# A Neglected Burden: The Ongoing Economic Costs of COVID-19 in Singapore

August 2023



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The following is a structured, product- and brand-agnostic, fact-based review of evidence on the economic costs of COVID-19, potential interventions to reduce these costs, and the current approach to these interventions taken by Singapore. This report does not constitute medical, legal, financial, or policy advice. It does not recommend specific decisions or policies relating to public health or economic responses, nor the trade-offs between them.


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# Preface

It has been over three years since the World Health Organization's declaration of a global pandemic, COVID-19 continues to have a profound impact on societies across Asia Pacific and the entire world. While vaccines, therapeutics, and rapid diagnostics have reduced severe illness, hospitalization, and deaths significantly, COVID-19 is still causing morbidity and mortality, particularly in vulnerable populations. Moreover, it continues to exert an ongoing and adverse impact on the economy. The cost of COVID-19 on healthcare systems, supply chains, and travel has received extensive attention over the past three years. However, as this white paper demonstrates, the indirect cost of workforce disruption is significant and underappreciated.

A deeper understanding of COVID-19's economic costs is critical to inform policies that can protect the growth and prosperity of the Asia Pacific region in the current stage of the pandemic. This report provides insights into these costs through evidence-based estimates across different COVID-19 infection scenarios in Singapore.

The purpose of this white paper is to inform policy discussions on assessing and mitigating COVID-19's ongoing economic impact. The report takes a high-level perspective, assessing COVID-19's potential consequences on Singapore's economy. It is inspired and informed by efforts to estimate the economic impact of COVID-19 in other economies.[1,2]

The discussion that follows is based on information available at the time of writing, and sources are provided throughout the text. Estimates are based on epidemiological scenarios that extrapolate hospitalization and transmission rates observed in Singapore during various periods between February 2020 and early 2023. All content and estimates have been reviewed for validity and accuracy at the end of February 2023.

This report is not intended to be a research document, and it is recognized that the fluid evolution of the pandemic and policy makers' varied responses to it presents challenges in any attempt to estimate future costs.

Findings in this report are taken from a wider regional report across five markets. Estimates provided in this report should not be directly compared across markets given their highly market-specific nature. The content included in this report relies upon the percentage of GDP and percentage of total cost figures to provide an estimate of trends.

This report is also not intended to be a health technology assessment that re-estimates the value of lost health, nor a marketing or cost-effectiveness analysis between interventions. However, the underlying results present an informed indication that the full economic costs of COVID-19 are greatly underappreciated and are an important, but missing factor in policy discussions. It is hoped that this report provides a fresh perspective that will be useful to policy stakeholders.

1. McKinsey & Company [Internet]. One billion days lost: How COVID-19 is hurting the US workforce. 2023 Jan 9. Available from: https://www.mckinsey.com/industries/healthcare/our-insights/one-billion-days-lost-how-COVID-19-is-hurting-the-us-workforce
2. Guilford G, Weber L. WSJ [Internet]. COVID drag on the workforce proves persistent. "It sets us back." 2022, Nov 7. Available from: https://www.wsj.com/articles/covid-workforce-absenteeism-productivity-economy-labor-11667831493

# Executive Summary

This white paper examines the ongoing impact of COVID-19 on Singapore's economy, with a more thorough assessment of the hidden economic costs to Singapore's society than has previously been made available. As Singapore moves from the pandemic to an endemic phase of COVID-19, we present a comprehensive view of the disease's financial impact, with a focus on indirect costs.

Our report begins with a brief introduction of our methodology in Section 2, followed by a deep discussion of the effects of the pandemic in Singapore in Section 3, and then a reflection on the countermeasures available to policymakers in Section 4. We conclude this paper in Section 5 by re-emphasizing the significant indirect economic costs and how these can be mitigated using available tools.

Previous analyses of COVID-19's economic impact in Singapore have provided widely varying assessments depending on the type of research carried out, from an estimated USD ~32 million (which took the impact of vaccines into account) to USD ~72 billion (based on COVID-19-related expenditure in past financial years).[3] We have adopted a cost-of-illness approach, a technique often used in policy decision-making, to provide more stable estimates. This allows us to anticipate the ongoing cost of three possible scenarios: a lower-estimate scenario, a base case scenario where current conditions continue, and a higher-estimate scenario.

Should current conditions prevail in Singapore under a base case scenario, the annual economic costs of COVID-19 in Singapore could reach about SGD ~3.6 billion annually, representing around 0.6% of the market's GDP. In a worst-case Pandemic 2.0 scenario, SGD ~16.0 billion p.a. would be lost, or around 2.8% of Singapore's GDP.

We study the direct costs of the disease, such as healthcare costs, as well as indirect costs – i.e., productivity losses due to missed work. Our findings show that indirect costs far outweigh direct costs, accounting for 96% of Singapore's total ongoing economic cost of COVID-19 in the base case scenario. Across all three scenarios, indirect costs remain the bulk of the economic burden well into the endemic phase of COVID-19.

One important example of such ensuing costs is in the health workforce, which continues to be impacted by personnel shortages and a greater risk of infection compared to the wider community. This susceptibility has significant consequences for health system capacity, efficiency, and quality of care.

Likewise, Singapore's logistics, travel and tourism, food and beverage, and education industries are also more vulnerable to the ongoing impacts of COVID-19. This is being driven largely by absenteeism caused either by workers contracting COVID-19 or providing care for dependents affected by the virus.

The report also shows an uneven distribution of costs, as not all community cohorts in Singapore face the same level of risk or have the same economic burden when infected. Vulnerable populations, such as older adults[4] and working-age adults with one or more comorbidities (such as high blood pressure, cancer, and/or diabetes) are likely to be disproportionately impacted. The economic impact from older people infected with COVID-19 is around SGD ~565 million per year, while that of working-age adults with comorbidities is double, at around ~SGD 1.1 billion per year.

Meanwhile, individuals affected by long COVID experience prolonged productivity losses, which increase indirect costs and reliance on health services, further escalating direct costs. This exerts a substantial burden on the health system, both in terms of capacity requirements and economic costs. In a base case

3. These studies had been conducted in USD currency.
4. Older adults refer to those aged 65 and above.

scenario, the total value of lost work and use of health systems due to long COVID would be SGD ~1.31 billion per year, which amounts to 37% of Singapore's total economic cost of COVID-19.

Having a full understanding of COVID-19's costs, both current and potential, is vital to designing effective countermeasures that can mitigate the ongoing impact (measures we have identified in the white paper) of the disease. It is hoped that this paper can provide Singapore policymakers with a useful frame of reference to anticipate potential developments as they prepare for the future, beginning with an appreciation of the full cost already being borne, including the often-overlooked indirect costs.

Looking ahead, policymakers may consider strengthening existing systems and protocols, whether that be community measures such as contact tracing and mask-wearing mandates, other infection control strategies, or medical responses like vaccines and therapeutics.

Acting now to address these impacts will contribute to protecting Singapore's economy, industries, livelihoods, and of course, its population's health.

# 1. Looking Forward: Examining The Potential Economic Futures For COVID-19

## 1.1 Three Key Questions: Characterizing The Economic Future Of COVID-19

As authorities managing the health and economic impacts of COVID-19 consider how to prepare for the next phase of the pandemic, they are grappling with uncertainty about how it will evolve. This uncertainty can be distilled into three key questions:

- What will the future number of cases be and how severe (i.e., the epidemiological future)?
- How does this translate into economic cost?
- What tools are available to reduce the burden of disease and its costs?

Each of these questions, on epidemiology (Section 2.1.1), costs (Section 3.3), and available tools (Section 4) will be examined in this white paper.

## 1.2 Existing Estimates: Building On Historical Scenarios For The Cost Of COVID-19

Existing estimates of the economic costs imposed by COVID-19 in Singapore, vary widely. Variation exists not only in the estimates themselves, but also in the methodologies, scopes, and assumptions used to derive them.

The disparity in cost estimates is generally driven by three factors:

- The epidemiological scenario captured in assumptions (often historical).
- A specific intervention being modeled.
- The scope of costs evaluated in the methodology.

This variation makes it difficult for decision-makers to find the relevant cost evaluations to inform whether and how much to invest in ongoing efforts to combat COVID-19. There is a need for estimates which capture plausible future epidemiological scenarios, using the expected or current set of interventions, and focusing on major costs to society. The following examples show that most existing estimates do not include indirect costs from productivity losses in their scope. As the subsequent cost estimate (Section 3.3) will demonstrate, indirect costs are substantial (~0.6% of GDP) and need to be better recognized.

The remainder of this chapter provides an overview of the existing estimates of costs in each market of interest, before turning to the methodology used for estimating economic costs.

Limitations of Estimate

Readers of this report should observe the following limitations in relation to the estimates provided:

- The fluid evolution of the pandemic and policy makers' varied responses to it presented challenges in any attempt to estimate future costs.
- The findings are not intended to be a health technology assessment that re-estimates the value of lost health, nor a marketing or cost-effectiveness analysis between interventions.

## 1.2.1 Estimates for Singapore

**Range of existing estimates of the cost of COVID-19: USD ~32 million to USD ~72 billion p.a.** This wide range is due to the various interventions explored, the epidemiological contexts assumed, and the scope of costs evaluated.

**Higher estimate: USD ~72 billion.** This is a historical estimate based on the Singaporean authorities' expenditure on COVID-19 in the past two financial years.[5] The scope includes direct costs to the health system and associated public health measures, as well as several indirect costs such as support measures for workers, businesses, households, and social support. This estimate is not tied to a specific epidemiological scenario, as the context in Singapore varied widely over the course of the past two years on which the estimate was based.

**Lower estimate: USD ~32 million.** This is based on calculations of a comparison of probable costs resulting from COVID-19 in several markets, and the effect of vaccination on these costs. Direct costs taken into account included vaccination program costs and medical treatment costs associated with COVID-19 infection, while indirect costs included productivity loss due to days spent in sickness, as well as premature death before retirement.[6] Epidemiological scenarios calculated included a comparison of costs when 0% versus 50% of the Singaporean population was fully vaccinated. A vaccination rate of 50% is predicted to save USD ~21 million, which reflects the epidemiological context of vaccination rates in Singapore in July 2021. This estimate also includes the value of lost health, albeit measured using quality-adjusted life years (QALYs).[7]

In another example, the short-term impacts of COVID-19 on consumer spending and labor market outcomes in Singapore were analyzed using historical data. It was found that COVID-19 reduced both components relatively quickly after its outbreak, followed by a rebound that was restriction-dependent. In the epidemiological context of the variants and infection rate at the peak of COVID-19 in April 2022, total household consumer spending decreased by 22.8% and labor income decreased by 5.9%.[8]

## 1.2.2 The need for better targeted, future-looking cost estimates

The variation in existing estimates of the economic impacts of COVID-19 leads to a lack of clarity. An approach better aligned to today's environment could take three steps to establish a more consolidated framework:

- **Establish a set of plausible epidemiological scenarios** that decision-makers find relevant for planning purposes.
- **De-anchor estimates from specific interventions used in the pandemic phase (e.g., lockdowns, vaccinations, welfare payments)** and ensure that estimates instead reflect conditions in today's reopened societies.
- **Target the scope of costs included to reflect the way the pandemic impacts society today:** health service utilization and productivity loss from missed work.

5. Kit TS. Channel News Asia [Internet]. Singapore spent S$72.3 billion to fight COVID-19 over past 2 years, lower than initially committed. 2022 Sep 13. Available from: https://www.channelnewsasia.com/singapore/singapore-spent-s723-billion-fight-covid-19-past-two-years-2934946
6. Jiang Y., Cai D., Shi S. Economic evaluations of inactivated COVID-19 vaccines in six Western Pacific and South East Asian countries and regions: A modeling study. Infectious Disease Modelling. 2022 Mar; 7(1): 109-121
7. The quality-adjusted life-year (QALY) is a measure of the value of health outcomes. This approach values both quality and length of life, with monetary values attached per condition, in contrast to the VSL approach, which applies a universal value to each life and life-year (unless adjusted).
8. Kim S., Koh, K., Zhang X. Short-term impact of COVID-19 on consumption and labor market outcomes: evidence from Singapore. Canadian Journal of Economics. 2022 Jun; 55(1): 115–134

# 2. Our Approach: Uncovering The Future Economic Costs Of COVID-19

## 2.1 The Cost-Of-Illness Concept In Estimating Economic Costs

This white paper uses the cost-of-illness concept to derive cost estimates and present a coherent snapshot of the COVID-19 price tag faced by Singapore. Commonly used to support decision-making, the cost-of-illness approach is a pragmatic health economics methodology that assesses two types of cost: direct costs of the illness (i.e., those incurred by the health system) and indirect costs (i.e., those resulting from productivity losses due to work missed by affected individuals). By assessing these two major categories of burden, the approach helps policymakers understand the value at stake when investing in interventions to address the disease.

This report has collated publicly available data and existing cost estimates of both direct and indirect costs into an overall estimate for Singapore and a detailed look into the factors affecting the market.

The cost-of-illness approach – particularly the focus on indirect costs – has been recently used in the 'One Billion Days Lost' analysis published by McKinsey & Company,[9] detailing the significant and ongoing economic costs wrought by COVID-19 on the US labor force. The approach to estimating economic costs arising from productivity loss in that piece of research is substantively similar to the approach used in this white paper. This report identifies factors driving productivity loss by focusing on cohorts of key affected individuals, such as working-age individuals (looking at those who can and cannot work from home), and caregivers of children unwell with COVID-19 (looking at the children's age and the caregiver's ability to work concurrently).

Cohorts contributing to direct costs include inpatients and outpatients. Within each cohort, the major determinants of cost are volume (i.e., number of people affected by COVID-19 in that cohort), price or value (i.e., of the service provided), and time (e.g., duration of service provision). For example, the costs arising from the cohort requiring inpatient care for COVID-19 would be the product of the number of patients admitted to hospitals, the average number of days they stay there, and the average cost per day of admission.

This approach does not typically account for the value of lost health, such as that quantified in a value of statistical life (VSL) methodology.[10] As a result, the cost-of-illness approach can lead to an underestimation of costs, as a population's willingness to pay to avoid harm is generally higher than the cost to the economy.

9. McKinsey & Company [Internet]. One billion days lost: How COVID-19 is hurting the US workforce. 2023 Jan 9. Available from: https://www.mckinsey.com/industries/healthcare/our-insights/one-billion-days-lost-how-covid-19-ishurting-the-us-workforce
10. Value of statistical life is an approach to estimating the value of reductions in the risk of physical harm.

### 2.1.1 Three epidemiological scenarios

Epidemiological scenarios help us to consider the potential courses that the COVID-19 pandemic may take in the future, providing a mechanism with which to anchor cost estimates to real-world conditions. Cost estimates can then be adjusted based on potential changes in these conditions.

While the price of medical services or the value of lost work in each cohort affected by COVID-19 is relatively straightforward to establish, other factors are contingent on the course of the pandemic. For example, a novel and more contagious strain may result in a greater number of infected individuals, unlike an earlier variant to which the population has already acquired a reasonably high level of immunity.

Three epidemiological scenarios have been developed:

- Normal 2.0: A lower estimate scenario, with more favorable conditions
- Base case: A middle estimate scenario, where current conditions prevail
- Pandemic 2.0: A higher estimate scenario, with more severe conditions

These scenarios are defined by two key features:

- Infection volume (driven by contagiousness and measured by cases per million population per year), and;
- Case severity (driven by a prevailing strain's virulence and measured by the resulting hospitalization rate).

These features allow low, base, and high scenarios to be used in cost estimates that reflect real-world conditions, improving their applicability to support decision-making. Estimates of the economic costs of COVID-19 using the cost-of-illness approach are detailed in Section 3 (Singapore) below.

To note, this report leverages Institute for Health Metrics and Evaluation (IHME)'s 2022 Reference Scenario data (last updated 18 November 2022) to inform the 'base case' for each of the markets in focus. The IHME is an independent global health research centre at the University of Washington. IHME aggregates real-time COVID-19 data and projects future scenarios for a number of markets, using a hybrid modelling approach incorporating statistical and disease transmission models.

This dataset includes:

- Historical actuals for daily confirmed cases and daily deaths
- Estimates of daily infections (not just those confirmed by a positive test) based on the SEIR disease transmission model that leverages data from seroprevalence surveys, daily cases, daily deaths, and daily hospitalisations where possible

IHME draws datasets from local and national authorities, hospital networks and associations, the World Health Organisation, and other sources / aggregators such as Johns Hopkins University and Our World in Data.

# 3. Economic Cost of COVID-19 in Singapore

**In Singapore, the future economic cost of COVID-19 could range from SGD ~1.1 billion p.a. (~0.2% of GDP) to SGD ~16.0 billion p.a. (~2.8% of GDP),** depending on the scenario that evolves. This represents a greater cost to society than is commonly recognized. COVID-19 not only inflicts health losses through illness and death but also imposes substantial economic costs, including a direct strain on the healthcare system and productivity losses from missed work.

As a society, Singapore has largely accepted the reality of living with ongoing transmission of the virus and the disease burden this incurs. However, there is an opportunity for better leveraging the tools available to reduce this burden. To better inform the ongoing discussion on COVID-19's impacts and the benefits of addressing them, it would be fruitful to understand the full range of economic costs imposed by COVID-19.

**There is a variety of potential epidemiological scenarios for how the COVID-19 pandemic may evolve.** This is reflected in the wide range of existing estimates for the economic costs resulting from COVID-19.[11] Possible epidemiological scenarios include a base case, where current conditions prevail, and alternative scenarios that differ in the rate of infections and their severity (driven, for example, by the interplay between variants and the level of immunity maintained in the population).

**In the base case scenario, total economic costs could be SGD ~3.6 billion p.a. (equivalent to ~0.6% of GDP),** assuming a transmission rate that results in ~3.3 million infections p.a. and ~8,200 hospitalizations p.a., with:

- The majority of costs (SGD ~3.4 billion p.a., ~96%) due to productivity losses (indirect costs) through missed work by both working-age adults and elderly in the workforce, either during their own illness or while caring for dependents (children and over 65-year-olds) affected by COVID-19;
- A further cost (SGD ~142 million p.a., ~4%) borne by the health system (direct costs), in both the inpatient (SGD ~68 million p.a.) and outpatient (SGD ~74 million p.a.) settings.

**In a Pandemic 2.0 scenario, economic costs could reach as high as SGD ~16.0 billion p.a. (~2.8% of GDP).** This assumes transmission rates that result in ~11.3 million infections per year (instead of ~3.3

11. Please see Section 1 for more details.

million as in the base case) and a severity that results in ~57,000 hospitalizations (compared with ~8,200 as in the base case). In contrast, at the lower end of the spectrum, a Normal 2.0 scenario could feature ~1.1 million infections over the course of a year with only ~2,000 hospitalizations, which would translate into direct and indirect costs of SGD ~1.1 billion p.a.

**These economic costs fall unevenly.** The health and logistics workforces, those affected by long COVID, and vulnerable populations are likely to be disproportionately impacted. For example, COVID-19 illness in vulnerable populations (see Section 3.4.7) contributes a loss of SGD ~1.7 billion p.a. in the base case scenario, while SGD ~1.9 billion p.a. in cost (~52% of total economic costs) results from infections in people eligible for oral antivirals, who are over 60 years old and/or affected by some comorbidity.

Separately, the health workforce is impacted by high levels of absenteeism and a high risk of infection, with consequences for health system capacity and quality of care. Economic costs arising from these disruptions to the health workforce total ~SGD 101 million p.a. in the base case scenario. Those affected by long COVID (see Section 3.4.8) are impacted most significantly, with the value of lost work and health system utilization totaling ~SGD 1.3 billion p.a. or ~37% of all economic costs.

**Fortunately, a range of countermeasures remains available** that may mitigate the economic costs of COVID-19 (see Section 4), including vaccination, therapeutics, and community measures (i.e., non-pharmaceutical interventions). Strengthening these countermeasures may allow Singapore to mitigate the potentially high economic costs of the continuing pandemic.

## 3.1 Context: The Situation In Singapore

**Today, Singapore is relatively free of restrictive measures.** Most of the community measures employed earlier in the pandemic, such as lockdowns and mandatory isolation, have been pared back. In their place, Singapore now has wide vaccine availability and uptake, while there is some usage of therapeutics such as antivirals which are available to a subset of the Singaporean population based on pandemic special authorization. As of February 13, 2023, Singapore has stepped down its remaining COVID-19 restrictions as it establishes an endemic new norm. Following on from that, since April 1, 2023, the authorities have scaled back pandemic subsidies, vowing to redirect financing schemes for COVID-19 testing and treatment to help address other acute illnesses.

**Over the three months to and including January 2023, Singapore experienced a stable period of infections and hospitalizations.** With ~5,200 new infections per day and an effective transmission number[12] of ~0.93, infection volumes were likely declining. By contrast, in January 2022 there were ~26,000 infections per day, with an effective transmission number of ~1.7, indicating the early stages of the first Omicron wave. Since then, however, most countermeasures have been pared back. The change in Singapore's pandemic response is both a reaction to the volume of infections, as well as a driver of subsequent infections.

12. The number of people a single case will infect, on average.

**Singapore's initial measures were effective at containment and then suppression of the virus, while also imposing significant economic costs.** By international standards, the countermeasures employed during the first phase (2020 to 2021) were largely successful. The number of reported cases (~280,000) and deaths (~830) were among the lowest in the OECD.[13] However, border closures, lockdowns, social-distancing requirements (including capacity limits on indoor spaces), and mask-wearing imposed significant hardships on the community. The successful rollout of vaccines[14] afforded an easing of many restrictions, although the immunity conferred was found to wane over time. This temporary and diminishing character of immunity necessitated third (and ultimately fourth) doses, while novel variants capable of immune escape, such as Omicron, also emerged.

**Oral antivirals have been added to Singapore's response toolkit** and will continue to remain fully subsidized for clinically eligible patients in outpatient (including primary care), ambulatory settings of public hospitals and nursing homes from 1 April 2023 until further notice. The necessarily short-term nature of restrictive community measures and the remaining health threat posed by COVID-19 led Singapore to broaden its approach to include oral antivirals, which had become available in Singapore between January and April 2022.[15] They are available to the over-60 age group, and to people above the age of 18 who exhibit additional risk factors; together, these could be termed as vulnerable populations. See Section 3.4.7 for further detail.

**Nevertheless, the health and economic outcomes of the reopening phase have been mixed.** The vast majority (~93%) of Singapore's infections to date occurred in 2022.[16] While the severity of infections remained relatively mild compared to early in the pandemic, the high volume of infections nevertheless made 2022 the busiest year for the hospital system during the pandemic, with ~52 admissions per day on average, compared to ~14 in 2021 and ~22 in 2020.[17] This also translated into the number of deaths increasing, to 861 in 2022, compared with 817 in 2021 and just 29 in 2020. It is worth noting that COVID-19 has potentially contributed to excess mortality (additional deaths relative to pre-pandemic mortality) both due to deaths caused by COVID-19 itself and deaths that may have arisen as a second-order impact of COVID-19 on health system capacity.

The high volume of infections has also wrought an economic impact, both in terms of costs borne directly by the health system in addressing COVID-19, and the economic losses borne indirectly by society in the form of absenteeism and productivity declines. These will be explored in detail in Sections 3.3.1 and 3.3.2. Singapore's reopening experience has illustrated that the costs of COVID-19 borne by Singaporean society extend beyond the value of health losses calculated merely by traditional health technology assessments. Indeed, productivity losses driven by infections across all age groups constitute a major economic cost.

Singapore has kept vaccination as its primary defense and updated its vaccination guidelines, as reflected in its National Vaccination Programme. While oral antivirals continue to remain fully subsidized for clinically eligible patients in outpatient, ambulatory settings of public hospitals and nursing homes, they too continue to play a role in treating those who are vulnerable and suffer from severe illness if they are found to be infected with COVID-19. **A better understanding of the economic costs of the pandemic may allow for a more accurate assessment of the costs and benefits of various measures to address the virus, as Singapore transitions to "living with COVID-19".**

13. Our World in Data [Internet]. Cumulative reported cases and deaths for Singapore from 2020 to 2021. Available from: https://ourworldindata.org/explorers/coronavirus-data-explorer?time=earliest..2021-12-30&facet=none&Interval=Cumulative&Relative+to+Population=false&Color+by+test+positivity=false&country=~AUS&Metric=Confirmed+cases
14. As in many international jurisdictions, a vaccine rollout strategy was adopted during 2021 as a conduit to an easing of various restrictions. As of January 2023, 92% of people aged 16 and over had received at least one dose of a COVID-19 vaccine while 83% had received 3 doses. Singapore Ministry of Health [Internet]. Vaccination Statistics. Available from: https://www.moh.gov.sg/COVID-19/vaccination/statistics
15. They are currently available for all COVID-19 positive patients over the age of 18 and with one additional risk factor, or those over the age of 60 regardless of risk factors. Risk factors include active cancer, chronic kidney disease and diabetes, among others.
16. There have been ~8.3 million infections in Singapore this year, compared to ~360,000 in 2021 and ~297,000 in 2020.
17. Institute of Health Metrics and Evaluation, used with permission. Available from: https://www.healthdata.org/covid/data-downloads

# 3.2 Key Assumptions In The Singapore Context

A range of informed assumptions is used to derive the estimates of economic costs in Singapore as a result of COVID. Exhibit 1 illustrates how these assumptions are used and provides a list of key assumptions used, while a full list of assumptions is given in the Appendix section.

Exhibit 1: Use of assumptions in the Singaporean context

**A | Epidemiological scenarios**

| Scenario | Infections (mn) p.a. | Hosp. rate (%) |
|---|---|---|
| Normal 2.0 | ~1.14 | 0.20 |
| Base | ~3.27 | 0.25 |
| Pandemic 2.0 | ~11.34 | 0.50 |

→

**B | Direct costs:** borne by the health system

| Key Base Case Assumptions | |
|---|---|
| # Ward admissions p.a. | ~7,400 |
| # ICU admissions p.a. | ~820 |
| % Infections that visit a GP | 1.8% |
| % Infections prescribed OAVs | 0.3% |
| # Long COVID cases p.a. | ~164,000 |

+

**C | Indirect costs:** economic productivity losses borne by society

| Key Base Case Assumptions | |
|---|---|
| Working-age infections as proportion of total | 64% |
| Proportion of working-age infections that can work | 99.7% |
| Proportion of working-age infections that can work from home | 80% |
| Average number of working days lost due to acute illness in working-age population | ~6 |
| Average daily salary | SGD 166 |

=

**D | Total economic cost to society**

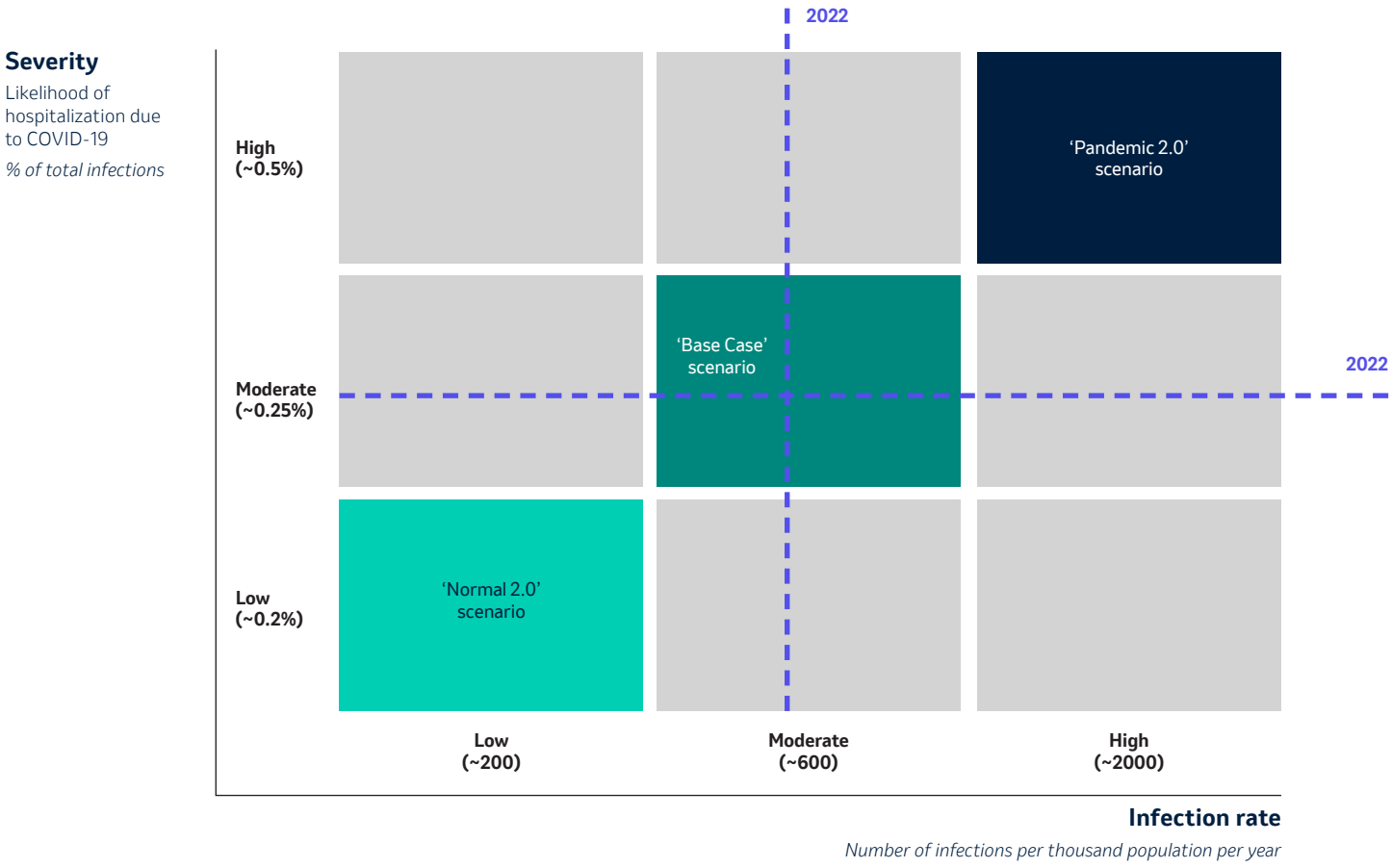
- **Total direct and indirect costs,** broken down by patient/demographic group
- **Costs per person** in each patient/ demographic group

  - E.g., if total inpatient costs are $68m, and 8,200 patients are admitted, the cost per person is ~ $8,300

A full list of assumptions is given in the appendix.

# 3.3 Future:
## Scenario-Based Estimates Of The Economic Costs Of COVID-19 In Singapore

Exhibit 2: Potential epidemiological scenarios




Scenarios are indicative only and based on the observed epidemiology of COVID-19 in Singapore in 2022.

Scenarios help us to consider and envisage the potential courses that the COVID-19 pandemic may take in the future. One way to express scenarios is in the form of low (Normal 2.0), base case, and high (Pandemic 2.0) epidemiological trajectories.

As Exhibit 2 illustrates, in the Singaporean context this could mean:

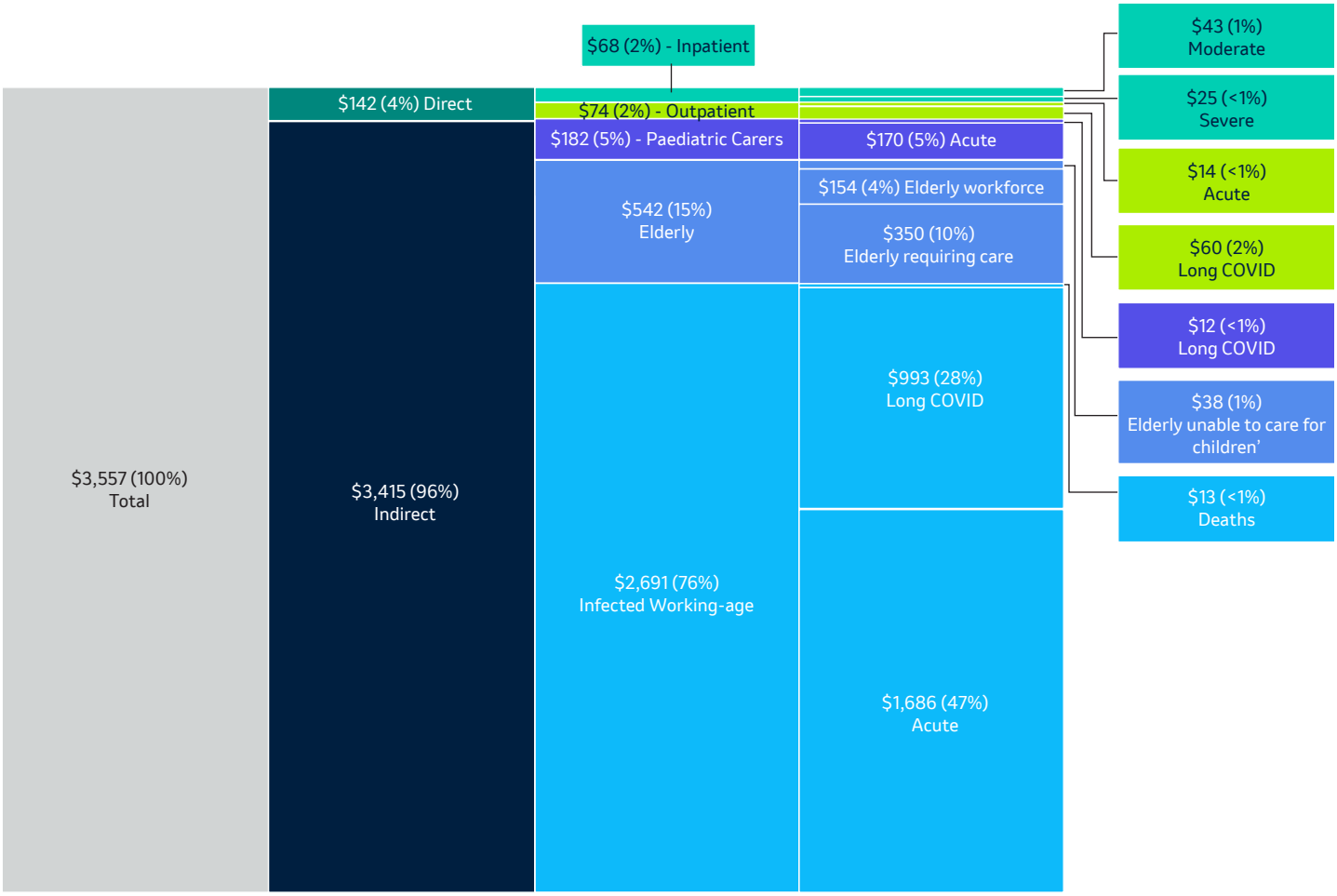
- A base case, with an economic cost of SGD ~3.6 billion p.a. (~0.6% of GDP, in addition to the value of lost health, such as that already considered in HTAs), which assumes a rate of infection and a viral severity similar to that seen in late 2022,[18] i.e., the costs Sections below.

18. Infection numbers and hospitalization rates are sourced from modelling of COVID-19 infections in Singapore by the Institute of Health Metrics and Evaluation (IHME; used with permission). Available from: https://www.healthdata.org/covid/data-downloads

- **A high or Pandemic 2.0 case, with an economic cost of SGD ~16.0 billion p.a. (~2.8% of GDP),** which assumes a higher rate of infection and a higher viral severity, similar to that seen in the first half of 2022, i.e., 2 million infections per million population per year, driving ~57,000 hospitalizations annually.

- **A low or Normal 2.0 case, with an economic cost of SGD ~1.1 billion p.a. (~0.2% of GDP),** which assumes a lower rate of infection and lower viral severity, similar to that seen in mid-late 2021, prior to the Omicron wave, i.e., ~200,000 infections per million population per year, driving ~2,000 hospitalizations.

Exhibit 3: Direct and indirect costs of COVID-19 to Singapore's economy in a base case scenario, SGD million p.a.

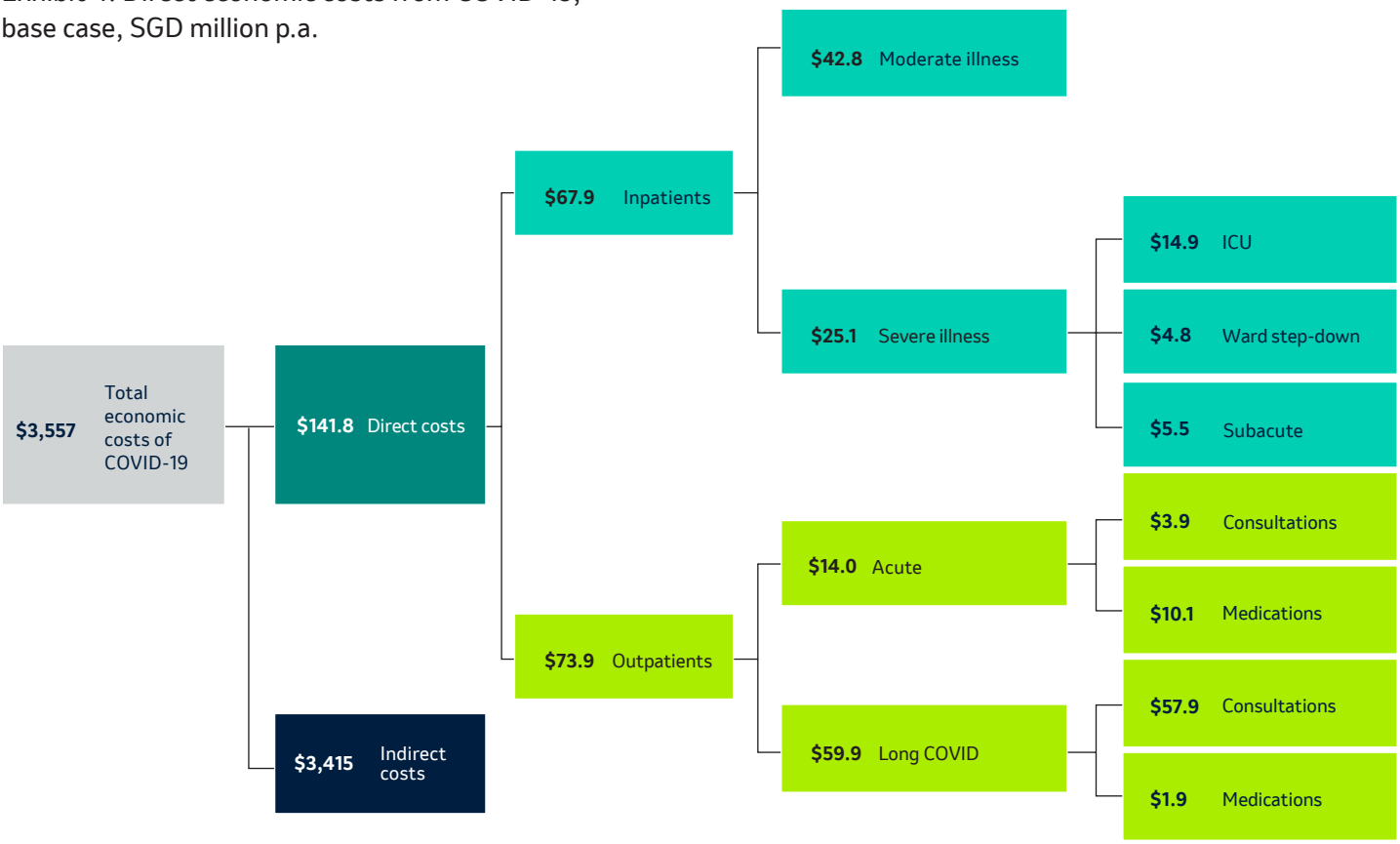



Costs are indicative only and based on the distribution of COVID-19 infections between cohorts in Singapore in 2022.

As Exhibit 3 illustrates, the base case scenario is designed to reflect a continuation of recent conditions. To do this, infection volumes and the prevailing hospitalization rate from Q4 2022 have been drawn from the Institute of Health Metrics and Evaluation (IHME; used with permission) model of COVID-19 and annualized.

## 3.3.1 Direct costs to the health system

Exhibit 4: Direct economic costs from COVID-19, base case, SGD million p.a.



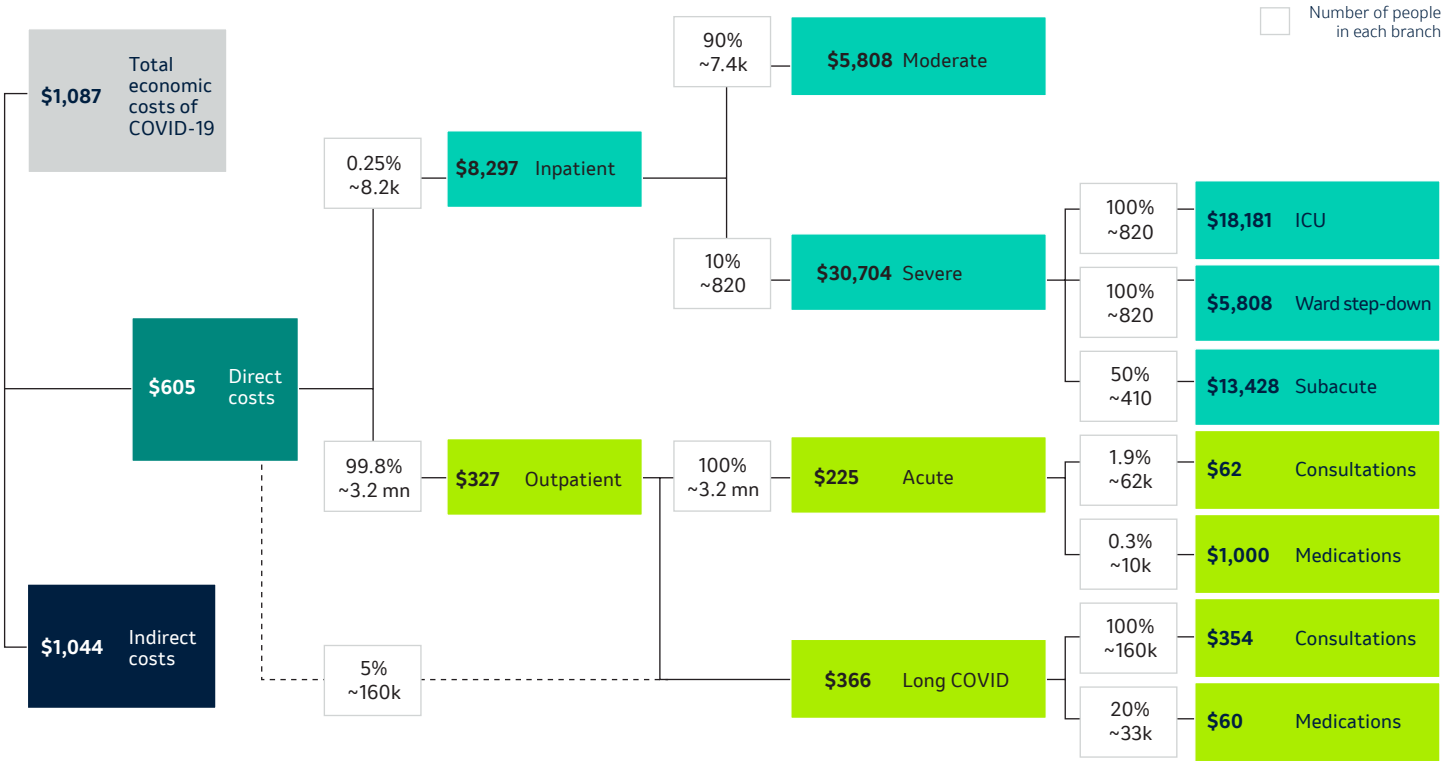

'Moderate illness' requires ward-based inpatient care and 'Severe illness' requires ICU-level care; 'Acute illness' refers to all infections not included in inpatient care; Long COVID refers to a small subset (~5%) of total infections and represents infections with symptoms lasting 12 weeks or more.

**With ~8,200 hospital admissions (including ~820 to the ICU) and ~164,000 cases of long COVID** in the base case scenario, a number of variables could have a significant cumulative impact in reducing the direct costs imposed by COVID-19 on the health system, namely limiting hospital admissions and reducing lengths of stay, as well as differences in recovery times and/or the incidence of long COVID. Given that those over 65 are over-represented in the COVID-19 inpatient population, preventing severe illness in this cohort would likely be particularly impactful in reducing direct costs.

**In this scenario, as displayed in Exhibit 4, COVID-19 could result in direct costs of SGD ~142 million p.a.** for the Singaporean health system. Despite the magnitude of this figure, direct costs are still a minority of the total economic costs of COVID-19 in Singapore, accounting for ~4% of the overall total. Indirect costs, comprising productivity losses due to missed work, account for the remainder and could add up to SGD ~3.4 billion p.a. These are discussed further in Section (3.3.2).

Despite the relatively minor weighting of direct costs within the wider economic impact of COVID-19, they remain significant on a per-infection basis. As illustrated in Exhibit 5, each infection that uses some form of health service could impose an average cost of SGD ~605.

Exhibit 5: Direct economic costs from COVID-19, per person, base case, SGD p.a.




Costs per person for each segment are calculated by dividing the total cost of that segment by the number of individuals in that segment that utilize a health service; 'Moderate illness' requires ward-based inpatient care and 'Severe illness' requires ICU-level care; 'Acute illness' refers to all infections not included in inpatient care, where ~2% visit a GP and 0.3% are prescribed medication; Long COVID refers to a small subset (~5%) of total infections and represents infections with symptoms lasting 12 weeks or more.

This is most concentrated in the costs of inpatient care, where a single ward admission could cost SGD ~5,808 and a single ICU admission (with subsequent ward and rehabilitation stays) could cost SGD ~30,704.

As indicated in Exhibit 4, direct costs are incurred in two major settings:

- Inpatient (hospital-based) care (SGD ~67.9 million p.a.; 48%; SGD ~8,297 per person)
- Outpatient (primarily GP-based) care (SGD ~73.9 million p.a.; 52%; SGD ~327 per person)

**The profile of inpatient care costs suggests that ameliorating the severity of illness acquired could have a significant impact on cost.** Particularly in a reopened economy, where individuals at risk of severe disease are less protected from infection by community health measures, the extent of ongoing costs to the health system underscores the importance of continuing to prevent, test for, and treat the disease.

Costs in this category comprise those arising from moderate infections requiring ward-based care (SGD ~42.8 million p.a.; SGD ~5,808 per person) and severe infections requiring ICU (SGD ~25.1 million p.a.; SGD ~30,704 per person). The more costly care for moderate infections is driven mostly by the large volume of patients exhibiting moderate infections (~7,400, compared to ~820 patients with severe infections), while the cost of care for severe infections is driven largely by high bed day costs (SGD ~2,300 per day in ICU), followed by substantial periods of inpatient rehabilitation.

**The profile of outpatient care costs indicates that limiting the incidence, duration, and/or severity of long COVID would have a substantial impact on this portion of the cost burden.** Outpatient care for COVID-19 infections adds SGD ~73.9 million p.a. to the total economic costs incurred due to COVID-19. While seemingly less resource-intensive, outpatient infections that use health services are also expensive on a per-person basis, each costing SGD ~327.

**Outpatient costs can be separated into acute outpatient care (consultations and medications;** SGD ~14 million p.a.) and chronic outpatient or Long COVID care (consultations and medications; SGD ~60 million p.a.; see Section 3.4.8).

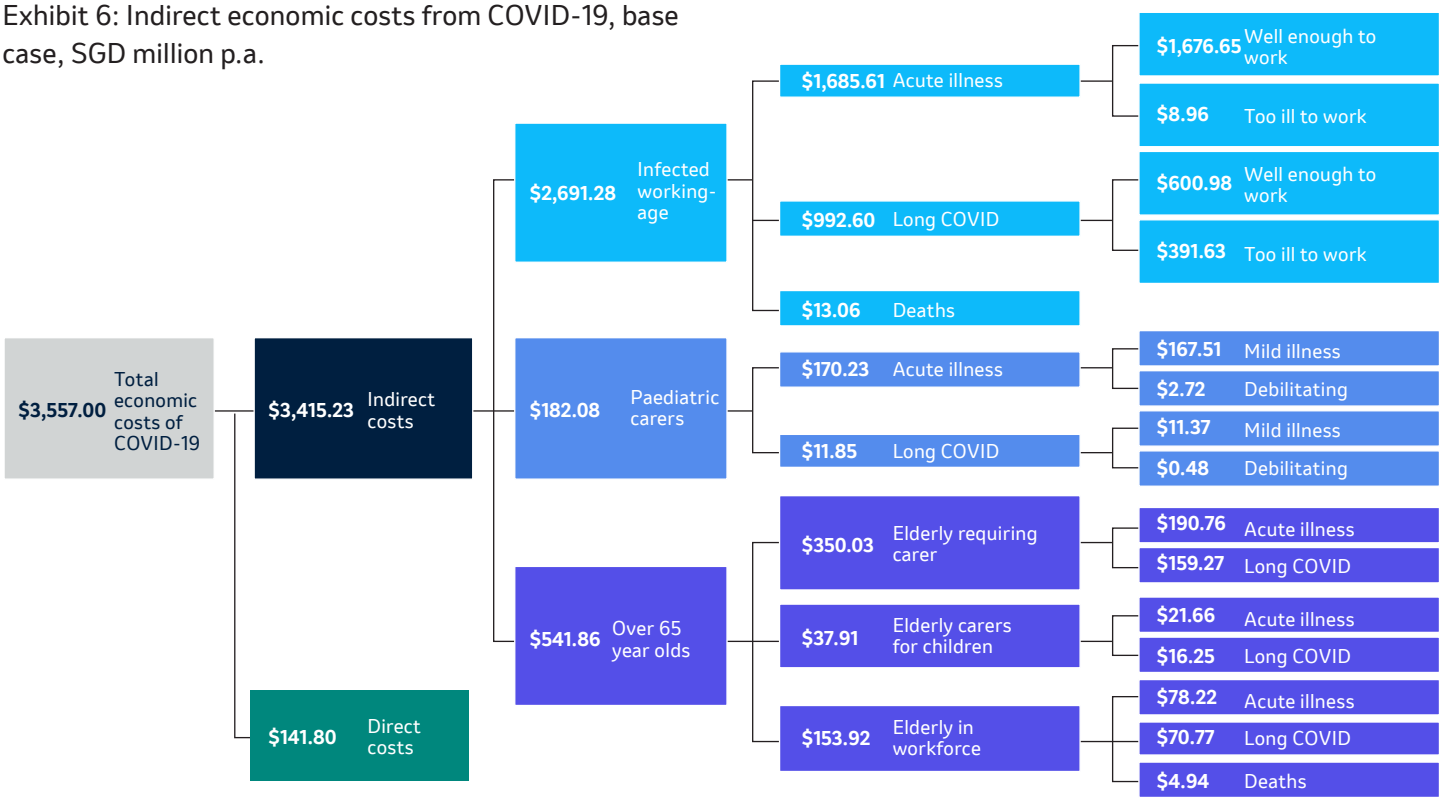
**While the cost of acute outpatient care is driven largely by the cost of medications (such as oral antivirals, SGD ~10.1 million),** this equates to just ~7% of all direct costs, representing a small investment towards partially reducing the much larger economic burden associated with COVID-19 (SGD ~3.6 billion p.a.), which could be larger still in the absence of such treatments. Visits to GPs account for the remainder of outpatient costs, which could total more than 60,000 consultations per year if ~2% of those infected seek the care of their GP. While the cost of these services is lower compared to inpatient costs (SGD 67.9 million p.a.), it is not insignificant and the patient volume represents a substantial additional burden on the primary care system.

**Together, direct costs from the inpatient and outpatient cohorts amount to SGD ~141.8 million p.a.** While significant on their own, these costs are in addition to the indirect costs to Singapore's economy (discussed below), the value of lost health they represent, and the secondary effects on the health system (such as its workforce) and other critical industries.

## 3.3.2 Indirect costs to the economy

**Reducing the sheer volume of COVID-19 infections and the duration of illness and/or recovery** time for working-age adults, children, and the older population would have a significant impact on the economic and societal costs of COVID-19.

Exhibit 6: Indirect economic costs from COVID-19, base case, SGD million p.a.




Note: Totals may not sum precisely due to rounding to 2 decimal places

Indirect costs arise from productivity losses incurred due to infection with COVID-19; 'Well enough to work' refers to those who can continue working while infected, albeit with reduced productivity; 'Too ill to work'' refers to those who cannot work, at least for a portion of the time, while infected; 'Acute illness' refers to all infections not included in inpatient care; Long COVID refers to a small subset (~5%) of total infections and represents infections with symptoms lasting 12 weeks or more.

**In the base case scenario, and as Exhibit 6 illustrates, COVID-19 could cost the Singaporean economy SGD ~3.4 billion p.a. in productivity losses** if current epidemiological conditions and response settings continue.[19] This estimate could be larger if stricter isolation protocols were to return. As with direct costs to the health system, this is a significant expense, equating to ~0.6% of GDP. While these costs are significant, as with direct costs, they still do not put an accurate value on the damage to health due to COVID-19, nor on the secondary impacts to critical industries and vulnerable populations, such as the health workforce.

As illustrated in Exhibits 6 and 7, indirect costs result from productivity losses borne by three major groups:

- **Infections in working-age adults (20-64 years old) – ~SGD 2.7 billion p.a.** (~79%; SGD ~1,285 per person)
- **Infections in the older population (65 years old and above) – ~SGD 542 million p.a.** (~16%; SGD ~998 per person)
- **Infections in children and adolescents (19 years old and under) – ~SGD 182 million p.a.** (~5%; SGD ~287 per person)

**Infections in working-age adults impose a significant economic burden on Singapore, through productivity losses valued at ~SGD 2.7 billion p.a.,** a significant figure that equates to ~0.5% of Singapore's GDP. This burden highlights the broader economic impact that can be inflicted by an illness that, although mild for most, can be significant enough to last ~12 days and impair productivity by ~35% for three-quarters of them.[20]

Productivity loss incurred by the working-age group can be considered in two ways:

- Acute illness (SGD ~1.7 billion p.a.), chronic illness or long COVID (SGD ~993 million p.a.), and deaths (SGD ~13 million p.a.);
- Infected adults with mild illness who are still well enough to work but with reduced capacity (SGD ~2.3 billion p.a.), and infected adults who are too ill to work (i.e., are hospitalized) (SGD ~400 million p.a.).

**Taking these together, acute illness in those who can still work but at reduced capacity accounts for ~63% of productivity losses incurred by working-age adults.** The magnitude of this cost illustrates that, despite the mildness of the illness for most, when modest reductions in working capacity are multiplied across a multi-day illness affecting ~3.3 million Singaporeans, the result is a substantial cost impact for the whole market.

**Infections in the older population impose SGD ~542 million p.a. in costs from productivity losses on the Singaporean economy,** adding to the burden from working-age adults. This highlights that productivity losses are not limited to those borne by the working-age population alone and that adjacent cohorts are of proportional importance.

Older people that incur productivity losses due to COVID-19 fall into three categories:

- **Older people with COVID-19 who require care from a working-age person** – ~380,000 working-age adults, incurring an SGD ~921 productivity loss – resulting in a total impact of SGD ~350 million p.a.
- **Older people who directly participate in Singapore's labor force** – estimated to be 33% of over-65s, 66% of whom work full-time. Infections in this group result in SGD ~154 million in productivity losses.
- **Older people (e.g., grandparents) who care for children to enable parents to work** – one in four households rely on grandparents as the main caregiver. When this work-enabling care is disrupted, productivity loss amounts to SGD ~38 million.

**Infections in the older population account for SGD ~565 million p.a., or ~16% of all direct and indirect costs combined,** serving as a stark reminder of the need to address costly infections in cohorts adjacent to working-age adults.

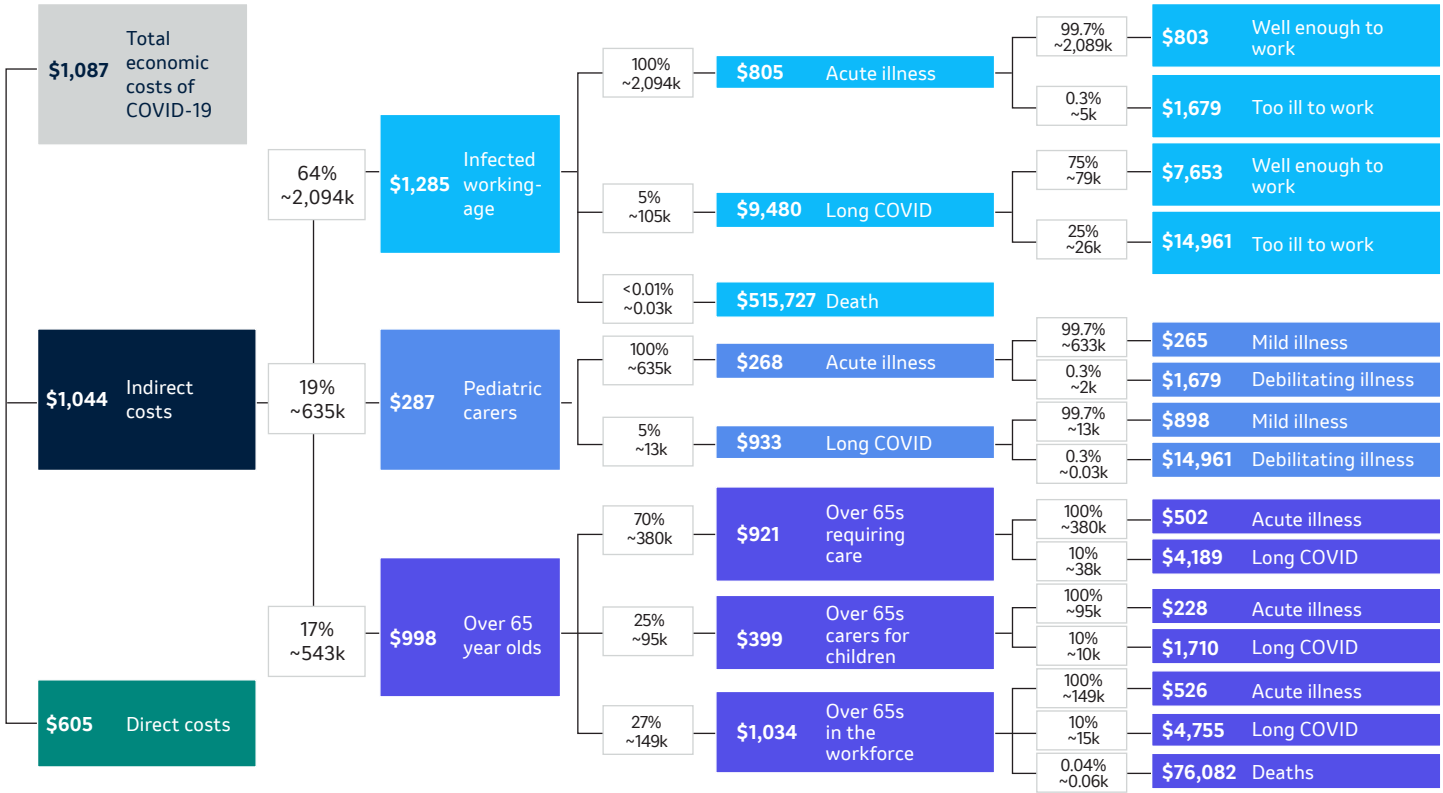
19. Based on a median monthly earnings figure of $5,070. Singapore Ministry of Manpower [Internet]. Income Summary Table. Available from: https://stats.mom.gov.sg/Pages/Income-Summary-Table.aspx
20. Johnsen et al. European Respiratory Journal [Internet]. Descriptive analysis of long COVID sequelae identified in a multidisciplinary clinic serving hospitalised and non-hospitalised patients. Available from: https://openres.ersjournals.com/content/erjor/7/3/00205-2021.full.pdf

**Finally, infections in children impose an additional economic cost of SGD ~182 million p.a.** owing to productivity losses borne by adults who are absent from or less productive at work while caring for children. Along with those from the older population, productivity losses arising from infections in children can be difficult to recognize in advance but are significant when they emerge.

Productivity losses arising from infections in children are predominantly driven by adults caring for children with acute, mild illness. The cohort of infected children, which constitutes the majority (~98%) of productivity losses in adults caring for children with acute illness, is worth SGD ~168 million p.a. This cost is driven by care for ~486,000 mild infections in children, who despite having a mild illness require one parent to care for them at home. The remaining ~2% is driven by productivity losses from caring for children with debilitating infections. For parents who can work from home (~80%), productivity is estimated to halve, while all productivity is foregone by parents who cannot (~20%). This is a substantial cost driven more by lost work than the illness itself, reiterating that significant costs imposed by productivity losses are not limited to infections in working-age adults.

Despite the apparent reduction in resource intensiveness compared to direct healthcare costs, the magnitude of productivity losses imposed by COVID-19 means indirect costs are nearly as expensive on a per-person basis (as indicated in Exhibit 7), with each infection costing SGD ~1,044 on average. This is concentrated in productivity losses resulting from infections in the working-age (SGD ~1,285 per person) and older populations (SGD ~998 per person).

Exhibit 7: Indirect economic costs from COVID-19, per person, base case, SGD p.a.




Costs per person for each segment are calculated by dividing the total cost of that segment by the number of individuals in that segment; Indirect costs arise from productivity losses incurred due to infection with COVID-19; 'Well enough to work' refers to those who can continue working while infected, albeit with reduced productivity; 'Too ill to work' refers to those who cannot work, at least for a portion of the time, while infected; 'Acute illness' refers to all infections not included in inpatient care; Long COVID refers to a small subset (~5%) of total infections and represents infections with symptoms lasting 12 weeks or more.

**Together, economic costs arising from productivity losses in these cohorts amount to SGD ~3.4 billion p.a. or ~0.6% of Singapore's GDP** and are in addition to the value of lost health and direct costs to Singapore's health system. Although already substantial, these costs are likely to underestimate the entirety of the burden imposed on society by COVID-19, including second-order impacts on health system capacity and knock-on effects on the health workforce, supply chains, and other aspects of critical industry; all of these factors contribute to directly measurable economic impacts.

The entirety of the economic burden imposed by COVID-19 needs also to be understood in the context of the prevailing epidemiological scenario, as the impacts and costs described can significantly increase under plausible scenarios where novel variants emerge. Such scenario variations are described below.

## 3.3.3 Alternative scenarios: costs of Pandemic 2.0 and Normal 2.0

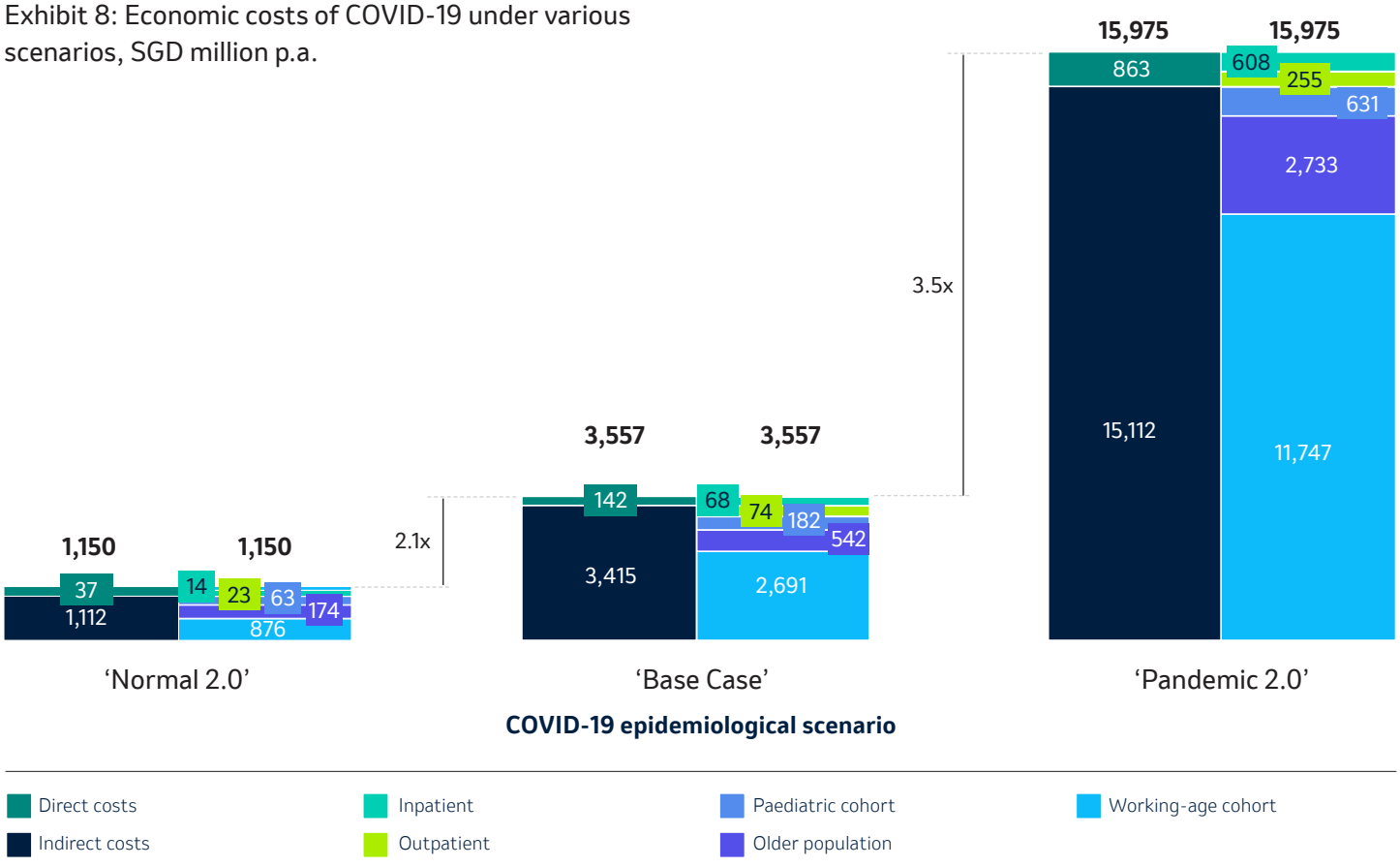
In addition to the base case, two further scenarios have been considered, as illustrated in Exhibit 8.

**In a Pandemic 2.0 scenario, total economic costs could reach SGD ~16 billion p.a.** Conversely, in the Normal 2.0 scenario, economic costs could be reduced to SGD ~1.1 billion p.a.

**The two example scenarios represent divergent epidemiological outcomes, both of which are plausible as the pandemic evolves.** Each theoretical scenario is constructed with two key features:

- Infection volume (driven by contagiousness; measured by cases per million population per year);

Exhibit 8: Economic costs of COVID-19 under various scenarios, SGD million p.a.




Normal 2.0 refers to a scenario featuring ~200,000 infections per million population and ~2,000 hospitalizations, reflecting conditions observed in mid-late 2021; Pandemic 2.0 refers to a scenario featuring ~2 million infections per million population and ~57,000 hospitalizations, reflecting conditions observed in the first half of 2022.

- Case severity (driven by a prevailing strain's virulence factors; measured by resulting hospitalization rate).

A Pandemic 2.0 scenario would feature a case volume of ~2 million cases per million population per year (i.e., the entire population is infected twice, on average) and a case severity that drives a hospitalization rate of 0.5% of all infections. This is in comparison to the base case scenario, where a case volume of ~580,000 infections per million population and a hospitalization rate of 0.25% is assumed.

In the Pandemic 2.0 scenario, economic impacts from COVID-19 could increase to SGD ~16 billion p.a., equating to ~2.8% of GDP and SGD ~1,476 per person. In this scenario, direct costs could be SGD ~863 million p.a. (i.e., SGD ~721 million p.a. higher than the base case, or a 6.1X increase), while indirect costs could reach SGD ~15.1 billion p.a. (i.e., SGD ~11.7 billion p.a. higher than the base case, or a 4.4X increase). These increases would be driven by the higher case volumes, resulting in an uptick in hospitalization rates and longer periods of stay, as well as augmented productivity losses, caused by a more prevalent incidence of debilitating illness and longer periods of missed work.

The magnitude of the cost increases that could result from a plausible epidemiological scenario such as this demonstrates the need for a range of preparedness settings, which include options to limit impacts at all junctures.

A Normal 2.0 scenario would feature a case volume of ~200,000 cases per million population per year and a hospitalization rate of 0.2%. Under a Normal 2.0 scenario, economic impacts from COVID-19 could reduce to SGD ~1.1 billion p.a., equating to ~0.2% of GDP and SGD ~1,005 per person. Direct costs could decrease to SGD ~37 million p.a. and indirect costs to SGD ~1.1 billion p.a. Decreases in costs would be driven by a fall in case volume, lower hospitalization rates, and diminished productivity losses, owing to reduced periods of missed work.

While these different scenarios help us to consider potential trajectories that the COVID-19 pandemic may take in the future, their scope is largely restricted to the consideration of quantifiable economic costs. Equally worthy of consideration are the 'second order' impacts that COVID-19 could exert on health system capacity and the knock-on effects that this would have on vulnerable populations and critical industries. This aptly demonstrates the broad economic and societal impacts of the pandemic.

## 3.4 Considerations For Particular Cohorts And Industries

The economic costs of COVID-19 described will impact different populations and industries disproportionately. This includes those that play a critical economic/social role (e.g., health care workers), those that are particularly vulnerable to severe disease (e.g., people with comorbidities), and those that go on to develop long COVID.

Interventions that protect health and productivity losses in these critical industries and populations may yield corresponding, disproportionate economic returns. Disruptions to these groups also cause significant economic and societal concern and may be worthy of additional focus when considering countermeasure approaches to mitigate the impacts of COVID-19.

## 3.4.1 Critical workers and industries

**As outlined above, some critical industries experience disproportionate workforce productivity losses that generate significant public concern.** Here, the focus is on five industries in particular – healthcare, logistics, travel and tourism, food and beverage, and education.

**The economic costs of COVID-19 borne by critical industries and their stakeholders may increase under a Pandemic 2.0 scenario.** In this scenario, workforces that are largely unable to work from home may be required to isolate while they recover. The resulting loss of productive time can be 30% greater (the equivalent of 1-2 workdays) than individuals in desk-based jobs.

## 3.4.2 Healthcare

**Singapore's health system serves as the market's first and last line of defense against COVID-19 and other health threats.** Healthcare expenditure is expected to reach SGD ~56 billion by 2030[21] and ~153,000 residents are currently employed in the Health and Social Services sector in Singapore.[22]

**At a potential minimum cost of SGD ~101 million p.a. (~2.8% of combined total cost),**[23] healthcare workers who become infected with COVID-19 represent a disproportionate slice of the impact that this disease exerts on the economy. However, this is likely to significantly underestimate the total costs to the Singaporean economy and citizens' welfare, as it would also translate into secondary impacts on patient outcomes.

**Health service employers experience higher rates of absenteeism due to COVID-19 compared with other industries.** Employees in the Health and Social Services industry were more likely to take outpatient sick leave and hospitalization leave in the first half of 2020 compared to other industries, with 55% taking outpatient sick leave and 14% taking hospitalization leave.[24] A root cause of these inflated figures is the heightened risk of COVID-19 infection that healthcare workers are exposed to in the workplace.[25] Productivity losses are not only incurred by sick workers but also by remaining workers who are required to take up additional responsibilities.

**The second-order economic impacts of COVID-19-related absenteeism among healthcare workers are significant,** as COVID-19 exacerbates pre-existing workforce shortages. Even recently, some emergency departments have experienced admission wait times of up to 50 hours, with hospitals also deferring non-urgent elective surgery and admissions to preserve beds and staff.[26] Such reductions in the availability and timeliness of medical care may subsequently lead to prolonged illness or recovery times for patients, who in turn accumulate their own, additional productivity losses.

**Additionally, during the COVID-19 pandemic, unprecedented levels of workforce burnout and attrition have been seen.**[27,28] Although the initial response to the COVID-19 pandemic has subsided, global talent shortages and mobility challenges are an ongoing concern.

**A countermeasure approach that targets healthcare workers could have a significant effect** in mitigating overall economic costs, as well as the impacts of COVID-19 on public health. This is demonstrated by the disproportionate costs of COVID-19 infections among healthcare workers, against the backdrop of an increasingly constrained talent market.

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21. International Trade Administration, Singapore [Internet]. Country Commercial Guide. 2022 Aug. Available from: https://www.trade.gov/singapore-country-commercial-guide
22. Department of Statistics Singapore [Internet]. Employed Residents Aged 15 Years And Over By Industry And Occupation. 2022 Oct. Available from: https://www.singstat.gov.sg/find-data/search-by-theme/economy/labour-employment-wages-and-productivity/latest-data
23. Based on a median monthly earnings figure of $4,680. Ministry of Manpower, Manpower Research and Statistics Department [Internet]. Statistical Table: Income. 2023 Jan 31. Available from: https://stats.mom.gov.sg/Pages/IncomeTimeSeries.aspx
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28. Nanda A. The Straits Times [Internet]. More doctors in Singapore face burnout, anxiety amid the pandemic. 2021 Aug 03. Available from: https://www.straitstimes.com/life/more-doctors-in-singapore-face-burnout-anxiety-amid-the-pandemic

## 3.4.3 Logistics

**COVID-19 has caused unprecedented disruption to Singapore's transport and logistics sector,** which delivers vital goods and services across the nation. It is an SGD ~255.5 billion industry, with a growing workforce of over 200,000 people.[29,30] During the pandemic, the sector experienced a disproportionate impact of productivity loss from workers, which has snowballed to disrupt local and global supply chain networks.

**Singapore's transport operators and distribution centers have experienced significant workforce shortages due to COVID-19 illness.** Among this workforce are warehouse staff, forklift drivers, unloading crews, and technicians, who are unable to complete their tasks at home while ill, isolating, or caring for others who have been infected with COVID-19. Consequently, these businesses struggle to retain other employees, who find themselves having to work longer hours to accommodate these gaps in capacity, leading to overwork and stress.

**Workforce shortages have downstream consequences for end-point retailers, users, and customers too.** In 2021, 32% of Singaporean organizations reported that their operations were significantly impacted by COVID-19, with the most impacted area being operation and supply chain.[31] Disruptions have the dual effect of driving inflation in the costs of goods and services while impeding the ability of businesses, and their workers, to deliver them. Among these, there are necessities of particular public concern – food, life-changing medicines, oil, and gas.

**The impact of workforce shortages may point to an incremental opportunity** for targeted COVID-19 countermeasures to support Singapore's logistics industry, as it grapples with the multitude of challenges (including geopolitical tensions) at the heart of today's "supply chain crisis".

## 3.4.4 Travel and tourism

**Despite a strong economic recovery, Singapore's travel and tourism sector continues to face headwinds due to workforce shortages.** One of the highest-yielding destinations in the world prior to the COVID-19 pandemic, by 2022 spending from tourists in Singapore had only returned to approximately 50% of 2019 levels.[32] The impact of the pandemic could be observed through the steep declines in visitor volumes and spending, due to border closures, stay-at-home restrictions, and hesitancy among travelers.

**However, the return of visitors to Singapore in large numbers may also entail risks of 'importing' COVID-19 infections and the economic impacts these carry.** By 2024, Singapore is expecting tourism arrivals and activity to recover to pre-pandemic levels.[33] To that end, in 2023, Singapore will host 19 MICE events[34] and the Singapore Grand Prix (among other major events). In 2022, the Grand Prix attracted a record crowd of 302,000 – many of whom were overseas visitors.[35] While these events bring positive economic returns, the potential inherent risk of imported COVID-19 infections should also be acknowledged – particularly given the recent removal of all COVID-19-related requirements for travelers entering Singapore.[36] This is of particular note given the impact that the pandemic and its various outbreaks have had on the airport and accommodation workforces.

29. Department of Statistics Singapore [Internet].Transport and Storage Industry. 2021. Available from: https://www.singstat.gov.sg/-/media/files/visualising_data/infographics/industry/transportation-and-storage.ashx
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33. Singapore Tourism Board [Internet]. Singapore's tourism sector recovers strongly in 2022, visitor numbers expected to double in 2023. 2023 Jan 17. Available from: https://www.stb.gov.sg/content/stb/en/media-centre/media-releases/Singapore-tourism-sector-recovers-strongly-in-2022-visitor-numbers-expected-to-double-in-2023.html
34. As of February 2023, Singapore has announced 19 MICE events to take place between February and October 2023; Visit Singapore [Internet]. Event Listing. Available from: https://www.visitsingapore.com/mice/en/event-listing/
35. Singapore Grand Prix [Internet]. Available from: https://singaporegp.sg/en/news
36. Immigration and Checkpoints Authority [Internet]. Entering Singapore. Available from: https://www.ica.gov.sg/enter-transit-depart/entering-singapore

**COVID-19-related absenteeism has wreaked havoc across airports and accommodation services:** ~30% of the workforce in the aviation sector was lost during the pandemic, which by late 2022 had only been restored to ~80% of the pre-COVID-19 levels.[37] This is contributing to delays at airports, with cargo processing times taking up to two weeks instead of the usual few days.[38]

**Countermeasures that are targeted at Singapore's travel and tourism workforce may help the sector fully overcome the remaining hurdles in its recovery from the COVID-19 pandemic.**

## 3.4.5 Food and beverage

**COVID-19 has significantly impacted Singapore's food and beverage industry, in particular through restrictions on dining in at restaurants and reductions in catering orders due to a lack of group gatherings.** Food and beverage sales in Singapore declined by 26% year-on-year in 2020, with a year-on-year decline of 51% specifically during the Circuit Breaker period from April to May 2020.[39] With COVID-19 compounding existing pressures in labor and rental costs, ~1,200 outlets in Singapore permanently shut between January and July 2020.[40]

**Frontline workers in this sector have faced disruption to their jobs, with most unable to work from home and some let go due to revenue declines.** 15,400 employees left the food and beverages sector in 2020, with low productivity in the sector further affecting job quality and wages for those that remain.[41] Operational changes have also occurred in the food and beverage sector aimed at reducing reliance on labor (e.g., installation of self-service kiosks); these developments continue to threaten the jobs of employees who earn, on average, below the 20th percentile income level of all full-time employed residents.[42]

**Given the importance of the food and beverage industry for Singapore's economy and as a source of income for Singaporeans, countermeasures that facilitate recovery in its workforce could assist with improving overall productivity.**

## 3.4.6 Education

**Although Singapore adapted rapidly to home-based learning, the full consequences of online teaching for Singaporean students, as a result of COVID-19, are yet to be seen.** During the circuit breaker period from April to May 2020, Singapore shifted toward fully home-based learning, with a pause also in preschool and student care center services.[43] The effects of this are mixed, with increased flexibility being counteracted by several disruptions, including the loss of peer-to-peer interaction, a lack of direct access to the teacher, and potentially unstable internet connection disadvantaging some students.[44]

37. Ministry of Trade and Industry, Economic Survey of Singapore Second Quarter 2022 [Internet]. Recovery of Air Travel and Tourism in Singapore. 2022 Aug. Available from: https://www.mti.gov.sg/-/media/MTI/Resources/Economic-Survey-of-Singapore/2022/Economic-Survey-of-Singapore-Second-Quarter-2022/BA_2Q22.pdf
38. Yong C. The Straits Times [Internet]. Covid-19 cases among staff, CNY holiday lead to cargo being stuck at Changi Airport. 2022 Feb 09. Available from: https://www.straitstimes.com/singapore/cargo-stuck-at-changi-airport-as-covid-19-causes-shortage-of-manpower
39. Qua K, Yeo M, Lee J, Chua K. Singapore Department of Statistics, Statistics Singapore Newsletter [Internet]. Impact of COVID-19 on the Retail and Food & Beverage Services Sectors. 2021 Mar. Available from: https://www.singstat.gov.sg/-/media/files/publications/industry/ssn121-pg1-5.ashx
40. Paulo DA, Klimowicz G. Channel News Asia [Internet]. For F&B outlets, COVID-19 is a wake-up call. Here are seven changes they can make. 2020 Oct 25. Available from: https://www.channelnewsasia.com/cnainsider/food-f-b-outlets-restaurants-covid-19-wake-up-call-seven-changes-980351
41. Low Y. Channel News Asia [Internet]. The Big Read: F&B manpower woes — whither the big productivity push? Or are there just too many eateries in Singapore? 2022 Apr 18. Available from: https://www.channelnewsasia.com/singapore/big-read-food-beverage-manpower-woes-eateries-robots-covid-19-2630486
42. As above
43. Ministry of Health, Singapore [Internet]. Circuit Breaker to Minimise Further Spread of COVID-19. 2020 Apr 03. Available from: https://www.moh.gov.sg/news-highlights/details/circuit-breaker-to-minimise-further-spread-of-covid-19
44. Jürgen R. Educational Research for Policy and Practice [Internet]. Perceived quality of online learning during COVID-19 in higher education in Singapore: perspectives from students, lecturers, and academic leaders. 2022 Nov 17. Available from: https://link.springer.com/article/10.1007/s10671-022-09325-0

**The education sector was further impacted by teacher absenteeism due to COVID-19.** Globally, countries faced an increase in teacher absences during the COVID-19 pandemic, with 40% of OECD countries needing to recruit temporary staff in order to fill absences and allow classes to continue with minimal disruption.[45] Furthermore, educators experienced increased burnout and stress as a result of the additional workload of teaching remotely, compounded by the effects of isolation during COVID-19 lockdowns.[46]

**Countermeasures that help reduce significant periods of illness and absenteeism in teachers and students could help maintain Singapore's high level of education in the future.**

## 3.4.7 Vulnerable populations

**COVID-19 illness in Singapore's vulnerable populations represents a minimum impact of SGD ~1.7 billion p.a. to Singapore's economy.** These populations are at greater risk of severe COVID-19 disease and are more heavily reliant on the healthcare system than others. Populations that have received particular attention throughout the pandemic include those over 65 years old and those with comorbidities.

**COVID-19 illness in Singapore's older population (65 years and over) could have an economic impact of SGD ~565 million p.a. (~16% of the combined annual impact).** This is significant on a per-person basis too, at SGD ~1,041. Despite accounting for just ~17% of confirmed cases, the older population represents a significantly higher proportion of deaths, with ~95% of deaths from COVID-19 occurring in those aged over 60.[47] This is unsurprising when one considers that the prevalence of comorbidities is particularly high in this age group. 37% of Singaporeans over 60 years old have three or more chronic health conditions.[48]

**Comorbidities in the younger, working-age population could also have a disproportionate impact of ~SGD 1.1 billion p.a.** Just one comorbidity doubles the risk of severe COVID-19,[49] subsequently increasing the likelihood of hospitalization and prolonging recovery time away from work. This could be a reality for ~40% of Singaporeans.[50]

**Given that ~47% of combined direct and indirect costs are borne by these vulnerable populations,** countermeasures that reduce the duration of illness and/or recovery time for this group alone could significantly mitigate the costly impacts of COVID-19. Countermeasures may include ongoing vaccination, community measures, or the use of oral antivirals. Indeed, infections in individuals eligible for oral antivirals account for SGD~ 1.9 billion p.a. in economic costs or ~52% of the total economic costs to Singapore.

45. Charbonnier E, Doumet MH et al. OECD [Internet]. The State of Global Education 18 Months into the Pandemic. 2021 Sep. Available from: https://www.oecd-ilibrary.org/docserver/1a23bb23-en.
46. Jürgen R. Educational Research for Policy and Practice [Internet]. Perceived quality of online learning during COVID-19 in higher education in Singapore: perspectives from students, lecturers, and academic leaders. 2022 Nov 17. Available from: https://link.springer.com/article/10.1007/s10671-022-09325-0
47. Reuters [Internet]. Singapore may see 2,000 COVID-19 deaths each year - minister. 2021 Nov 1. Available from: https://www.reuters.com/world/asia-pacific/singapore-may-see-2000-covid-19-deaths-annually-minister-2021-11-01/
48. Choo F. Tomorrow's Medicine, The Straits Times [Internet]. Proportion of older adults with multiple chronic diseases surges. 2019 May 8. Available from: https://www.sgh.com.sg/news/tomorrows-medicine/proportion-of-older-adults-with-multiple-chronic-diseases-surges
49. Liu B, Spokes P, He W, Kaldor J. BMC Infectious Diseases [Internet]. High risk groups for severe COVID-19 in a whole of population cohort in Australia. 2021 Jul 16. Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-021-06378-z
50. Shu YT, Kaiwei JL, Ying X et al. The Annals, Academy of Medicine, Singapore [Internet]. Healthcare cost of patients with multiple chronic diseases in Singapore public primary care setting. 2021 Nov 29. Available from: https://annals.edu.sg/healthcare-cost-of-patients-with-multiple-chronic-diseases-in-singapore-public-primary-care-setting/

## 3.4.8 Long COVID

**Long COVID[51] has a potential minimum impact of SGD ~1.31 billion p.a. on Singapore's economy.** Individuals who develop this condition experience prolonged productivity losses (increasing 'indirect costs') and reliance on health services (increasing 'direct costs').

**Direct costs due to long COVID collectively amount to at least SGD ~60 million** (SGD ~366 per person), largely driven by the need for ongoing medical consultations. This higher figure results from the incidence and the relative complexity and duration (90 days) of long COVID illness. When case complexity and duration are factored in, this could mean ~982,000 healthcare consultations are required for this cohort alone.[52] Therefore, long COVID represents a substantial burden on the health system, both in terms of capacity requirement and economic costs.

**Productivity losses from long COVID could amount to SGD ~1.25 billion p.a.** (SGD ~7,645 per person and ~37% of all indirect costs). By a significant margin, the largest contributor is productivity loss arising from long COVID in the working-age population (SGD ~0.99 billion p.a. or ~79% of indirect costs from long COVID). To illustrate this further, an adult with long COVID could still lose the equivalent of 46 work days over a three-month period of illness, because of impairments to productivity, despite being well enough to work.[53]

**Given the large share (~37%) of total economic costs that long COVID imposes on the Singaporean economy,** any countermeasure able to reduce the incidence and/or duration of this condition would contribute a great deal to mitigating economic costs associated with the pandemic. Current conservative estimates suggest that the incidence and course of long COVID are at 5% and 90 days respectively; however, the evidence is still nascent, and these impacts may yet be shown to be underestimates.

51. Also commonly described as 'post-COVID 19 syndrome', long COVID describes the prolonged duration of COVID-19 symptoms beyond twelve weeks after the initial infection.
52. Estimating ~164,000 long COVID cases, where each case could require 6 consultations on average over the 90-day period of long COVID illness.
53. Based on an average of 9 days of sick leave and reported reductions in productivity while working, due to long COVID.

# 4. Shaping The Future: Our Toolkit For Averting The Neglected Economic Burden of COVID-19

## 4.1 The Countermeasures Toolkit

In the face of the significant economic costs of COVID-19, there exists access to a wide range of countermeasures to address this burden. As illustrated in Exhibit 10, countermeasures include community measures such as social distancing as well as the utilization of vaccines and therapeutics, including oral antivirals.

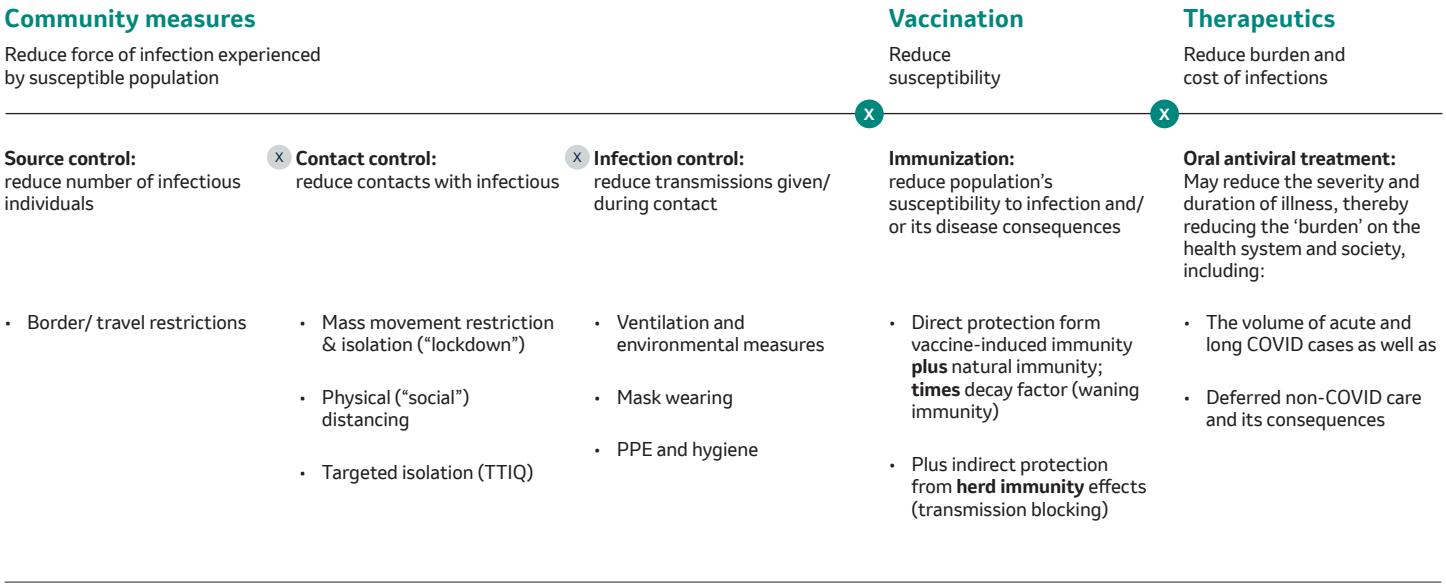
However, despite significant ongoing economic costs, uptake of these countermeasures has been incomplete. Examples of incomplete uptake include variable adherence to isolation requirements, waning uptake of booster vaccination doses, and variable awareness and availability of oral antivirals. There is an opportunity for policymakers to consider the optimal utilization of the full set of countermeasures available to mitigate the continued economic and societal impact of COVID-19.

When used widely, such countermeasures have been very effective at containment and suppression of the COVID-19 virus, while managing to limit economic costs. For Singapore, the countermeasures employed during the first phase of the pandemic (2020 to 2021) were generally very successful. The number of reported cases and deaths in Singapore were among the lowest in the developed world. However, border closures, social-distancing requirements, strict contact tracing, and mask-wearing mandates still imposed significant hardships on affected communities. The successful rollout of vaccines afforded an easing of many restrictions in 2022, although the immunity conferred was found to wane over time. The resulting reduced population immunity has been challenging, as novel variants have emerged, including Omicron.

**Oral antivirals have been added to response toolkits.** The necessarily short-term nature of restrictive community measures and the remaining health threat of COVID-19 led Singapore's authorities to broaden their approach to include oral antivirals.

The three categories of countermeasures and their differing potential to mitigate the economic costs of COVID-19 are summarized in Exhibit 9 below.

Exhibit 9: The countermeasure toolkit




## 4.1.1 Community measures – reducing the force of infection

**Community measures were central to managing the impact of COVID-19 globally,** particularly during the initial phases of the pandemic before the development and roll-out of vaccines and therapeutics. Community measures reduce the 'force' of infection through three potential levers:

- **Source control** to reduce the number of infectious individuals, such as travel/border restrictions.
- **Contact control** to reduce contact between healthy and infectious individuals, including 'lockdowns', 'social' distancing, and targeted isolation (TTIQ).
- **Infection control** to reduce infection transmission during contact, including mask-wearing and ventilation measures.

**While protecting population health, there are significant challenges and economic frictions associated with community measures.** Community measures typically depend on a high degree of collaboration from a market's population, as many perceive social 'freedoms' as being forgone for mask-wearing, lockdowns, and other mandates. As such, monitoring and encouraging adherence to community measures can be resource intensive for authorities. However, they pose broader economic frictions too. For example, the high cost of productivity loss when businesses are forced to close due to revenue losses (especially food and accommodation services) or reduced labor headcounts.

**2022 saw a shift away from community measures in the management of COVID-19.** This was driven by an epidemiological course of COVID-19 that was considered to be less severe, widespread vaccine uptake, and increasing access to antivirals in the market.

### 4.1.2 Vaccines – reducing population susceptibility

**COVID-19 vaccines have had a significant benefit to economies,** in addition to health outcomes for individuals. Singapore has achieved high rates of vaccination relative to international peers, with 83% of the population having received three doses.[54] By reducing the population's susceptibility (both directly for the recipient of the vaccine and indirectly by reducing the risk of onward transmission),[55] vaccines have the potential to reduce the volume and severity of infections. This lessens the overall costs borne by the health system and costs that arise from productivity losses due to COVID-19 illness.

**COVID-19 vaccines highlighted the benefits of rapid and widespread access to medical innovations** once they were authorized or approved. The adaptability of health technology assessment (HTA) processes to meet an urgent public need was particularly celebrated. In light of this, stakeholders in the policy and scientific communities are calling for reforms that place greater emphasis on broader social and economic benefits in the assessment of and investment in vaccines and medicines.[56]

**The evolution and roll-out of COVID-19 vaccines may be an ongoing investment** to combat new variants and sub-variants of COVID-19 capable of evading conferred immunity.

### 4.1.3 Therapeutics – reducing the burden

**Therapeutics have the potential to further curb the economic impact of COVID-19, in both markets with largely vaccinated populations and those with lower vaccination rates.** Therapeutics such as antivirals are so far typically limited to high-risk categories. These include older populations and adults with comorbidities/chronic illnesses. For these populations, therapeutics may reduce the chances of being hospitalized or dying from disease, and subsequently the costs due to productivity losses and burden on health systems.[57]

**There may be an opportunity to broaden the use of therapeutics.** Currently, populations that are eligible for oral antivirals could represent ~52% of the economic impact of COVID-19 in Singapore, assuming high levels of uptake. Given the challenges associated with community measures, and that Singapore has already achieved high vaccination coverages, investment in therapeutics for a broader population, if found to be efficacious for a wider cohort in reducing time to symptom resolution, could be a subsequent consideration in Singapore's response.

54. Ministry of Health Singapore[Internet]. Vaccination Statistics. 2023 Feb 1. Available from: https://www.moh.gov.sg/COVID-19/vaccination/statistics
55. Edwards KM, Orenstein WA. UpToDate [Internet]. COVID-19 Vaccines, Impact on Transmission Risk. [cited 2023 Feb 27]. Available from: https://www.uptodate.com/contents/COVID-19-vaccines#H1606921902
56. Medicines Australia [Internet]. New report indicates COVID-19 vaccines saved Australia's economy. 2022 Dec 19. Available from: https://www.medicinesaustralia.com.au/media-release/new-report-indicates-COVID-19-vaccines-saved-australias-economy/
57. Centers for Disease Control and Prevention [Internet]. COVID-19 Treatments and Medications, 2023 Feb 10. Available from: https://www.cdc.gov/coronavirus/2019-ncov/your-health/treatments-for-severe-illness.html

# 4.2 Utilization Profile: Countermeasures In Singapore

Exhibit 10: Summary of countermeasures in Singapore

| | Community measures | Vaccination | Therapeutics/Oral Antivirals |
|---|---|---|---|
| **2022** | • **Social gatherings** - no group size limit as of April 2022<br>• **Mask wearing** - compulsory in indoor settings until August 2022; currently optional except for healthcare facilities, residential care homes, ambulances, and public transport<br>• **Isolation** - from October 2022, self-isolation required for 72 hours, can exit if ART negative, or on day 7 (for fully vaccinated) or on day 14 (for unvaccinated/partially vaccinated)<br>• **Border restrictions** - non-fully vaccinated travelers no longer required to undergo 7 days in home quarantine as of August 2022 | • As of January 2023:<br>- 92% of Singaporeans have received at least one vaccination dose<br>- 83% have minimum protection (3 x mRNA or Novavax/Nuvaxovid, or 4 x CoronaVac)<br>- 49% have up-to-date vaccination (minimum protection and last dose received within one year)<br>• Vaccinations available to all (above 6 months of age) - can walk into Joint Testing and Vaccination Centres<br>- ≥80 years old can walk into any Polyclinic to receive vaccination | • Nirmatrelvir/ritonavir (Paxlovid) and molnupiravir (Lagevrio) were granted interim authorization by Singapore Health Sciences Authority in February and April 2022 respectively. Molnupiravir has since been reclassified with Special Access Route (SAR) status with effect from 1 April 2023.<br>- Eligibility criteria according to Singapore's COVID-19 treatment guidelines include being ≥60 years old or ≥18 years old with at least one risk factor (e.g. chronic kidney disease. serious heart conditions. immunosuppression, diabetes, COPD, obesity, active cancer) |
| **2020-21** | • **Social gatherings** - no household visitors or group gatherings during circuit breaker (~April 2020), group size limited throughout most of 2020 and 2021<br>• **Border restrictions** - international borders closed to all short-term visitors in March 2020, with returning Singapore residents needing to undertake 14 days quarantine<br>• **Contact tracing** - government implemented TraceTogether program for community contact tracing, including an app enabled by Bluetooth | • Vaccination program commenced December 2020 - first Asian market to launch<br>- Healthcare workers prioritized<br>• Elderly eligible for vaccinations from January 2021<br>• Vaccinations available to population (≥12 years old) from June 2021 | |

As of February 6, 2023.[58,59,60,61]

58. Ministry of Health Singapore [Internet]. COVID-19 updates and statistics. Available from: https://www.moh.gov.sg/covid-19/
59. The Straits Times [Internet]. Timeline of S'pore's measures over the last 2 years. Available from: https://www.straitstimes.com/singapore/two-years-of-twists-and-turns-a-timeline-of-singapores-covid-19-measures
60. Ministry of Health Singapore [Internet]. COVID-19 Vaccination Registration. Available from: https://www.vaccine.gov.sg/
61. National Centre for Infectious Diseases [Internet]. Treatment Guidelines for COVID-19. Available from: https://www.ncid.sg/Health-Professionals/Diseases-and-Conditions/Documents/Treatment%20Guidelines%20for%20COVID-19%20v10.1%20-for%20circulation_Final%20%5B29-8-2022%5D.pdf

# 5. Conclusion

Singapore's initial experience of COVID-19 in 2020 and early 2021 was marked by an aggressive, proactive and largely successful approach to countermeasures,[62] with some of the lowest reported cases and deaths in the OECD.[63] A critical element of those countermeasures was the market's successful, and world-leading vaccination drive.[64,65] Singapore began to ease restrictions in 2022,[66] and since early 2023 has adapted to an endemic situation in line with other countries.[67]

In anticipation of the challenges that lie ahead, this report has presented a number of future scenarios, all of which point to a need for pandemic preparedness. Indeed, even in the lower-estimate scenario (Normal 2.0), the total economic cost would already amount to SGD ~1.1 billion p.a. (~0.2% of GDP). In the base case scenario, where current COVID-19 conditions prevail, the total economic cost is estimated at SGD ~3.6 billion p.a. (~0.6% of GDP); while in a higher-estimate Pandemic 2.0 scenario, Singapore could face a cost of SGD ~16.0 billion p.a. (~2.8% of GDP).

The findings in the report shed light on factors and considerations that impact Singapore's efforts to mitigate COVID-19, and are intended to provide additional insights to policymakers in their planning.

## 5.1 Economic costs

In our base case scenario, the total economic cost of COVID-19 is SGD ~3.6 billion p.a., which is equivalent to ~0.6% of GDP, with:

- Direct costs to the Singapore health system of SGD ~142 million p.a. in both inpatient and outpatient settings, a significant expense which equates to ~4% of the total economic cost.
- The remaining 96% of costs due to productivity losses through missed work by both (i) adults as a result of their own illness or while caring for dependents (children and over 65 year-olds); as well as (ii) elderly people in the workforce affected by COVID-19.
- COVID-19 infections in vulnerable populations costing SGD ~1.7 billion p.a., including a cost of SGD ~565 million p.a. arising from infections in the older population (65 years-old and above).

A 'Pandemic 2.0' scenario (where economic costs reach SGD ~16.0 billion p.a.) assumes a higher rate of infection of ~11.3 million infections per year and a higher viral severity that results in ~57,000 hospitalizations annually. At the lower end, a 'Normal 2.0' scenario (imposing an economic cost of SGD ~1.1 billion p.a.) assumes a total of ~1.1 million infections.

62. Ansah JP, Matchar DB, Shao Wei SL, Low JG, Pourghaderi AR, et al. 2021. The effectiveness of public health interventions against COVID-19: Lessons from the Singapore experience. PLOS ONE [Internet]. https://doi.org/10.1371/journal.pone.0248742
63. Our World in Data [Internet]. Cumulative reported cases and deaths for Singapore from 2020 to 2021. Available from: https://ourworldindata.org/explorers/coronavirus-data-explorer?facet=none&country=~SGP&Metric=Confirmed+deaths&Interval=Cumulative&Relative+to+Population=true&Color+by+test+positivity=false
64. As of January 2023, 92% of people aged 16 and over had received at least one dose of a COVID-19 vaccine, while 83% had received 3 doses. Singapore Ministry of Health [Internet]. Vaccination Statistics. Available from: https://www.moh.gov.sg/covid-19/statistics
65. Deutsche Welle [Internet]. COVID: Singapore is now the most-vaccinated country. 2021 Aug 29. Available from: https://www.dw.com/en/coronavirus-digest-singapore-is-now-the-most-vaccinated-country/a-59016931
66. Ministry of Health [Internet]. [Updated] Further Easing of Community Measures. 2022 Oct 10. Available from: https://www.gov.sg/article/further-easing-of-community-measures
67. Chen L. Singapore relaxes COVID travel curbs, mask rules further. Reuters [Internet]. 2023 Feb 9. Available from: https://www.reuters.com/world/asia-pacific/singapore-relaxes-covid-travel-curbs-mask-rules-further-2023-02-09/

## Health system capacity

For policymakers, preventing COVID-19 hospitalizations is therefore a major concern not only because of the high cost it imposes on government accounts, but also because of its effect on the wider community's access to care.

To elaborate, in a base case scenario where current conditions prevail, Singapore can expect an annual outlay of SGD ~142 million in direct costs to its health system. These direct costs comprise both inpatient and outpatient care costs in almost equal proportions – where inpatient care costs SGD ~67.9 million p.a.; while outpatient care costs SGD ~73.9 million p.a.

Dissecting this further, inpatient care costs are driven by ~8,200 hospital admissions, including ~820 admissions to the ICU; whereas outpatient care costs are largely a result of ongoing long COVID, where incidence, complexity, and duration (90 days) could result in 982,000 healthcare consultations.

Given this burden, it is evident that testing, treating, and ameliorating the severity of illness – especially among vulnerable populations – remains just as important during the endemic phases of COVID-19 that Singapore has now entered.

## Workers and critical industries

Singapore's healthcare workforce has been disproportionately impacted by the pandemic, with comparatively higher levels of absenteeism and a greater risk of infection This has led to negative consequences for the country's health system capacity and quality of care. In a base case scenario, the economic costs arising from such disruptions to the health workforce could total SGD ~101 million p.a.

Several other key industries have also faced significant disruption, including the logistics, education, travel and tourism, and food and beverage sectors. The impact of COVID-19 on Singapore's logistics sector has had knock-on effects on operations and supply chains, with disruptions driving inflation in the costs of goods and services, while impeding the ability of businesses and their workers to deliver them.[68]

## Vulnerable populations

Besides workers and critical industries, the other groups of people most affected include vulnerable populations and those suffering from long COVID. For example, vulnerable populations impacted by COVID-19 (see section 3.4.7) account for a total economic cost of SGD ~1.7 billion p.a. in the base case scenario; whereas infections in people eligible for oral antivirals, who tend to be older and/or affected by comorbidity, account for an estimated SGD ~1.9 billion p.a., or ~52% of total economic costs. Most significantly impacted are those affected by long COVID (see section 3.4.8), with the value of lost work and use of health system resources totaling SGD ~1.3 billion p.a., or ~37% of all economic costs.

68. PwC [Internet]. Global Crisis Survey 2021 Singapore. 2021 May. Available from: https://www.pwc.com/sg/en/publications/global-crisissurvey-2021.html

# 5.2 How can we mitigate COVID-19 and reduce its overall cost?

Fortunately, a range of countermeasures remain available to mitigate the economic costs of COVID-19. These can be categorized as community measures, such as contact tracing, mask-wearing mandates, and other infection control strategies; or medical countermeasures, which include vaccines and therapeutics.

## Keep community measures on the table and keep innovating

Many of the most effective measures in tackling COVID-19 have been at the community level, including the introduction of digital tools for tracking and analyzing the spread of the virus. Learning from successes elsewhere in the world and developing new, innovative approaches to the social impact of the disease will be vital for ongoing mitigation and cost reduction. Other measures, such as lockdowns and social distancing measures, can also play an important role in blunting infection volumes. However, while these measures are effective in protecting population health, they also impose significant challenges and economic frictions, and should not be treated as a first resort.

## Continue vaccinating and developing new vaccines

By reducing individuals' susceptibility to the virus, COVID-19 vaccines have provided a significant benefit to the Singapore economy and greatly facilitated reopening. In doing so, vaccines have highlighted the benefits of rapid and widespread access to medical innovations. Keeping up the momentum of vaccinations and acquiring new vaccines to address prevalent strains and accommodate particular needs is essential to reduce the ongoing incidence and cost of COVID-19.

## Inclusion of therapeutics

Therapeutics such as oral antivirals have the potential to further curb the economic impact of COVID-19 by playing a role in reducing the burden of disease. For example, while ~52% of the economic costs could be borne by those who are eligible for oral antivirals, only a relatively small proportion of infected individuals (~0.3%) receive them in practice. With Singapore now well into the endemic phase, there is an opportunity to reduce the severity of COVID-19 symptoms and thereby soften the impact of the disease on productivity.

As has been described, Singapore faces substantial and wide-ranging costs from the pandemic which are often not fully recognized in traditional evaluations of its economic impacts. If policymakers respond to the scale of the challenge by strengthening their toolkit of countermeasures, they will be in a stronger position to mitigate the high costs of COVID-19, ensuring that their population and economy are adequately prepared for all eventualities.

# Appendix: Assumptions

## Singapore

Exhibit A1: Key overall assumptions

| 3rd Level | 4th/5th Level | Value | Source | Commentary |
|---|---|---|---|---|
| Total | Total COVID-19 infections | 3,272,126 | The Institute for Health Metrics and Evaluation (IHME) (released December 16, 2022) | • ~Q4 2022 annualized<br>• Note: IFR ratio is 0.008%. IHME corrects to ensure reported deaths reflect actual deaths due to COVID-19 |
| | Total COVID-19 cases (detected) | 1,161,709 | | |
| | Total COVID-19 deaths | 263 | | |

Exhibit A2: Key direct cost assumptions

| 3rd Level | 4th/5th Level | Parameter Name | Value | Source | Commentary |
|---|---|---|---|---|---|
| Inpatient | | Hospitalization rate | 0.25% | Institute for Health Metrics and Evaluation | • Rolling average hospitalization rate for Q4 2022 |
| | | Number of admissions | 8,180 | Calculation | • Total infections (~3.27m) multiplied by hospitalization rate |
| | Moderate | Ward admission rate | 90% | Institute for Health Metrics and Evaluation | • IHME-modelled number of required hospital beds versus number of required ICU beds |
| | | Ward length of stay | 5.7 days | SingHealth | • Average length of stay of 177,000 admissions to SingHealth, 2019-20 |
| | | Ward bed day cost | $1,019 | • Sample of 8 Singapore hospitals<br>• MoH Inpatient Doctor Attendance benchmark<br>• SingHealth | • Daily costs including ~$470 accommodation, ~$300 medical and nursing care costs, ~$245 pathology |
| | Severe | ICU admission rate | 10% | Institute for Health Metrics and Evaluation | • Modelled number of required ICU beds as proportion of required hospital beds |
| | | ICU length of stay | 8 days | MoH | • Midpoint of LOS estimates for ICU stay with Omicron variant |
| | | ICU bed day cost | $2,273 | • MoH<br>• The Straits Times | • MoH estimates the total cost of an ICU stay at $25,000 for a Delta case with average LOS of 11 days = $2,273/day |

Exhibit A2: Key direct cost assumptions (continued)

| 3rd Level | 4th/5th Level | Parameter Name | Value | Source | Commentary |
|---|---|---|---|---|---|
| Inpatient | Severe (cont.) | Proportion of ICU admissions requiring subacute care | 50% | • Annals of Intensive Care<br>• British Medical Journal | • 45-50% of COVID patients admitted to ICU required rehabilitation or subacute care |
| | | Subacute length of stay | 12 days | Proceedings of Singapore Healthcare | • 12-day duration of COVID-specific inpatient rehabilitation |
| | | Subacute bed day cost | $1,119 | • SingHealth<br>• MoH | • ~$820 unsubsidized accommodation cost, ~$300 medical and nursing care costs |

Exhibit A2: Key direct cost assumptions (continued)

| 3rd Level | 4th/5th Level | Parameter Name | Value | Source | Commentary |
|---|---|---|---|---|---|
| Outpatient | Acute | Number of acute outpatient infections | 3,263,946 | Calculation | • Total infections (~3.3mn) minus number of hospital admissions |
| | | Proportion of total infections that visit an Emergency Department | 0.1% | • COVID Journal study of attendances to SGH in 2019-20<br>• Australian Institute of Health and Welfare | • Singaporean data triangulated with Australian data |
| | | Number of ED visits per year for COVID | 3,457 | Calculation | • Number of acute outpatient infections multiplied by 0.1% |
| | | Cost per Emergency Department visit | $120 | • SingHealth<br>• The Straits Times | • Emergency department attendance fees of $120-$140 |
| | | Proportion of infections prescribed OAV | 0.3% | • MoH<br>• The Straits Times | • ~3,200 prescriptions made in first ~3 months of 2022, annualized and divided by number of annual infections |
| | | Number of infections prescribed medication | 10,000 | Calculation | • ~3,200 prescriptions made in first ~3 months of 2022, annualized |
| | | Number of GP visits | ~60,000 | Calculation | • Assumption that 1 in 6 GP visits for COVID results in an OAV prescription |
| | | Cost per GP visit | SGD 62 | SingHealth | • Full/unsubsidized cost of a primary care visit |

Exhibit A2: Key direct cost assumptions (continued)

| 3rd Level | 4th/5th Level | Parameter Name | Value | Source | Commentary |
|---|---|---|---|---|---|
| Outpatient | Chronic | Incidence of Long COVID | 5% | Singapore National Centre for Infectious Diseases | • Estimates incidence of long COVID to be ~5% among vaccinated population and ~10% among unvaccinated population |
| | | Average duration of Long COVID | 12 weeks | World Health Organization | • Globally accepted consensus on duration of Long COVID of 12 weeks |
| | | Average number of clinic visits per Long COVID patient | 6 | Calculation | • 1 clinic visit per fortnight over 12-week illness |

Exhibit A3: Key indirect cost assumptions

| Parameter | | Value | Source | Commentary |
|---|---|---|---|---|
| Age distribution of infections | Working-age | 64% | • Department of Statistics Singapore – Singapore Residents By Age Group, Ethnic Group and Sex (last updated 27 Sep 2022) | • Assume mirrors population age demographics |
| | Pediatric carers | 19% | | |
| | Elderly | 17% | | |
| Cross-cutting assumptions | Acute illness | 100% | | • Assume all COVID-19 infections experience short-term 'illness' which can be symptomatic or asymptomatic |
| | Long COVID – for working-age population | 5% | • Australian National University Evidence from the COVID-19 Impact Monitoring Survey Series, August 2022 | • Estimate of incidence in Australia of 4.7%; implies 700,000 annual cases |
| | Detected | 36% | • The Institute for Health Metrics and Evaluation (IHME) (released December 16, 2022) | • Calculated based on cases divided by total infections for comparable timeframe as infections assumption |
| | Proportion of people who will isolate for required time period | 100% | | • Assume 100% adherence to guidelines for COVID-19 self-isolation |
| | Weighted average length of self-isolation | 6.1 days | • Covid.gov.sg – Living with COVID-19 | • As per protocol 2 – self-isolation of 72 hours, followed by continued self-isolation until ART returns negative OR until Day 7 (for vaccinated and children <12yo) OR until Day 14 (for unvaccinated / partially vaccinated)<br>• Weighted average length of self-isolation calculated based on assumptions of:<br>- 80% RAT positive at Day 3 with a reduction in % of RAT positive per day of subsequent isolation<br>- 83% of population being fully vaccinated |

Exhibit A3: Key indirect cost assumptions (continued)

| Parameter | | | Value | Source | Commentary |
|---|---|---|---|---|---|
| Specific to working-age and elderly | Acute - well enough to work | Proportion of acute infections well enough to work | 99.7% | • The Institute for Health Metrics and Evaluation (IHME) | • Modelled based on infection to hospitalization rate – assumes well enough to work if not hospitalized |
| | | Proportion of people who can work from home | 80% | • Singapore Business Review | • "8 in 10 Singapore employers allow their staff to work from home" |
| | | Duration of acute illness | 12 days | • Medline (2022) | • 10-14 days for mild to moderate illness |
| | | Average number of days too ill to work / fully taken off work with COVID-19 | 3 days | • The Straits Times (2013) and Channel News Asia (2022) | • "Employees use up, on average, only about four days of their outpatient sick leave" but "68% did not take any leave for 12 months"<br>• Assumes not all sick leave would typically be used in one illness, but residents may be more likely to take sick leave for COVID-19<br>• 3 days of 0% work (e.g. sick leave taken and/or too sick to work at all) assumed for each acute COVID-19 infection – in line with Australia |
| | | Productivity loss on days worked while ill | 35% | • European Respiratory Society | • Cross-Sectional study of positive COVID-19 diagnosis. 3 months after discharge or resolution of acute disease. Uses WPAI. 35% work impairment for non-hospitalized and 10% for hospitalized, 20% overall; make conservative estimate that long-COVID symptoms cause same level of productivity loss as when working with acute illness. |
| | | Median monthly earnings | $5,070 | • Ministry of Manpower | • Median Gross Monthly Income 2022 |
| | Acute – too ill to work | Duration of acute debilitating (inpatient) illness | 10.1 days | • See direct cost length of stay assumptions | • Weighted average LOS from direct model: 7.1 days<br>• + Recovery time at home (off work) assumed to be ~3 days (same as outpatient) |
| | Long COVID – well enough to work | Average # of days taken as sick leave from work | 9 days | • European Respiratory Society | • 2021 Cross Sectional study of patients at 3 months who had missed 10% of work time due to health if non-hospitalized |

Exhibit A3: Key indirect cost assumptions (continued)

| Parameter | | Value | Source | Commentary |
|---|---|---|---|---|
| Specific to working-age and elderly | Proportion of elderly receiving / requiring care from a working-age adult who is not employed as their carer | 70% | • Ministry of Social and Family Development Aging Families in Singapore 2010-2020; International Psychogeriatrics (Ha et al, 2018) | • 34% of households have at least one member >65yo; one in five households employs FDWs and nearly 50% of familial caregivers engage FDWs specifically to care for frail seniors<br>• Assume FDWs in 10% of households (50% of one in five) are in households with elderly<br>- ~30% of elderly are cared for by FDWs<br>- Remaining 70% require care from a working-age adult who is not employed as their carer |
| | Proportion of elderly providing childcare while parents work | 25% | • Health Promotion Board (2012) | • One in four rely on grandparents as main caregiver. 35% of seniors over the age of 55 look after their grandchildren on a regular basis. |
| | Proportion of elderly participating in the workforce | 27% | • MRSD Labour Force report (2021) | • Participation rate is 33% for >65yo. ~66% of >65yo are full time. Adjust 33% down by 5.5% to account for part time work |
| | Median monthly income of elderly | $2,543 | • MRSD Labour Force report (2021) | • Median monthly earnings for >60yo |
| Specific to pediatric | Average duration of acute illness | 6 days | • Illness duration and symptom profile in symptomatic UK school-aged children tested for SARS-CoV-2 (2021) | • Mean duration of illness is 5-7 days<br>• Assumed to be applicable across all markets (same virus) |
| | Average productive loss due to providing care for a child with acute mild / outpatient illness | 25% | • Macquarie University (2021) | • Australian study of lockdown care coverage used as a proxy and applicable across markets due to limited availability of data<br>• Survey respondents spent 10.7 hours per week home-schooling (including feeding meals etc.) children, and one or more other adults spent an average of 3.4 hours with the same child = 14.1 hours total (2 hours on average per day) |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