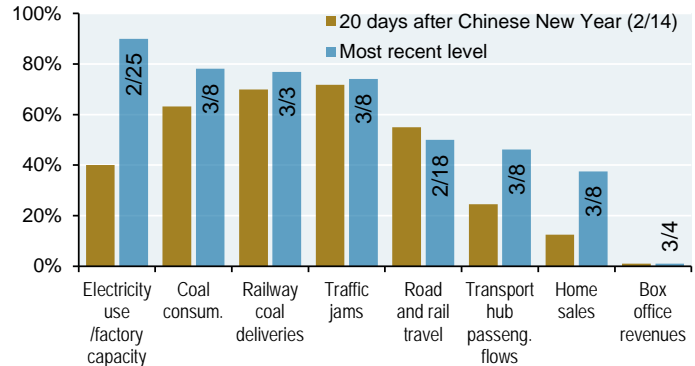
Chinese manufacturing and services business surveys at all time low; Index, 50+ = expansion



Source: Markit PMI. February 2020.

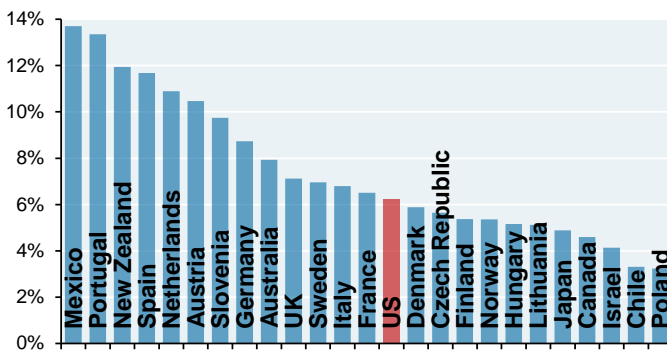
High frequency Chinese economic indicators

Indicated level as a % of historical average



Source: J.P. Morgan Emerging Markets Research, Goldman Sachs. Mar 9, 2020.

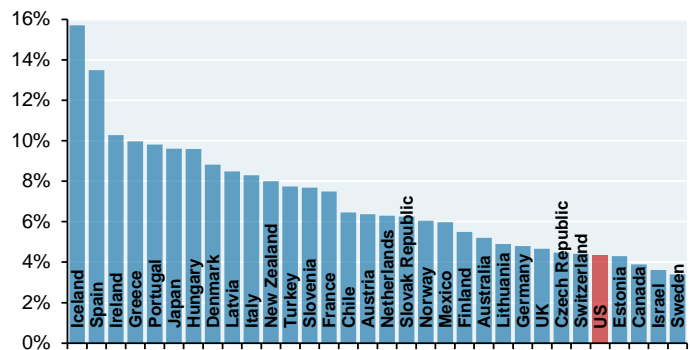
Domestic and inbound tourism spending to GDP
GDP %



Source: OECD, J.P. Morgan Asset Management. 2018.

Tourism employment to total employment

Total employment %



Source: OECD, J.P. Morgan Asset Management. 2018.

¹² “Can we contain the COVID-19 outbreak with the same measures as for SARS?”, Wilder-Smith et al, London School of Hygiene and Tropical Medicine, March 5, 2020

¹³ “Serial interval of novel coronavirus infections”, International Journal of Infectious Diseases, March 4, 2020



NOT FOR RETAIL DISTRIBUTION: This communication has been prepared exclusively for institutional, wholesale, professional clients and qualified investors only, as defined by local laws and regulations.

This material is for information purposes only. The views, opinions, estimates and strategies expressed herein constitutes Michael Cembalest's judgment based on current market conditions and are subject to change without notice, and may differ from those expressed by other areas of J.P. Morgan. This information in no way constitutes J.P. Morgan Research and should not be treated as such.

The views contained herein are not to be taken as advice or a recommendation to buy or sell any investment in any jurisdiction, nor is it a commitment from J.P. Morgan Asset Management or any of its subsidiaries to participate in any of the transactions mentioned herein. Any forecasts, figures, opinions or investment techniques and strategies set out are for information purposes only, based on certain assumptions and current market conditions and are subject to change without prior notice. All information presented herein is considered to be accurate at the time of production. This material does not contain sufficient information to support an investment decision and it should not be relied upon by you in evaluating the merits of investing in any securities or products. In addition, users should make an independent assessment of the legal, regulatory, tax, credit and accounting implications and determine, together with their own professional advisers, if any investment mentioned herein is believed to be suitable to their personal goals. Investors should ensure that they obtain all available relevant information before making any investment. It should be noted that investment involves risks, the value of investments and the income from them may fluctuate in accordance with market conditions and taxation agreements and investors may not get back the full amount invested. Both past performance and yields are not reliable indicators of current and future results.

J.P. Morgan Asset Management is the brand for the asset management business of JPMorgan Chase & Co. and its affiliates worldwide.

To the extent permitted by applicable law, we may record telephone calls and monitor electronic communications to comply with our legal and regulatory obligations and internal policies. Personal data will be collected, stored and processed by

J.P. Morgan Asset Management in accordance with our privacy policies at <https://am.jpmorgan.com/global/privacy>.

This communication is issued by the following entities: in the United Kingdom by JPMorgan Asset Management (UK) Limited, which is authorized and regulated by the Financial Conduct Authority; in other European jurisdictions by JPMorgan Asset Management (Europe) S.à r.l.; in Hong Kong by JPMorgan Asset Management (Asia Pacific) Limited, or JPMorgan Funds (Asia) Limited, or JPMorgan Asset Management Real Assets (Asia) Limited; in Singapore by JPMorgan Asset Management (Singapore) Limited (Co. Reg. No. 197601586K), this advertisement or publication has not been reviewed by the Monetary Authority of Singapore; in Taiwan by JPMorgan Asset Management (Taiwan) Limited; in Japan by JPMorgan Asset Management (Japan) Limited which is a member of the Investment Trusts Association, Japan, the Japan Investment Advisers Association, Type II Financial Instruments Firms Association and the Japan Securities Dealers Association and is regulated by the Financial Services Agency (registration number "Kanto Local Finance Bureau (Financial Instruments Firm) No. 330"); in Australia to wholesale clients only as defined in section 761A and 761G of the Corporations Act 2001 (Cth) by JPMorgan Asset Management (Australia) Limited (ABN 55143832080) (AFSL 376919); in Brazil by Banco J.P. Morgan S.A.; in Canada for institutional clients' use only by JPMorgan Asset Management (Canada) Inc., and in the United States by J.P. Morgan Institutional Investments, Inc. or JPMorgan Distribution Services, Inc., both are members of FINRA; J.P. Morgan Investment Management, Inc. or J.P. Morgan Alternative Asset Management, Inc.

Copyright 2020 JPMorgan Chase & Co. All rights reserved.