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

July 2023

MSD
INVENTING FOR LIFE

Table of Contents

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 Taiwan. 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.

MSD
INVENTING FOR LIFE

MSD
INVENTING FOR LIFE

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 Taiwan.

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 Taiwan'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 market-specific hospitalization and transmission rates observed in Taiwan 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 Taiwan's economy, with a more thorough assessment of the hidden economic costs to Taiwanese society than has previously been available. Due to a range of factors including health system capacity, impacts on workforce and business, and heightened vulnerability of certain demographics, Taiwan finds itself susceptible to the ongoing economic toll of COVID-19. As the market 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 on the effects of the pandemic in Taiwan 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.

Limited previous analyses of the indirect costs of COVID-19's economic impact in Taiwan have provided widely varying assessments – from USD ~10 billion to USD ~20 billion p.a. – depending on the type of research carried out.[3] We have adopted a cost-of-illness approach, a technique often used in policy decision-making, to provide a more stable estimate. 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 a base case scenario, the annual economic costs of COVID-19 could reach about TWD 233 billion in Taiwan, representing around 0.9% of the market's GDP. In a worst-case Pandemic 2.0 scenario, TWD 573 billion would be lost, around 2.3% of 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 86% of Taiwan's total ongoing economic cost of COVID-19 in the base case scenario. While direct costs to the health system in Taiwan are substantial, accounting for TWD ~32.9 billion p.a., indirect costs (such as productivity loss) will 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 high levels of absenteeism 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. Meanwhile, Taiwan's logistics, as well as travel and tourism industries – both of which depend on manual or on-site labor – are also particularly affected by workforce shortages.

Not all community cohorts face the same level of risk or contribute the same economic burden when infected. The report shows an uneven distribution of costs across Taiwan society. Vulnerable populations, such as older adults,[4] working-age adults with one or more comorbidities (such as high blood pressure, cancer, and/or diabetes), as well as indigenous populations, are likely to be disproportionately impacted.

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

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

base case scenario, the total value of lost work and use of health systems due to long COVID is TWD ~73 billion p.a., which amounts to 32% of the market's total economic cost of COVID-19.

Taiwan's authorities and policymakers have been relatively successful in managing COVID-19 to date, which should continue through the endemic phase, ensuring Taiwan's population and economy are equipped to overcome any eventuality. Part of that ongoing effort may include further strengthening of 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.

Having a full understanding of COVID-19's cost, both current and potential, is therefore vital to designing effective countermeasures that can mitigate the disease's ongoing impact (measures we have identified in the white paper). It is hoped that this paper can help Taiwan policymakers 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.

Acting now to address these impacts will contribute to protecting Taiwan'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 Taiwan vary widely. Variation exists not only in the estimates themselves, but also in the methodologies, scopes, and assumptions used to drive 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 (0.8% of GDP) and need to be better recognized.

The remainder of this chapter provides an overview of the existing estimates of costs in Taiwan, 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 Taiwan

Range of existing estimates of the cost of COVID-19: USD ~10 billion to USD ~20 billion p.a. There is a disparity between estimates, which is primarily due to specific interventions being modeled, the epidemiological context, and the scope of costs evaluated. Despite the need for a comprehensive cost evaluation of COVID-19's impact on Taiwan, neither of the available high or low estimates provides this.

Higher estimate: USD ~20 billion p.a. This reflects costs saved by employing wastewater surveillance rather than traditional nasopharyngeal testing alone.[5] The estimate includes both direct costs to the health system as well as indirect costs in the form of productivity losses from missed work incurred by those infected, but does not include the value of lost health.

Lower estimate: USD ~10 billion p.a. By contrast, this study – conducted in the context of the variants prevalent in late 2020 – estimates that not pursuing a national vaccination program would impose lower costs on the economy.[6] This estimate includes both direct costs of inpatient care for unvaccinated individuals who become unwell and productivity losses incurred as a result of missed work while hospitalized.

Again, these examples demonstrate how studies' focus on particular interventions in different epidemiological contexts lead to varying estimates, highlighting the need for analysis that accounts for all prevailing interventions and a range of epidemiological scenarios.

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. Chan Y. Cost-Effectiveness Analysis of Conventional Epidemiological Surveillance with the Counterpart of the Add-on Environmental Surveillance for COVID-19 [dissertation]. National Taiwan University; 2022. 30 p.
6. Wang, W., Fann, J., Chang, R., Jeng, Y., Hsu, C., Chen, H., Liu, J., Yen, A. Economic evaluation for mass vaccination against COVID-19. Journal of the Formosan Medical Association. 2021 Jun; 120(1): 95-105

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 Taiwan. 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 Taiwan 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,[7] 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.[8] 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.

7. 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
8. 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 (Taiwan) 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 hospitalizations 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 Taiwan

In Taiwan, the future economic cost of COVID-19 could range from TWD ~91 billion p.a. (~0.4% of GDP) to TWD ~573 billion p.a. (~2.3% of GDP) depending on the scenario that evolves. These costs are far greater than commonly recognized. COVID-19 not only inflicts health losses through illness and death but also imposes substantial economic costs including direct costs on the healthcare system and productivity losses from missed work.

Living with ongoing transmission of the virus and the burden of disease it incurs is a reality that markets have had to come to terms with. However, there has been an incomplete uptake of the tools available to reduce this burden. To better inform the ongoing discussion on COVID-19's impacts and how we could benefit from addressing these impacts, it is important to understand the full range of economic costs imposed by COVID-19.

There is a range of potential epidemiological scenarios for how the COVID-19 pandemic may evolve.[9] This is reflected in the wide range of existing estimates for the economic costs due to COVID-19 (which also vary due to interventions studied and the scope of costs included). Possible epidemiological scenarios include a base case, where current conditions prevail, and alternative scenarios that differ in the volume of infections and their severity (driven by, for example, the interplay between variants and the level of immunity maintained in the population).

In the base case scenario, total economic costs could be TWD ~233 billion p.a. (~0.9% of GDP), with:

- The majority (TWD ~200 billion p.a., ~86%) 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 minority (TWD ~33 billion p.a., ~14%) borne by the health system (direct costs), in both inpatient (TWD ~9.5 billion p.a.) and outpatient (TWD ~23.5 billion p.a.) settings.

In a Pandemic 2.0 scenario, economic costs could reach as high as TWD ~573 billion p.a. (~2.3% of GDP). This assumes transmission rates that result in ~24 million infections per year (instead of ~20 million in the base case) and a severity that results in ~110,000 hospitalizations

9. Institute of Health Metrics and Evaluation [Internet]. Institute of Health Metrics and Evaluation. 2022 Nov, used with permission. Taiwan, 2022 Nov, used with permission. Institute of Health Metrics and Evaluation (IHME) [Internet]. COVID-19 Results Briefing, Taiwan. 2022 Dec 15. Available from: https://www.healthdata.org/sites/default/files/covid_briefs/8_briefing_Taiwan_Province_of_China.pdf

(compared with ~77,000 in the base case). In contrast, at the lower end of the spectrum, a Normal 2.0 scenario might feature ~6.7 million infections over the course of a year with only ~30,000 hospitalizations, which would translate to direct and indirect costs of TWD ~91 billion p.a.

These economic costs are unevenly distributed. The health and logistics workforces, those affected by long COVID (see Section 3.4.6), and vulnerable populations are likely to be disproportionately impacted. For example, economic costs in the health workforce total TWD ~15.9 billion p.a. (~0.1% of GDP). This is driven by high levels of absenteeism and a likelihood of infection that is twice as high as that of the general population, with consequences for health system capacity and quality of care. Those affected by long COVID are impacted most significantly, with the value of lost work and health system utilization totaling TWD ~73 billion p.a. (~0.3% of GDP) or ~32% of all economic costs. Finally, COVID-19 illness in vulnerable populations contributes TWD ~118 billion p.a. (~0.5% of GDP; see Section 3.4.5).

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 Taiwan to mitigate the potentially high economic costs of the continuing pandemic.

3.1 Context: The Situation In Taiwan

Today, Taiwan is relatively free of restrictive measures. Most of the community measures employed earlier in the pandemic, such as border closures and sophisticated contact tracing, have been pared back. These measures have now been replaced by the widespread availability and uptake of vaccines. Therapeutics such as antivirals have also been made available to a subset of the Taiwanese population that meets eligibility criteria indicating they are at high risk of developing severe disease.

As of early December 2022, Taiwan was experiencing a reduction in the volume of infections following its second Omicron wave. With ~40,000 new infections per day, and an effective transmission number[10] of ~0.99, infection volumes were stabilizing. Just two months earlier, however, in October 2022, at the height of this second wave, there were ~120,000 new infections per day. By contrast, in January 2022 there were just ~700 infections per day.[11] This occurred when wide-ranging response measures were still in place and the Omicron variant had not yet emerged. The change in Taiwan's pandemic response approach is both a reaction to the volume of infections and a driver of the subsequent infection volume.

10. The number of people a single case will infect, on average.
11. Institute of Health Metrics and Evaluation [Internet]. COVID-19 estimates, 2022 reference scenario, Taiwan. 2022 Dec. Available from: https://ihmecovid19storage.blob.core.windows.net/archive/2022-12-16/data_download_file_reference_2022.csv

Taiwan's initial measures were very effective at containment and suppression of the virus while managing to limit economic costs. By international standards, the countermeasures employed during the first phase (2020 to 2021) were very successful. The number of reported cases (~17,000) and deaths (~1,000) were among the lowest in the OECD. In addition, Taiwan managed to avoid negative economic growth in each of the pandemic's three years, an outcome matched neither by the G20 nor by other comparable OECD markets.[12] However, border closures, social-distancing requirements, strict contact tracing, and mask-wearing mandates still imposed significant hardships on the community. The successful rollout of vaccines[13] afforded an easing of many restrictions in April 2022, although the immunity conferred was found to wane over time. This waning immunity necessitated third (and ultimately fourth) doses. However, the emergence of novel variants such as Omicron continued to reduce population immunity in general.

Oral antivirals have been added to Taiwan's response toolkit. The necessarily short-term nature of restrictive community measures and the remaining health threat posed by COVID-19 led Taiwan to broaden its approach to include oral antivirals, which became available in Taiwan in January 2022.[14]

Nevertheless, the health and economic outcomes of the reopening phase have been mixed. The vast majority (>99%) of Taiwan's infections occurred in 2022.[15] While infections were not as severe as early in the pandemic, the high volume of infections led to the busiest year of the pandemic yet for the hospital system, with an average of ~200 hospital admissions per day, compared to ~9 in 2021 and just ~2 in 2020.

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

A better understanding of the economic costs of COVID-19 may better inform the assessment of the costs and benefits of various measures to address COVID-19. Indeed, despite the ongoing burden on society, while vaccination coverage has been widespread, the use of antivirals tends to track infection waves, and use remains relatively uncommon at a prescription rate of ~3% of all infections.[16]

12. National Statistics Republic of China (Taiwan) [Internet]. Economic Growth Rate. Available from: https://eng.stat.gov.tw/Point.aspx?sid=t.1&n=4200&sms=11713
13. As in many international jurisdictions, a vaccine rollout strategy was adopted in 2021 as a conduit for an easing of various restrictions. The resulting population-wide vaccination program (which excluded ineligible children) delivered a double-dose national vaccination rate of >90% by November 2021. As of December 2022, 94% of the eligible population have had two COVID-19 vaccine doses. Uptake waned somewhat after the second dose, with the third 'booster' only reaching 74%. Taiwan National Centre for High-performance Computing [Internet]. Vaccination Dashboard. 2023 Apr 7. Available from: https://covid-19.nchc.org.tw/dt_002-csse_covid_19_daily_reports_vaccine_city2.php?language=en
14. Oral antivirals are currently available to all COVID-19 positive patients over the age of 12 who are at high risk of severe disease, to be taken within 5 days of symptom onset.
15. There have been ~8 million COVID-19 infections in Taiwan this year, compared to ~17,000 in 2020-21. Institute of Health Metrics and Evaluation. COVID-19 projections. 2022 Nov 18. Available from: https://www.healthdata.org/covid/data-downloads
16. Based on a tendered volume of doses ordered by Taiwanese authorities (~700,000), divided by the projected annual number of infections (~20 million). Taiwan Centers for Disease Control [Internet]. 公開招標公告 (Tender documents for 700,000 doses of Paxlovid). 2022 Dec 6. Available from: https://www.cdc.gov.tw/Uploads/files/b16f6eed-8d74-4531-a826-a1b9202c1ec3.pdf

3.2 Key Assumptions In The Taiwan Context

A range of informed assumptions is used to derive the estimates of economic costs in Taiwan 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 Taiwanese context

A | Epidemiological scenarios

Scenario	Infections (mn) p.a.	Inpt. admiss. (k)
Normal 2.0	~7	~30
Base	~20	~77
Pandemic 2.0	~26	~111

→

B | Direct costs: borne by the health system

Key Base Case Assumptions	
# Ward admissions p.a.	~70,000
# ICU admissions p.a.	~7,000
% Infections that visit a GP	3-12%
% Infections prescribed OAVs	3.3%
# Long COVID cases p.a.	~990,000

+

C | Indirect costs: economic productivity losses borne by society

Key Base Case Assumptions	
Working-age infections as proportion of total	67%
Proportion of working-age infections that can work	99.6%
Proportion of working-age infections that can work from home	63%
Average number of working days lost due to acute illness in working-age population	~6
Average daily salary	TWD 1,433

=

D | Total economic cost to society

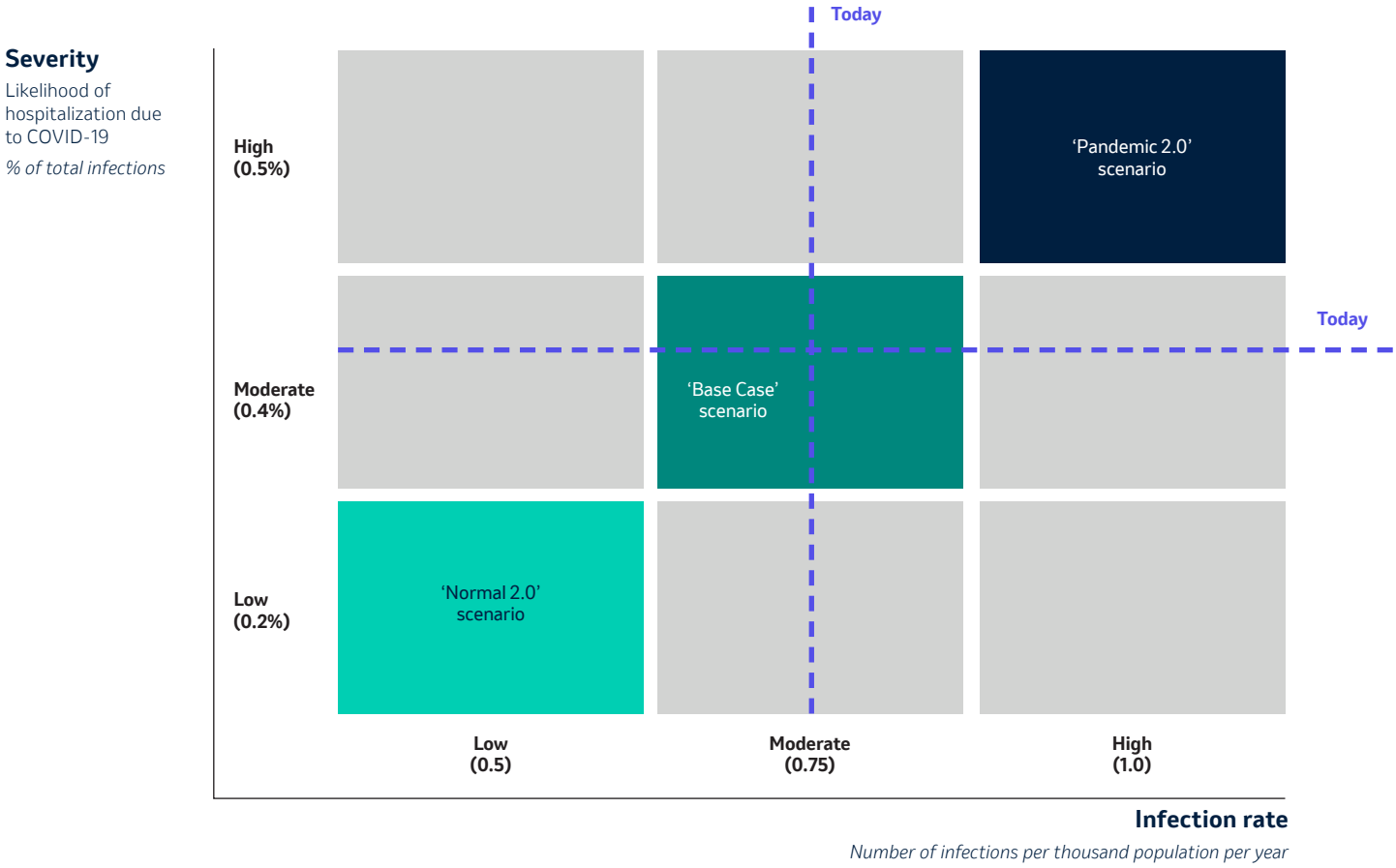
- **Total direct and indirect costs,** broken down by patient/demographic group
- **Costs per person** in each patient/ demographic group

  - E.g., if total inpatient costs are $1bn, and 75,000 patients are admitted, the cost per person is ~ $13,000

A full list of assumptions is given in the appendix.

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

Exhibit 2: Potential epidemiological scenarios



Scenarios are indicative only and based on the observed epidemiology of COVID-19 in Taiwan 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 Taiwan context this might mean:

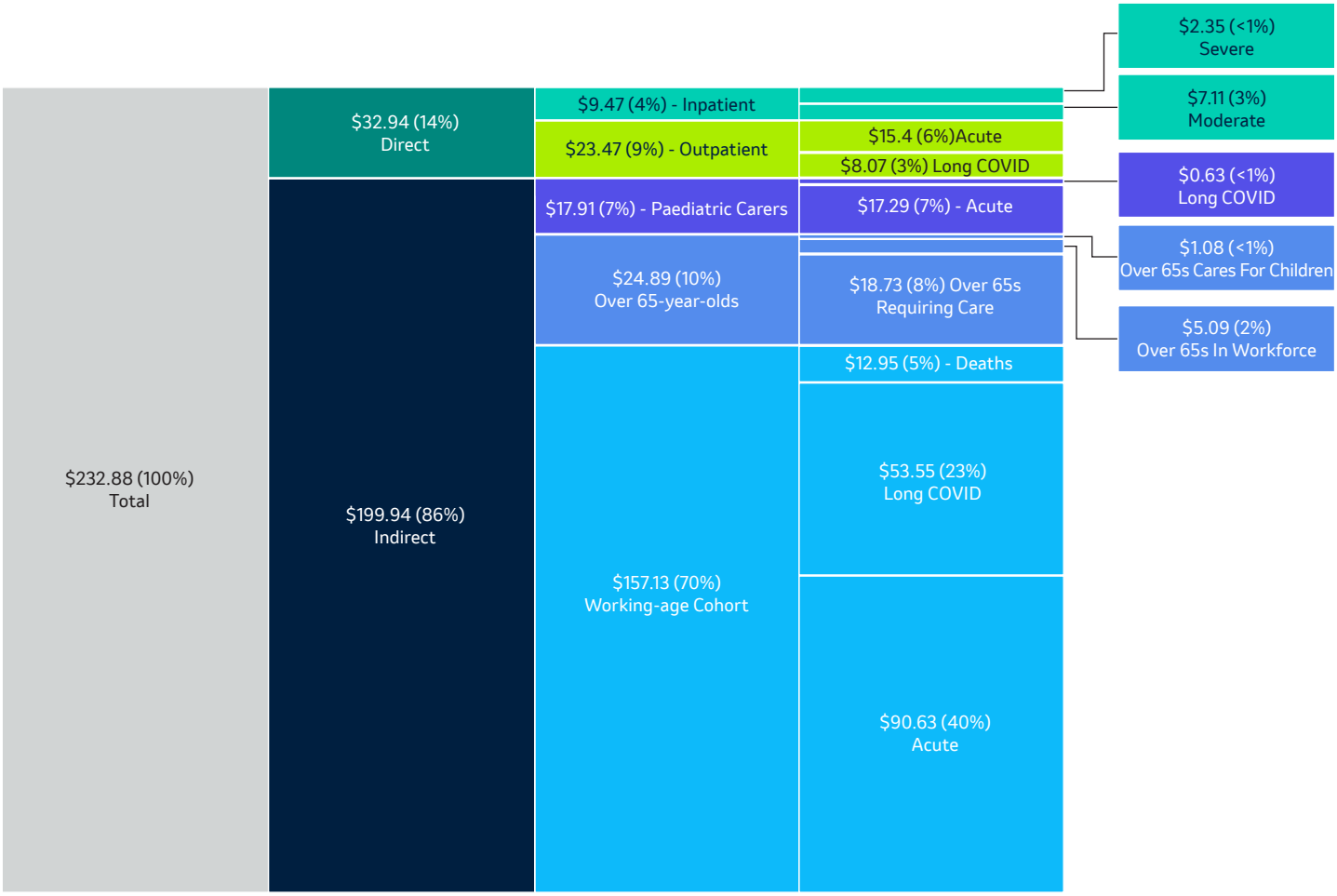
- A base case, with a total economic cost of TWD ~233 billion p.a. (~0.9% of GDP), (in addition to the value of lost health, such as that already considered in HTAs), which assumes a rate of infection (e.g., ~840,000 infections per million population annually) and a viral severity driving ~77,000 hospital admissions annually, similar to what was seen in August 2022.[17] This is the scenario shown in Exhibit 3 below and described in the direct (3.3.1) and indirect (3.3.2) costs sections below.

17. Infection numbers and hospitalization rates are sourced from modeling of COVID-19 infections in Taiwan by the Institute of Health Metrics and Evaluation (IHME; used with permission). In Taiwan, infection numbers are twice the number of reported cases, recognizing the volume that is not detected by the testing process.

- **A low or Normal 2.0 case, with an economic cost of TWD ~91 billion p.a. (~0.4% of GDP)** which assumes a lower rate of infection (e.g., ~290,000 infections per million population per year) and a viral severity driving ~30,000 hospitalizations, reflecting reported case numbers from November 2022.[18] As this scenario is based on reported case numbers, it should be noted that 'actual' COVID-19 infection volumes could be up to ~2 times higher.

- **A high or Pandemic 2.0 case, with an economic cost of TWD ~573 billion p.a. (~2.3% of GDP)** which assumes a higher rate of infection (e.g., 1 million infections per million population per year) and a higher viral severity driving ~110,000 hospitalizations annually, reflecting a scenario where each individual contracts the virus once per year.

Exhibit 3: Direct and indirect costs of COVID-19 to Taiwan's economy in a base case scenario, TWD billion p.a.



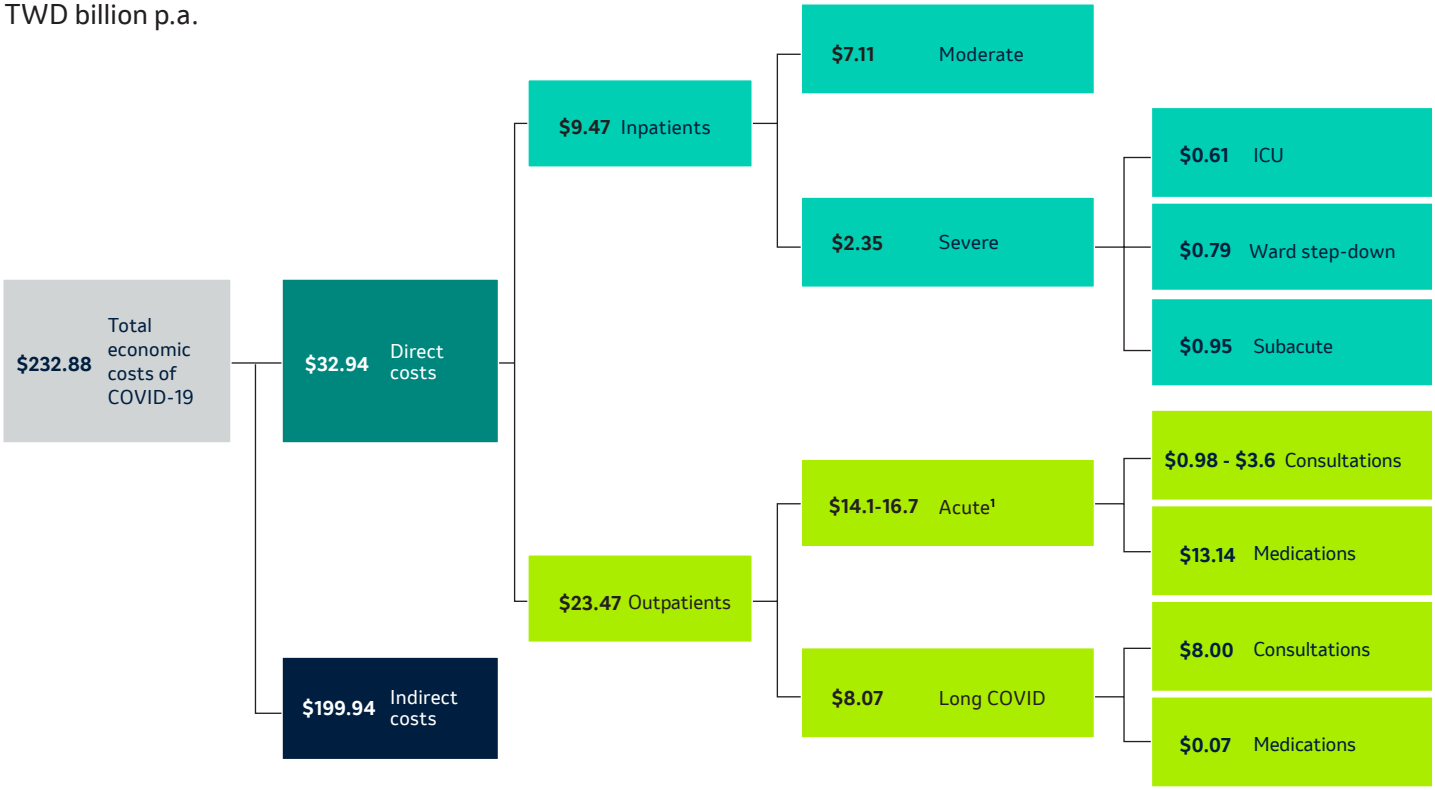
Costs are indicative only and based on the distribution of COVID-19 infections between cohorts in Taiwan in 2022.

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 Q3 in 2022 have been drawn from the Institute of Health Metrics and Evaluation (IHME; used with permission) model of COVID-19 and annualized.

18. Case volumes reflect an annualized figure based on total reported cases in November 2022. COVID-19 statistics. Available from: https://sites.google.com/cdc.gov.tw/2019ncov/taiwan. Our World in Data [Internet]. COVID-19 Data Explorer. Available from: https://ourworldindata.org/explorers/coronavirus-data-explorer?facet=none&uniformYAxis=0&Interval=Cumulative&Relative+to+Population=false&Color+by+test+positivity=false&country=~TWN&Metric=Confirmed+cases

3.3.1 Direct costs to the health system

Exhibit 4: Direct economic costs from COVID-19, TWD billion p.a.



Note: Totals may not sum due to rounding
1. A range is given for acute consultations to reflect the range of possible values for the number of GP consultations for COVID-19 assessment and treatment.

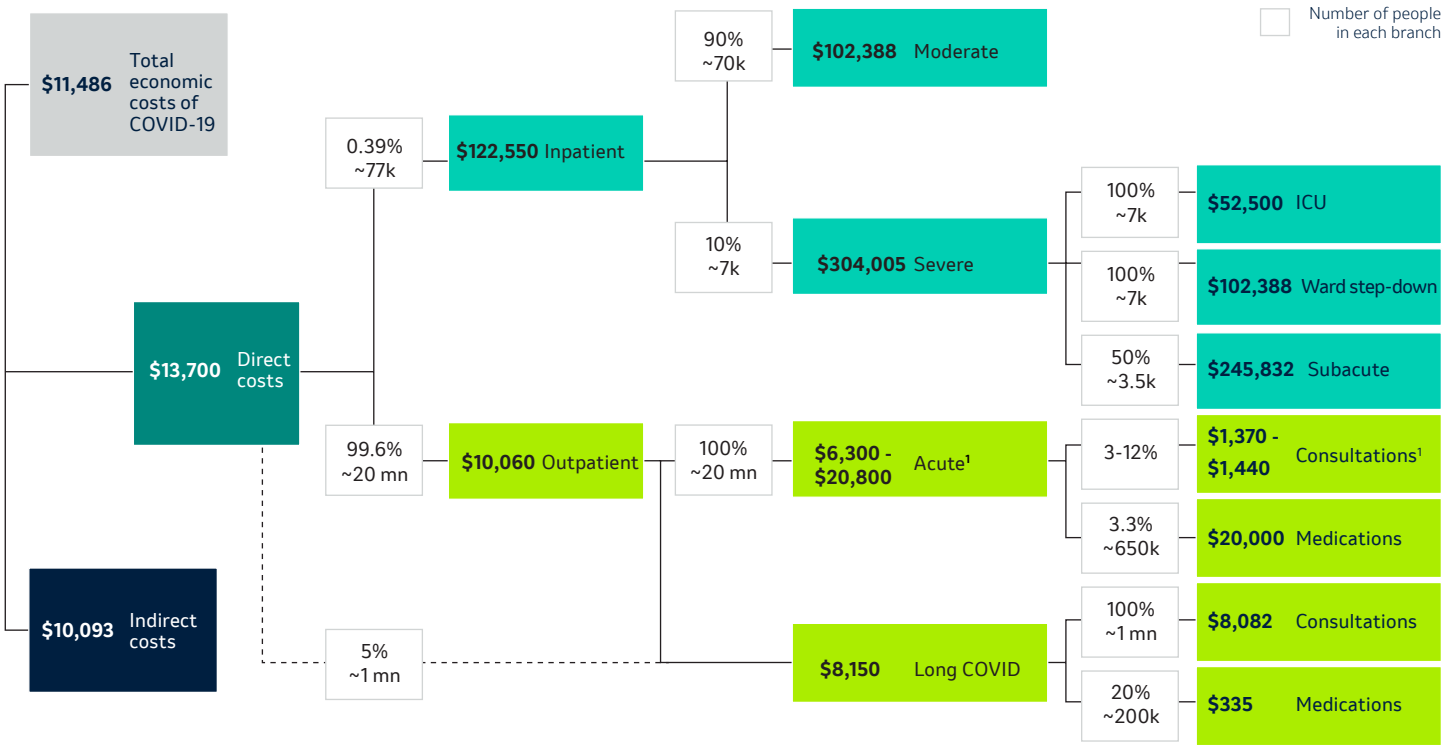
Moderate illness requires ward-based inpatient care, and 'Severe illness' requires ICU-level care; 'Acute illness' refers to all infections not included in inpatient care; Long COVID refers to a small subset (~5%) of total infections and represents infections with symptoms lasting 12 weeks or more.

With ~77,000 hospital admissions (including ~7,000 to the ICU) and ~1 million cases of long COVID in the base case scenario, preventing admissions (including to ICU), reducing lengths of stay, time to recovery, and/or the incidence of long COVID would have a significant impact on reducing the direct costs imposed by COVID-19 on the health system.

In this scenario, as displayed in Exhibit 4, COVID-19 could cost the Taiwan health system TWD ~32.9 billion p.a. This is a significant expense, equating to ~0.1% of Taiwan's GDP. Despite the magnitude of this figure, direct costs are still a minority of the total economic costs of COVID-19 in Taiwan, accounting for ~14% of the total. Indirect costs, comprising productivity losses due to missed work, account for the remainder and could be TWD ~200 billion p.a. These are discussed further in Section (3.3.2). While combined, these direct and indirect costs amount to a significant expense, they still do not account for the value of health lost due to COVID-19, nor the ripple effects on critical industries and vulnerable populations such as the health workforce.

Despite their relatively lower significance in the wider scheme of COVID-19's economic impact, direct costs 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 TWD ~13,700. This is concentrated in the costs of inpatient care, where

Exhibit 5: Direct economic costs from COVID-19, per person, TWD 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; Long COVID refers to a small subset (~5%) of total infections of which symptoms last 12 weeks or more.

a single ward admission could cost TWD ~102,400 and a single ICU admission (with subsequent ward and rehabilitation stays) could cost TWD ~304,000.

As indicated in Exhibits 4 and 5: direct costs are incurred in two major settings:

- Inpatient (hospital-based) care (TWD ~9.47 billion p.a.; 30%; TWD ~122,550 per person)
- Outpatient (primarily clinic-based) care (TWD ~23.47 billion p.a.; 70%; TWD ~10,060 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 test for and treat the disease.

Costs in this category comprise those arising from moderate infections requiring ward-based care (TWD ~7.1 billion p.a.; TWD ~102,400 per person) and severe infections requiring ICU admission (TWD ~2.35 billion p.a.; TWD ~304,000 per person). The more costly care for moderate infections is driven largely by length of stay in the ward (~11 days on average), while the cost of care for severe infections is driven mostly by higher bed day costs (TWD ~11,200 per day in ICU), followed by substantial periods of inpatient rehabilitation (with a median stay of 24 days.)[19]

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 TWD ~23.47 billion p.a. to the

19. National Health Insurance Administration [Internet]. Annual Statistical Report 2021. Available from: https://www.nhi.gov.tw/Content_List.aspx?n=82BE88F79016A334&topn=23C660CAACAA159D

total economic costs incurred due to COVID-19. While seemingly less resource-intensive, outpatient infections are not inexpensive on a per-person basis, each costing TWD ~10,060.

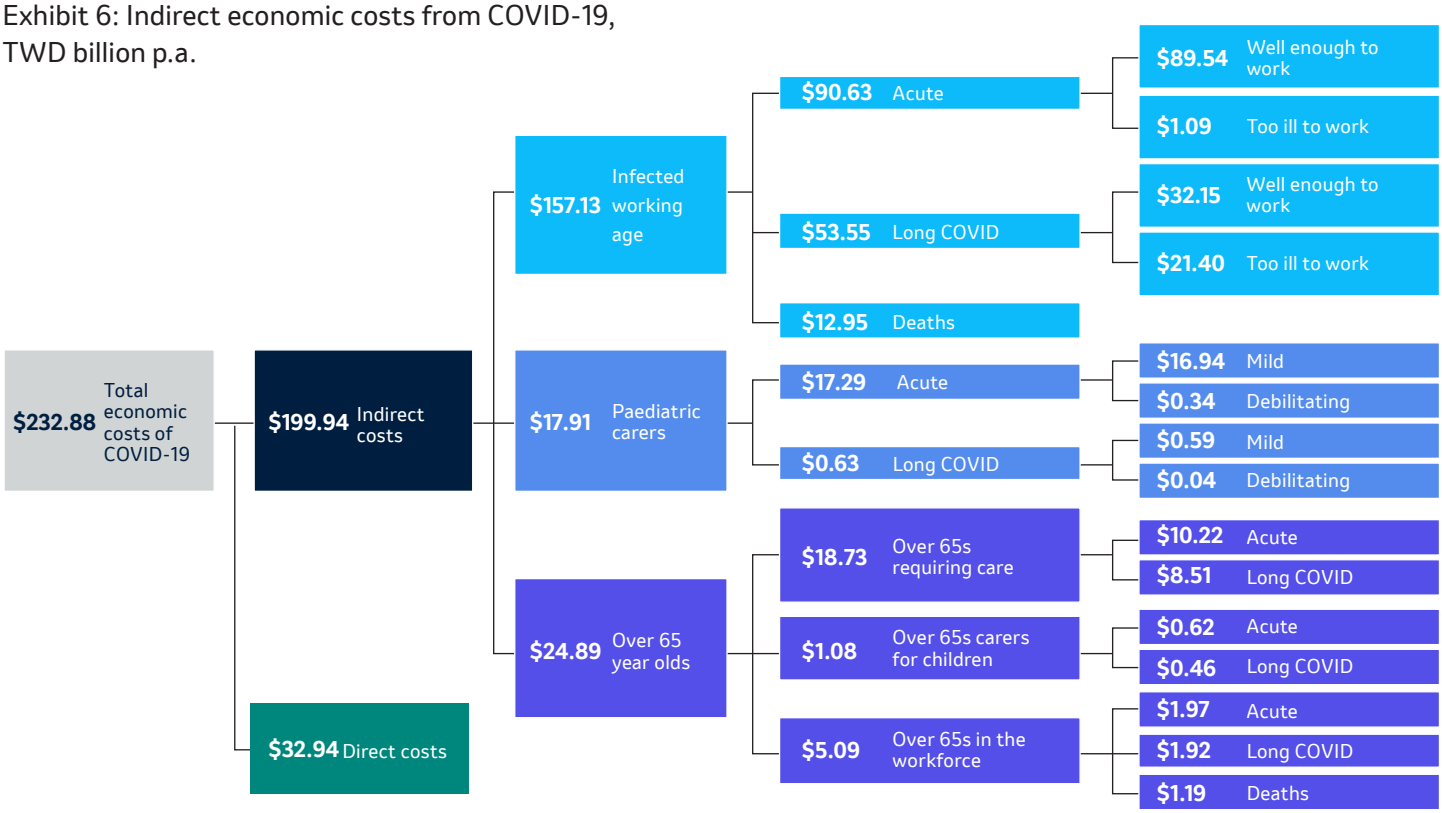
Outpatient costs can be separated into acute outpatient care (consultations and medications; TWD ~15.4 billion p.a.) and chronic outpatient or long COVID care (consultations and medications; TWD ~8 billion p.a.; see also Section 3.4.6).

The cost of acute outpatient care is driven largely by the cost of medications (such as oral antivirals, TWD ~13 billion p.a.) which, equating to ~6% of total economic costs, represents a small investment towards partially reducing a large burden of direct and indirect costs (TWD ~233 billion p.a.). In addition to this, it is important to recognize healthcare labor costs associated with prescribing medications. For example, if a complex treatment is chosen that requires additional checks or reviews, every additional 10-minute period of healthcare labor is worth TWD ~44,[20] without accounting for the opportunity cost of servicing other patients, which is imposed by the additional burden. Aggregate consultation costs in this cohort are lower because there are fewer of them – it is estimated that 2% of all infected patients visit a clinic (~395,000 visits p.a.).[21]

The combined direct costs from the inpatient and outpatient cohorts amount to TWD ~32.9 billion p.a. or ~0.1% of Taiwan's GDP. While significant on their own, these costs are in addition to indirect costs to Taiwan's economy (discussed below in Section 3.3.2), the value of lost health they represent, and flow-on effects to the health system (such as its workforce) and other critical industries.

20. Based on a median weekly earnings figure of $14,934. Statista [Internet]. Average monthly earnings of employees in Taiwan in 2022, by industry. 2023 Feb 27. Available from: https://www.statista.com/statistics/1293585/taiwan-average-monthly-wage-by-industry/
21. Goldstein EV, Seiber EE et al. Journal of Primary Care & Community Health [Internet]. Early Data on Predictors of COVID-19 Treatment Frequency at Community Health Centers. 2021 Dec 23. Available from: https://journals.sagepub.com/doi/full/10.1177/21501319211069473

Exhibit 6: Indirect economic costs from COVID-19, TWD billion 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.

3.3.2 Indirect costs to the economy

Reducing the sheer volume of COVID-19 infections, the duration of illness, and recovery time for working-age adults, children, and the older population would considerably reduce the economic and societal costs of COVID-19 in Taiwan.

In the base case scenario, and as illustrated by Exhibit 6: COVID-19 could cost the Taiwan economy TWD ~200 billion p.a. in productivity losses if current epidemiological conditions and response settings continue.[22] As with direct costs to the health system, this is a significant expense, equating to ~0.8% of GDP. While these costs are significant, as with direct costs, they still do not account for the value of health lost due to COVID-19, nor the flow-on effects to critical industries and vulnerable populations such as the health workforce.

As illustrated in Exhibit 6 indirect costs resulting from productivity losses are borne by three major groups:

- **Infections in working-age adults (19 to 64-year-olds) – TWD ~157 billion p.a.** (~78%; TWD ~11,800 per person)
- **Infections in the older population (65-year-olds and above) – TWD ~24.9 billion p.a.** (~12%; TWD ~10,470 per person)
- **Infections in children and adolescents (18 years old and younger) – TWD ~17.9 billion p.a.** (~9%; TWD ~4,300 per person)

Infections in working-age adults impose a significant economic burden on Taiwan, through productivity losses valued at ~TWD 157 billion p.a., a significant figure that alone equates to ~0.6% of Taiwan's GDP. This burden highlights the impact that an illness that is mild for most but significant enough to last ~12 days – and impair productivity by ~35% for a ~fifth of them – can have on the broader economy.

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

- Acute illness (TWD ~90.6 billion p.a.), chronic illness or long COVID (TWD ~53.6 billion p.a.), and deaths (TWD ~13.0 billion p.a.), or
- Infected adults still well enough to work, but with reduced capacity (TWD ~121.7 billion p.a.), and infected adults who are too ill to work (i.e., are hospitalized) (TWD ~22.5 billion p.a.)

Taking these together, acute illness in those who can still work but at reduced capacity accounts for ~45% (TWD ~89.5 billion) of all productivity losses incurred across the age groups. 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 ~13 million people in Taiwan, a cost impact of substantial proportions results.

Infections in the older population impose TWD ~24.9 billion p.a. (~0.1% of GDP) in costs from productivity losses on the Taiwan economy, adding to the burden from working-age adults. This highlights that productivity losses are not limited to those borne by the working-aged and that adjacent age cohorts are also 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** – ~2.4 million working-age incurring a TWD ~8,000 productivity loss[23] – resulting in a total impact of TWD ~18.7 billion p.a.
- **Older people who directly participate in Taiwan's labor force** – ~10% of over-65s.[24] Infections in this group result in TWD ~5.1 billion p.a. of productivity losses.

22. Based on a median weekly earnings figure of TWD ~10,033. 全台平均月薪43K，但難以追上通膨！實體薪資幾乎零成長 (The average monthly salary in Taiwan is 43K, but it is difficult to catch up with inflation! Physical salary growth is almost zero) Business Next [Internet]. 2022 Sep 8. Available from: https://www.bnext.com.tw/article/71613/salary--average-22
23. ~99% of Taiwan's 65+ population do not receive long-term care services (either in facilities or home-based). This proportion is assumed to be consistent in the 65+ cohort that becomes infected with COVID-19. 行政院主計總處 (Directorate General of Budgeting, Accounting, and Statistics) [Internet]. 2022 Nov 30. Available from: https://ws.dgbas.gov.tw/Download.ashx?u=LzAwMS9VcGxvYWQvNDYzL3JlbGZpbGUvMTA5ODAvMjMwMTYyL2M5NWE5ZWU5LWI1OTEtNGNkMS04YzAwLTI3NTkyYjJhOGRlNC5wZGY%3d&n=MTA55bm05Lq65Y%2bj5Y%2bK5L2P5a6F5pmu5p%2bI57i95aCx5ZGK57Wx6KiI57WQ5p6cLeaWsOiBnueovy5wZGY%3d
24. National Statistics Republic of China (Taiwan) [Internet]. Statistical Tables. Available from: https://eng.stat.gov.tw/News.aspx?n=2401&sms=10889

- **Older people (e.g., grandparents) who care for children to enable parents to work** – one survey found that ~20% of grandparents (including in multi- and single-generation households) provided care for grandchildren.[25] When this work-enabling care is disrupted, the productivity loss amounts to TWD ~1.1 billion p.a.

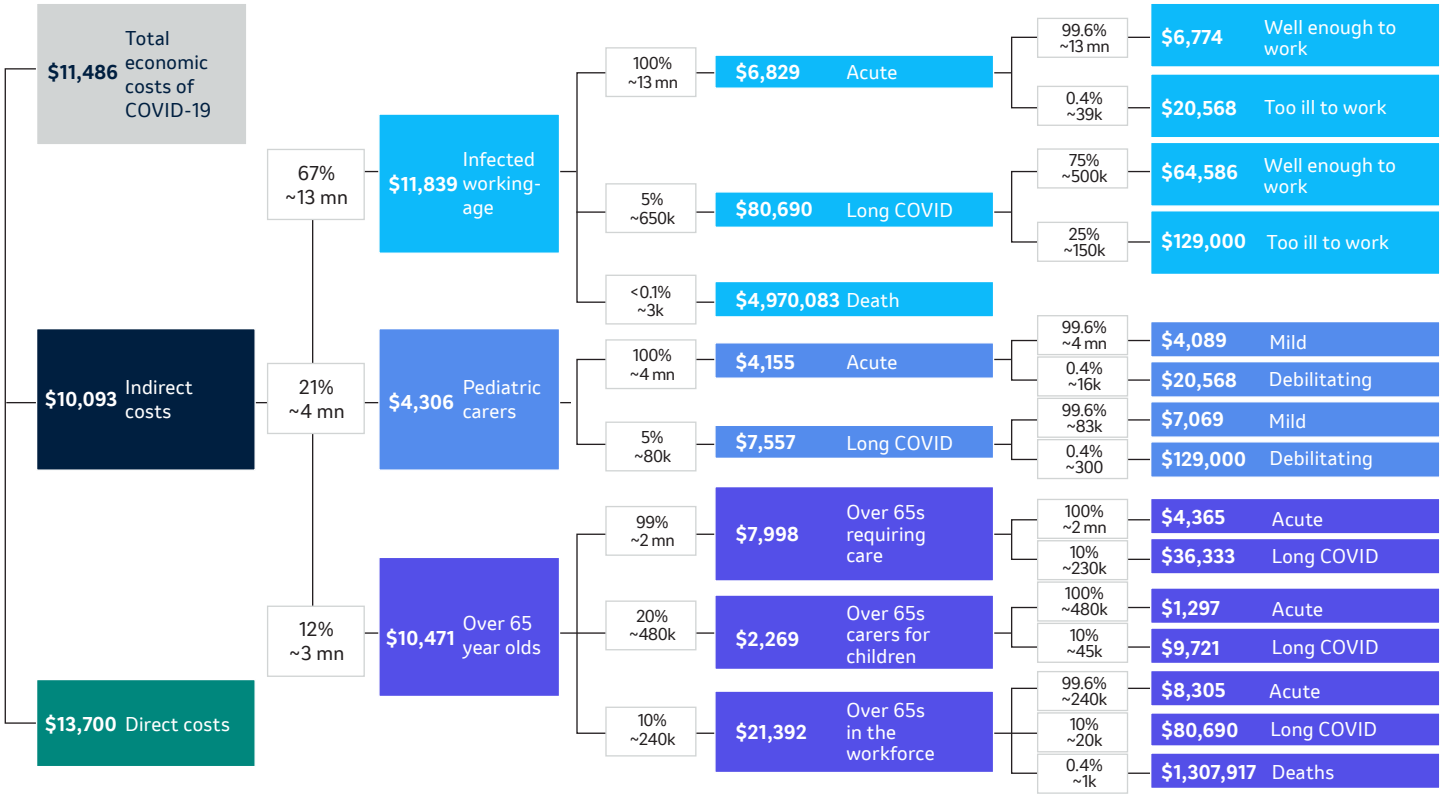
Infections in the older population account for TWD ~29 billion p.a., or ~13% of all direct and indirect costs combined, serving as a stark reminder of the need to address costly infections in cohorts adjacent to working-age adults.

Finally, infections in children impose an additional economic cost of TWD ~17.9 billion p.a. (~0.07% of GDP) 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 TWD ~16.9 billion p.a. This cost is driven by care for ~3.3 million mild but symptomatic 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

25. Ku LE, Stearns SC, Van Houtven CH, Lee SD, Dilworth Anderson E, Konrad TR. The Journals of Gerontology: Series B [Internet]. Impact of Caring for Grandchildren on the Health of Grandparents in Taiwan. 2013 Sep 21; 68(6): 1009-21. Available from: https://academic.oup.com/psychsocgerontology/article/68/6/1009/658299?login=false

Exhibit 7: Indirect economic costs from COVID-19, per person, TWD 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.

children with debilitating infections. For parents who can work from home (~63%), productivity is estimated to halve, while all productivity is foregone from parents who cannot work from home (~37%).[26] This is a substantial cost driven more by lost work than the illness itself, reiterating that substantial costs imposed by productivity losses are not limited to infections in working-age adults.

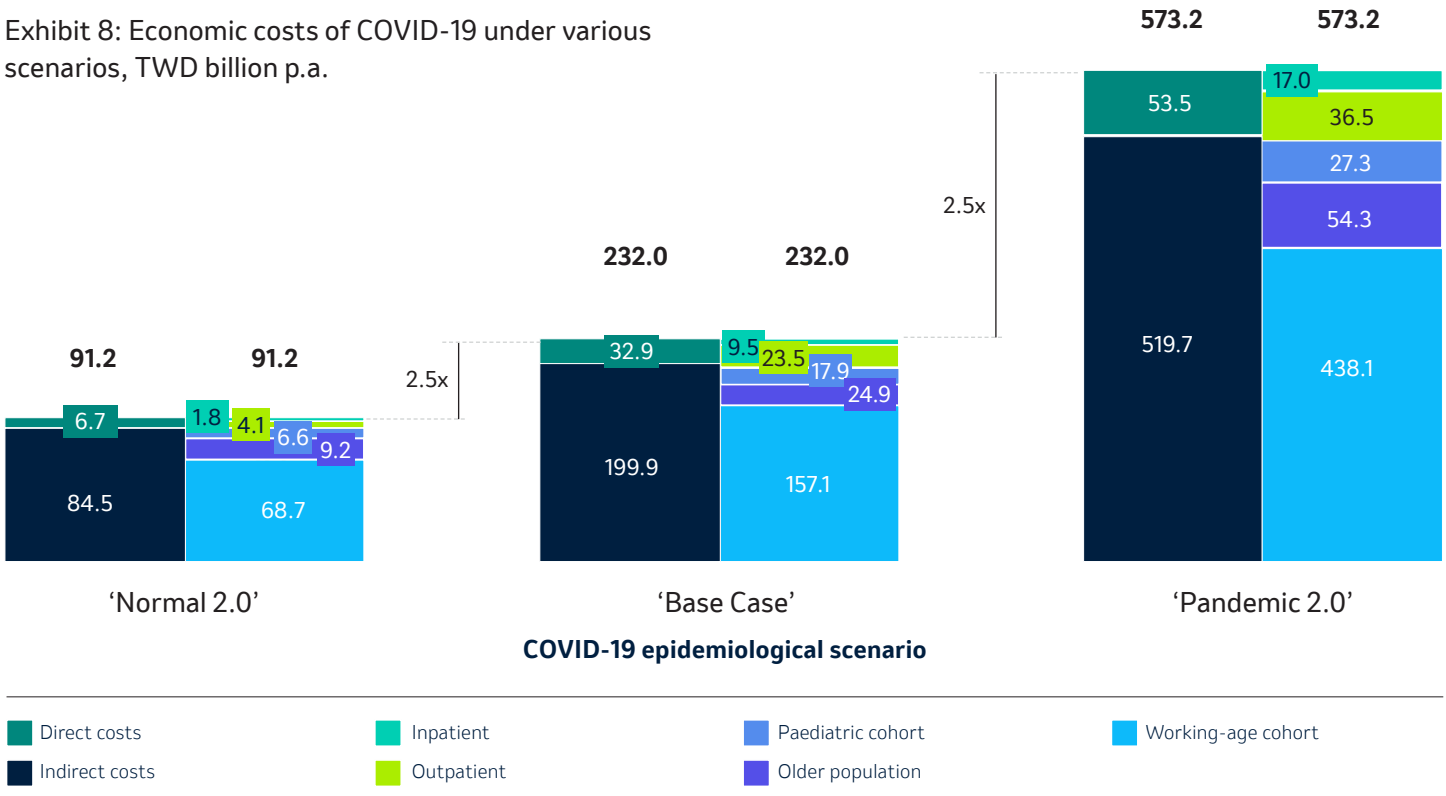
Despite the seeming reduction in resource intensiveness compared to direct healthcare costs, the magnitude of productivity losses imposed by COVID-19 means indirect costs are actually significant and comparable on a per-person basis (as indicated in Exhibit 7), with each infection costing TWD ~10,100 (versus TWD ~13,700 for direct costs) on average. This is concentrated in productivity losses resulting from infections in the working-age (TWD ~11,800 per person) and the older population (TWD ~10,470 per person).

Together, indirect economic costs arising from productivity losses in these groups amount to TWD ~200 billion p.a. or ~0.8% of Taiwan's GDP and are in addition to the value of lost health and direct costs to Taiwan's health system. Although already substantial, these costs are likely to underestimate the entirety of the burden imposed on society by COVID-19, as second-order impacts on health system capacity and flow-on effects to the health workforce, supply chains, and other aspects of critical industry are all additive to directly measurable economic impacts.

The entirety of the economic burden imposed by COVID-19 also needs 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.

26. Taipei Times [Internet]. Companies consider reinstating work from home amid spike in COVID-19. 2022 Apr 16. Available from: https://www.taipeitimes.com/News/biz/archives/2022/04/16/2003776668

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



Normal 2.0 refers to a scenario featuring ~290,000 infections per million population and ~30,000 hospitalizations, reflecting conditions observed in mid-late 2022; Pandemic 2.0 refers to a scenario featuring ~1 million infections per million population and ~111,000 hospitalizations, reflecting conditions observed in early 2022.

3.3.3 Alternative scenarios: costs of Pandemic 2.0 and Normal 2.0

In addition to the base case, two further scenarios are considered, as illustrated in Exhibit 8:

In a Pandemic 2.0 scenario, total economic costs could reach TWD ~573 billion p.a. Conversely, in the Normal 2.0 scenario, economic costs could decrease to TWD ~91 billion p.a.

The two example scenarios represent divergent epidemiological outcomes that are both plausible as the pandemic evolves. Each theoretical scenario is defined by two key features:

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

A Normal 2.0 scenario would feature a case volume of ~290,000 cases per million population per year and ~30,000 hospitalizations.[27] These thresholds represent reported case numbers prevalent in Taiwan in November 2022, annualized. Under a Normal 2.0 scenario, economic impacts from COVID-19 could decrease to TWD ~91 billion p.a., equating to ~0.4% of GDP and TWD ~13,570 per person. Direct costs could decrease to TWD ~6.7 billion p.a. and indirect costs to TWD ~85 billion p.a. Decreases in costs would be driven by lower hospitalization rates and diminished productivity losses owing to reduced periods of missed work.

By contrast, a Pandemic 2.0 scenario would feature a case volume of ~1 million cases per million population per year (i.e., the entire population is infected once, on average) and a case severity that drives ~111,000 hospitalizations. This compares to the base case scenario featuring a case volume of ~840,000 infections per million population and ~77,000 hospitalizations.[28]

In this scenario, economic impacts from COVID-19 could increase to TWD ~573 billion p.a., equating to ~2.3% of GDP and TWD ~24,300 per person. In this scenario, direct costs could be TWD ~53.5 billion p.a. (a 1.7 times increase of TWD ~21 billion p.a.) and indirect costs could reach TWD ~520 billion p.a. (a 2.6 times increase of TWD ~320 billion p.a.). These increases would be driven by increased hospitalization rates, longer lengths of stay, and augmented productivity losses from an increased 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 described above demonstrates the need for a range of preparedness settings that include options to limit impacts at all junctures.

While scenarios help us to consider potential courses that the COVID-19 pandemic may take in the future, their scope is largely restricted to the consideration of quantifiable economic costs. Equally important to consider are the 'second-order' impacts that COVID-19 could have on health system capacity and flow-on effects to vulnerable populations and critical industries, demonstrating its broad reach in economic and societal impact.

---

27. Case volumes reflect an annualized figure based on total reported cases in November 2022. Taiwan Centre for Disease Control [Internet]. COVID-19 statistics. Available from: https://sites.google.com/cdc.gov.tw/2019ncov/taiwan

    Our World in Data [Internet]. COVID-19 Data Explorer. Available from: https://ourworldindata.org/explorers/coronavirus-data-explorer?facet=none&uniformYAxis=0&Interval=Cumulative&Relative+to+Population=false&Color+by+test+positivity=false&country=~TWN&Metric=Confirmed+cases

28. Infection numbers and hospitalization rates are sourced from modeling of COVID-19 infections in Taiwan by the Institute of Health Metrics and Evaluation (IHME; used with permission). In Taiwan, infection numbers are ~twice the number of reported cases, recognizing the volume that is not detected by the testing process.

3.4 Considerations For Critical Cohorts And Industries

The economic costs of COVID-19 described will impact different populations and industries disproportionately. This includes cohorts that play a critical economic or societal role (e.g., logistics workers, 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. These groups may be worthy of additional focus when considering countermeasure approaches to mitigate the impacts of COVID-19.

Specifically, interventions that protect health and productivity losses in these critical industries and populations may yield corresponding disproportionate economic returns.

3.4.1 Critical workers and industries

As outlined above, some critical industries experience disproportionate indirect costs (i.e., productivity losses) that generate significant public concern. Here, the focus is on three industries in particular – healthcare, logistics, and travel and tourism.

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 (up to the equivalent of one to two workdays) than that of individuals in desk-based jobs who are able to perform work tasks in their home environment.

3.4.2 Healthcare

Taiwan's health system serves as its first and last line of defense against COVID-19 and other health threats. National healthcare expenditure is TWD ~1.3 trillion and the industry employs ~350,000 healthcare practitioners.[29,30]

At a potential minimum cost of TWD ~15.9 billion p.a. (~0.06% of GDP; ~7% of combined total cost),[31] healthcare workers who become infected with COVID-19 represent a disproportionate slice of the impact of this disease on the economy. However, this is likely to significantly underestimate the total impact on the Taiwanese economy and citizens' welfare, due to flow-on effects on patient outcomes.

Health services typically experience higher rates of COVID-19-related absenteeism compared to other industries. A root cause of these inflated figures is healthcare workers' increased risk of exposure to COVID-19 infection in the workplace, estimated at almost twice that of the general population.[32] Productivity losses are not only incurred by sick workers but also by the remaining workers who are required to take up additional responsibilities. Taking Chi Mei Hospital as an example, an infection rate of 20% among medical staff meant others were caring for seven, instead of five, patients.[33] The extra workload reduces time to complete tasks in addition to patient care and contributes to exhaustion, reduced empathy, and an increased risk of workplace errors.[34]

29. Ministry of Health and Welfare; [Internet]. 國民醫療保健支出(NHE) (National Health Care Expenditure Statistical Table). (cited 2021). Available from: https://dep.mohw.gov.tw/DOS/cp-5071-66025-113.html
30. Ministry of Health and Welfare [Internet]. [統計指標(人口、死亡率、醫療設施等) (Statistical indicators [population, death rate, medical facilities, etc.]) cited 2021. Available from: https://dep.mohw.gov.tw/DOS/lp-5083-113.html
31. Based on a median weekly earnings figure of TWD ~14,934. Statista [Internet]. Average monthly earnings of employees in Taiwan in 2022, by industry. Available from: https://www.statista.com/statistics/1293585/taiwan-average-monthly-wage-by-industry/
32. 工會估2.6萬醫護曾染疫，僅465人申請職災給付：院方阻撓刁難，要求證明「因公確診」(The trade union estimates that 26,000 medical staff have been infected with the epidemic, and only 465 people applied for occupational benefits) [Internet]. The New Lens; 2022 Jul 15. Available from: https://www.thenewslens.com/article/169683
33. The Reporter [Internet]. Omicron疫情下的急診室，醫師說：20年來最恐怖！(In the emergency room under the Omicron epidemic, the doctor said: the scariest in 20 years!) 2022 Jul 22. Available from: https://www.twreporter.org/a/emergency-overstrain-2022-situation
34. Shiu C, Chen W, Hung C, Huang EP, Lee TS. Journal of the Formosan Medical Association [Internet]. COVID-19 stigma associates with burnoutamong healthcare providers: Evidence from Taiwanese physicians and nurses. 2021 Sep 30; 121(2022): 1384. Available from: https://escholarship.org/content/qt8kg630k1/qt8kg630k1_noSplash_f126cba31894e48fa5f96c1ef9d7ce2d.pdf

The economic ripple effects of COVID-19-related absenteeism among healthcare workers are significant. COVID-19 has exacerbated pre-existing workforce shortages, resulting in poorer quality and safety of healthcare provision. Even recently, shortages have contributed to two- to three-fold increases in emergency department wait times in some hospitals.[35] These wait times apply to, among others, patients with myocardial infarction, respiratory failure, or septic shock. Such reductions in the availability and timeliness of medical care may lead to prolonged illness or delayed recovery for patients, who incur their own productivity losses as a result.

Additionally, the COVID-19 pandemic has seen unprecedented levels of workforce burnout and attrition.[36] Although the initial response to the COVID-19 pandemic has subsided, global talent shortages and mobility limitations are ongoing challenges.

A countermeasure approach that targets healthcare workers is essential in mitigating overall economic costs as well as COVID-19's impact 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.

3.4.3 Logistics

COVID-19 has caused unprecedented disruption to Taiwan's transport and logistics sector, which delivers vital goods and services across the nation. It is a TWD ~1.7 trillion industry, with a growing workforce of ~300,000 people.[37,38] During the pandemic, the sector was disproportionately impacted by productivity losses from workers, which snowballed into local and global supply network disruptions.

Taiwan's transport operators and distribution centers have experienced significant workforce shortages due to COVID-19 illness. This workforce includes warehouse staff, forklift drivers, unpack crews, and technicians, who are unable to fulfill work obligations at home while ill, isolating, or caring for others who have been infected with COVID-19. Subsequently, these businesses struggle to retain other employees who are required to work longer hours to compensate for the lost labor.

Workforce shortages have downstream consequences for end-point retailers, users, and customers. Disruptions have the dual effect of driving inflation in the costs of goods and services, as well as impeding the ability of businesses and their workers to deliver them. Among these goods are necessities of public importance such as food, life-altering medicines, gas, and oil.[39]

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

35. The Reporter [Internet]. Omicron疫情下的急診室，醫師說：20年來最恐怖！(In the emergency room under the Omicron epidemic, the doctor said: the scariest in 20 years!) 2022 Jul 22. Available from: https://www.twreporter.org/a/emergency-overstrain-2022-situation
36. Public Television Service Foundation (PTS) [Internet].; 2至5月近800護理人員離職 衛福部否認有護理人員離職潮 (Nearly 800 nursing staff resigned from February to May, 2021) 2021 Jun 5. Available from: https://news.pts.org.tw/article/529444. Institute of Health Metrics and Evaluation [Internet]. Worldwide shortage of health workers threatens effective health coverage 2022 May 23. Available from: https://www.healthdata.org/news-release/worldwide-shortage-health-workers-threatens-effective-health-coverage. Turton M. Taipei Times [Internet]. Does Taiwan's nursing problem have a cure? 2022 Feb 21. Available from: https://www.taipeitimes.com/News/feat/archives/2022/02/21/2003773473
37. Taiwan Ministry of Transportation and Communication [Internet]. Taiwan Services Trade Information Platform. Available: https://www.taiwanservices.com.tw/internet/en/index.aspx?cat=9&istop=1#
38. National Statistics, R.O.C. (Taiwan) [Internet]. 國情統計通報 (National Statistical Bulletin). Available from: https://www.stat.gov.tw/News.aspx?n=2661&sms=11020&_CSN=588
39. Kang R. HKTDC Research [Internet]. Taiwanese Industries Struggle to Weather Global Commodity Price Hike. 2021 Oct 20. Available from: https://research.hktdc.com/en/article/ODcwMDk4NTg0

3.4.4 Travel and tourism

Despite a strong recovery since re-opening borders in October last year, Taiwan's travel and tourism sector continues to face headwinds due to workforce shortages. Prior to the COVID-19 pandemic, Taiwan's tourism sector contributed ~4.4% to the national economy and supported 1 in 11 jobs nationwide.[40] However, the pandemic led to steep declines (up to ~50%) in visitor numbers and tourism spending due to border restrictions, isolation orders, and hesitancy to travel.[41]

Absenteeism linked to COVID-19 has wreaked havoc across industries such as airports and accommodation services. Unexpected staff shortages due to illness exacerbate a labor gap already at ~13%.[42] This is contributing to flight disruptions that can impede corporate travelers' productive work time and impact holidaymakers' spending.

Countermeasures targeted at Taiwan's travel and tourism workforce are needed to help these industries recover from the COVID-19 pandemic.

3.4.5 Vulnerable populations

COVID-19 illness in Taiwan's vulnerable populations represents a minimum impact of TWD ~118 billion p.a. (~0.5% of GDP) on Taiwan's economy. These populations are at greater risk of severe COVID-19 disease and are more heavily reliant on the healthcare system than others. Vulnerable populations that have received particular attention throughout the pandemic include those over 65 years old, those with comorbidities, and Taiwan's indigenous peoples.

COVID-19 illness in Taiwan's older population (65 years and older) could have an economic impact of TWD ~29 billion p.a. (~13% of the combined annual impact), a significant TWD ~12,370 per person. Despite representing just ~12% of confirmed cases, the older population represents ~20% of COVID-19 hospitalizations.[43] This figure is not surprising considering the high prevalence of comorbidities such as high blood pressure, cancer, and diabetes in this age group, which affect ~80% of those over 65 years old.[44]

Comorbidities in the younger, working-age (19-64 years) population could also have a disproportionate impact of TWD ~88 billion p.a. (~0.4% of GDP). Just one comorbidity doubles the risk of severe COVID-19,[45] subsequently increasing the likelihood of hospitalization and prolonging time off work to recover. This could be a reality for at least ~50% of 40-64-year-olds in Taiwan.[46]

40. World Travel and Tourism Council [Internet]. Taiwan, China 2022 Annual Research: Key Highlights. Available from: https://wttc.org/DesktopModules/MVC/FactSheets/pdf/704/242_20220613171216_Taiwan,%20China2022_.pdf
41. Kang R. HKTDC Research [Internet]. Taiwan's Tourism Sector Readies Itself for Visitor Spike as Borders Re-Open. 2022 Oct 14. Available from: https://research.hktdc.com/en/article/MTE4NDYxMjg5Ng
42. Xue Y, Wu J. Public Television Service Foundation (PTS) [Internet]. 邊境解封地勤人力不足 民航局坦言缺員6、7百人 (Insufficient manpower for ground staff due to unsealed borders). 2022 Oct 17. Available from: https://news.pts.org.tw/article/6047800
43. Calculated based on age distribution of respiratory diseases. Statistics on the total number of outpatient and inpatient visits. 2021NHI Statistics on Taiwan Healthcare [Internet]. 2022 Dec.
44. The figure represents the percentage of those aged 65 and older who have one or more chronic illnesses or comorbidities. It excludes chronic mental health conditions and hip fractures which account for 8% of chronic conditions among those aged 65 and older. Health Promotion Administration [Internet]. Long-term follow-up survey on the physical and social living conditions of middle-aged elderly peoples of the Republic of China. 2022. Available from: https://apps.who.int/iris/bitstream/handle/%2010665/194271/9789241509312_eng.pdf
45. 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; 21(685). Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-021-06378-z
46. Approximately ~57% of 54-59year-olds and ~69% of 60-64-year-olds have 1 or more chronic illnesses (excluding mental health conditions and hip fractures). Hypertension (high blood pressure) is the most prevalent COVID-19 comorbidity affecting ~26.76% of 40-64-year-olds. Therefore, a conservative estimate of a ~50% severe illness risk among 40-64-year-olds has been made. Ministry of Health and Welfare [Internet]. Health Promotion Administration. Available from: https://www.hpa.gov.tw/Home/Index.aspx

COVID-19 continues to exacerbate the health gap between indigenous and non-Indigenous Taiwanese peoples. The indigenous community has high rates of chronic illness and faces inequalities in access to health services which heightens their susceptibility to severe COVID-19. In addition, the pandemic has amplified the social determinants of health, which account for one-third of the health gap. These determinants include employment, hours worked, the completion of schooling, and household incomes – all of which decline when individuals become ill or need to care for loved ones.[47,48]

Vulnerable populations bear ~50% of the combined direct and indirect costs of COVID-19. Countermeasures that reduce the duration of illness and/or speed up recovery time among these populations could significantly mitigate the pandemic's impact. Countermeasures may include ongoing vaccination for individuals aged five years and older,[49] community interventions, or the use of oral antivirals.[50] Oral antivirals were introduced in Taiwan in the second quarter of 2022 to strengthen the suite of countermeasures in the market.

3.4.6 Long COVID

Long COVID[51] has a potential minimum impact of TWD ~73 billion p.a. (~0.3% of GDP; TWD ~73,867 per person) on Taiwan's economy. Individuals who develop this condition experience prolonged productivity losses (increasing indirect costs) and reliance on health services (increasing direct costs).

The direct costs of long COVID, largely driven by consultations, collectively amount to at least TWD ~8.1 billion (TWD ~8,150 per person). When the incidence, complexity, and duration (90 days) of long COVID are factored in, this could mean ~6 million healthcare consultations[52] are required for this cohort alone.[53] Long COVID, therefore, represents a substantial burden on the health system, both in terms of required capacity and economic costs.

Indirect costs or productivity losses resulting from long COVID could amount to at least TWD ~65 billion p.a. (TWD ~66,079 per person and ~33% of all indirect costs). Long COVID productivity losses among the working-age population contribute the bulk of this figure (TWD ~53.5 billion p.a. or ~82%). An adult with long COVID, for instance, could lose up to 45 workdays over a three-month period in reduced productivity.[54]

Long COVID contributes a large share (~32%) of total economic costs, economy. and therefore countermeasures to reduce the incidence and duration of this condition would greatly mitigate pandemic-associated costs. Conservative estimates place the incidence and duration of long COVID at 5% and 90 days respectively. However, as studies on long COVID are still evolving, the full scope of long COVID might still be underestimated.

47. 行政院 (Executive Yuan) [Internet]. 改善原鄉健康不平等 (Improve health inequalities in origin). 2022 Jul 31. Available from: https://www.ey.gov.tw/Page/5A8A0CB5B41DA11E/dcef57a2-e619-40fa-b992-455260a27a23
48. United News Network [Internet].每4人就有1人確診 全台染疫率最高鄉鎮 為何在原民部落?(1 out of every 4 people is diagnosed. Why is the town with the highest infection rate in Taiwan located in an aboriginal tribe?) 2022 Jun 9. Available from: https://udn.com/news/story/6841/6375217
49. Taiwan Centers for Disease Control, Ministry of Health and Welfare [Internet]. Pfizer-BioNTech COVID-19 Vaccine Information Sheet for Student Immunization (ages 5-17). 2022 Sep 12. Available from: https://www.cdc.gov.tw/Uploads/394492b5-0a4d-46a6-9b13-4d816d969f80.pdf
50. Oral antivirals are indicated for patients over the age of 18 who have a confirmed COVID-19 infection, severe risk factors, are within 5 days of onset of illness, and are unable to use other recommended medications. Taiwan Centers for Disease Control. Adoption Program for Therapeutic Use of Publicly-funded COVID-19 Oral Antiviral Drugs [Internet]. 2022 June 16. Available from: https://www.cdc.gov.tw/Uploads/files/b286452d-8068-4a1f-90e1-79a03e4fc926.pdf
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. Due to limited data availability, statistics in this report have been assumed as applicable to the Taiwanese context. Commonwealth of Australia House of Representatives, Standing Committee on Health, Aged Care and Sport [Internet]. Impacts of Long COVID and repeated COVID infections. 2022 Oct. Available from: https://www.aph.gov.au/longandrepeatedcovid
53. Each case could require 6 consultations on average over a 90-day period of long COVID illness.
54. Based on an average of 7.2 days of sick leave and reported reductions in working hours 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 9, countermeasures include community measures such as social distancing as well as the utilization of vaccines and therapeutics, including oral antivirals.

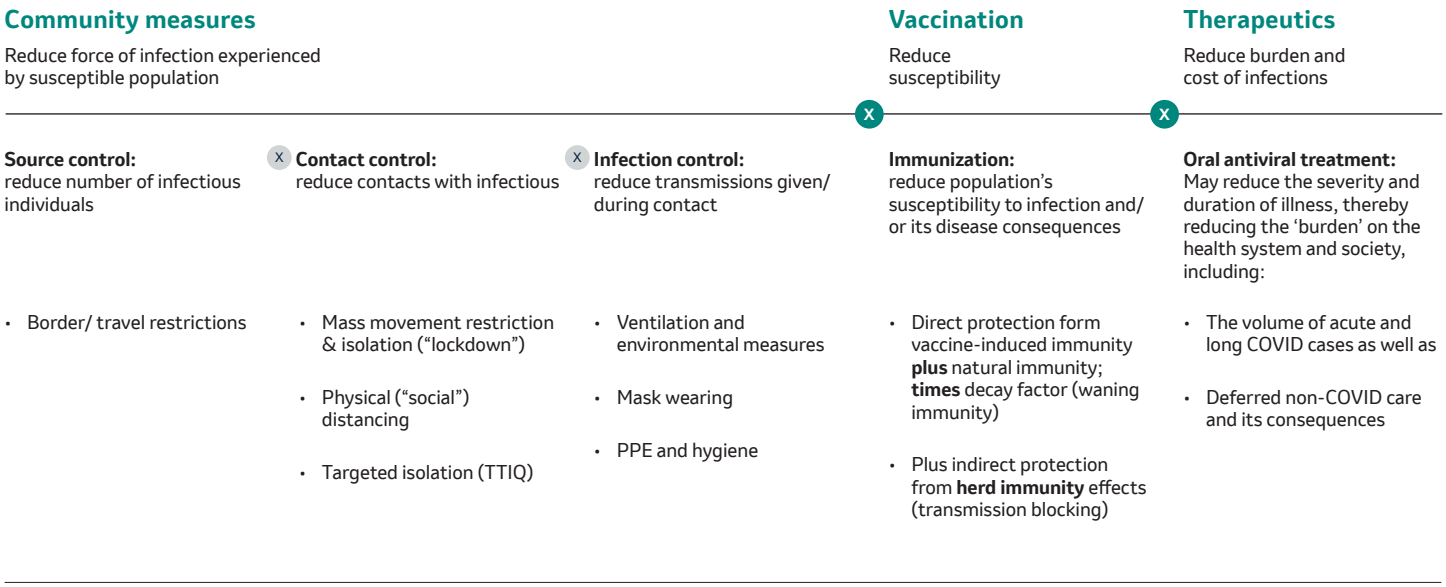
However, despite significant ongoing economic costs, uptake of these countermeasures has been incomplete. Examples of incomplete uptake include waning uptake of booster vaccination doses, and variable awareness and availability of oral antivirals. There is an opportunity for policymakers to consider 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 Taiwan, 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 Taiwan 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 the Taiwanese 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. Taiwan has achieved high rates of vaccination relative to international peers, with 88% of the population having received two doses.[55] By reducing the population's susceptibility (both directly for the recipient of the vaccine and indirectly by reducing the risk of onward transmission),[56] 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.

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 represent ~50% of the economic impact of COVID-19 in Taiwan, assuming high levels of uptake. Given the challenges associated with community measures, and that Taiwan 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 Taiwan's response.

55. Holder J. New York Times [Internet]. COVID Vaccinations tracker. 2023 Mar 13. Available from: https://www.nytimes.com/interactive/2021/world/covid-vaccinations-tracker.html
56. 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
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 Taiwan

Exhibit 10: Summary of countermeasures in Taiwan

	Community measures	Vaccination	Therapeutics
2022	• **Isolation** - there is a 5 day mandatory isolation period for those who test positive for COVID-19 • **Mask wearing** - masks are required to be worn in public spaces	• As of December 2022, ~60 million doses administered with 88% of the population receiving 2 doses • People aged 50 to 64 and people 18 or older who need to travel abroad eligible to receive Moderna's second- generation Spikevax COVID-19 vaccine dose as a booster shot • People between 12-17 age can get a Novavax COVID-19 vaccine as a first. second, or booster shot	• Oral antivirals became available in Q2 2022 • Cohorts eligible for oral antivirals include those 65+ years old and 12+ years old weighing ≥40kg at high risk of severe illness
2020-21	• **Border restrictions** - international borders were closed from March 2020 to October 2022 • **Testing and contact tracing** - a contact tracing program was implemented to track travel and contact history of confirmed COVID-19 cases; a digital home quarantine monitoring system implemented for travelers	• Roll-out commenced in August 2021 • Compulsory for medical personnel, airline or ship crew members, care facility employees, workers at airports and other ports of entry	

As of December 23, 2022.[58]

58. Ministry of Health and Welfare [Internet]. COVID-19 Timely Border Control. 2022 Jul. Available from: https://covid19.mohw.gov.tw/en/cp-4774-53783-206.html

5. Conclusion

By international standards, Taiwan achieved positive results in its initial efforts to contain the COVID-19 pandemic. Community measures employed during the first three years were largely successful, helping the market avoid negative economic growth during 2020 to 2022.[59,60] However, our analysis demonstrates that both direct and indirect costs arising from COVID-19 will continue to impact Taiwan's economic outlook – an estimated ~0.9% of GDP p.a. under a base case and up to ~2.3% of GDP in a Pandemic 2.0 scenario.

Even in the most optimistic of scenarios, the pandemic will still affect Taiwanese individuals, families, and businesses in a myriad of ways, from limiting access to health services to staffing key industries, to protecting household incomes and supporting vulnerable populations.

Indirect costs on productivity and livelihoods in Taiwan are expected to have the greatest ongoing impact. Infections among older people and children will continue to cause productivity losses among the working-age population, many of whom need to take time off to care for sick family members. Certain cohorts, such as health professionals, those affected by long COVID and vulnerable populations[61] are likely to be disproportionately impacted too.

These findings shed light on the many factors and considerations that contributes to Taiwan's response to COVID-19, and are intended to help policymakers plan better for that future.

5.1 Economic costs

In our base case scenario, the total economic cost of COVID-19 is ~0.9% of Taiwan's GDP, with:

- Direct costs to the health system accounting for 14% of the total economic cost. Health system costs could amount to TWD ~32.9 billion p.a, or ~0.1% of Taiwan's GDP, driven by an estimated ~77,000 admissions and ~990,000 cases of long COVID.
- The remaining 86% of costs due to productivity losses through missed work by adults as a result of their own illness or while caring for dependents (children and over-65 year-olds[62]); as well as elderly in the workforce affected by COVID-19. These indirect costs could cost the Taiwan economy TWD ~199.9 billion p.a.
- COVID-19 illness in Taiwan's vulnerable populations, which includes those over 65 years old, those with comorbidities and Taiwan's indigenous populations represents a minimum impact of TWD ~118 billion p.a. to Taiwan's economy. Infections in elderly Taiwanese alone could account for TWD ~29 billion p.a.

In the Pandemic 2.0 scenario, economic costs could rise to TWD ~573.2 billion or ~2.3% of GDP. This assumes a higher rate of infection of ~1 million cases per million and a higher viral severity driving ~110,000 hospitalizations annually. This reflects a scenario where each individual contracts the virus once per year. At the lower end of the spectrum, a Normal 2.0 scenario might feature fewer infections over the course of a year than in the base case and fewer hospitalizations.

59. Economics Observatory [Internet]. How has Taiwan navigated the pandemic? 2021 Dec 1. Available from: https://www.economicsobservatory.com/how-has-taiwan-navigated-the-pandemic
60. Focus Taiwan [Internet]. Taiwan GDP growth hits 2.43% in 2022, shy of forecast. 2023 Jan 18. Available from: Taiwan GDP growth hits 2.43% in 2022, shy of forecast - Focus Taiwan
61. Broadly, those over 65, adults under 65 with one or more comorbidities, and indigenous populations.
62. In Taiwan, the retirement age is 65.

Health system capacity

Taiwan's roughly 350,000-strong health workforce has been significantly impacted by COVID-19, seeing higher rates of COVID-19-related absenteeism due to greater susceptibility, which has caused major disruptions and system capacity issues.

Looking forward, economic costs arising from these disruptions could total TWD ~15.9 billion p.a., or ~0.06% of GDP (base case scenario). Long COVID also represents a substantial burden on the health system, both in terms of required capacity and economic costs. When the incidence, complexity, and duration (90 days) of long COVID are factored in, this could mean an extra 6 million healthcare consultations to address the impact alone.

Workers and critical industries

At the same time, the disease has had a major impact on several of Taiwan's key industries and sectors. Its transport and logistics, as well as travel and tourism industries are particularly affected, with the productivity of those industry workforces facing unique challenges throughout the ongoing health crisis.

Taiwan's TWD ~1.7 trillion transport and logistics sector employs an estimated 300,000 people and is a vital element in the market's ongoing operation, including delivering basic necessities such as food, life-altering medicines, and fuel. However, many of these workers are unable to fulfil work obligations either due to infection or because they need to isolate or care for others who have been infected, exacerbating today's 'supply chain crisis'.

Taiwan's travel and tourism industry, meanwhile, is still recovering from the estimated ~50% decline in visitors and tourism spending during the height of the pandemic.[63] Absenteeism linked to COVID-19 and staff shortages is also exacerbating flight disruptions, delaying corporate and holiday travel.

Vulnerable populations

Being especially susceptible to severe disease and heavily reliant on the health services, Taiwan's most vulnerable populations have all experienced greater impacts from the COVID-19 crisis, and are likely to continue to be disproportionately affected moving forward.

For example, despite representing just 12% of confirmed cases, Taiwan's elderly account for 20% of COVID-19 hospitalizations,[64] due largely to the high prevalence of comorbidities such as high blood pressure, cancer, and diabetes in this cohort. Younger people with comorbidities in Taiwan also face increased risk of severe COVID-19, adding further demand on hospitals and prolonging recovery and time off work. The health gap between indigenous and non-indigenous Taiwanese peoples continues to expand, largely because of high rates of chronic illness among this group and barriers to care.

Together, these key vulnerable cohorts will likely bear ~50% of the combined direct and indirect costs of COVID-19 on Taiwan's economy under a base case scenario. This will be an important factor for policymakers to consider as they look to bolster support mechanisms and access to health services as part of their future response to COVID-19.

63. Kang R. HKTDC Research [Internet]. Taiwan's Tourism Sector Readies Itself for Visitor Spike as Borders Re-Open. 2022 Oct 14. Available from: https://research.hktdc.com/en/article/MTE4NDYxMjg5Ng
64. Calculated based on age distribution of respiratory diseases. Statistics on the total number of outpatient and inpatient visits. 2021NHI Statistics on Taiwan Healthcare [Internet]. 2022 Dec.

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

Fortunately, a range of countermeasures remains available to mitigate the economic costs of the disease. These can be categorized as community measures (including contact tracing, quarantine, isolation, and other infection control), 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 to 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 Taiwan 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 fresh 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, which became available in Taiwan at the beginning of 2022, have the potential to further curb the economic impact of COVID-19 by helping to reduce the disease burden. There may also be an opportunity to broaden the use of therapeutics, given that the cost of medications (such as oral antivirals, TWD ~13 billion p.a.) equate to 6% of total economic costs, representing a small investment towards partially reducing a large burden of direct and indirect costs. With Taiwan now accepting COVID-19 as endemic along with the rest of the world, there is opportunity for reducing the severity of its symptoms and thereby softening its blow to productivity.

As has been described, the costs of the pandemic on Taiwan are substantial and wide-ranging, but 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 the continuing pandemic, ensuring that their population and economy are adequately prepared for all eventualities.

Appendix: Assumptions

Taiwan

Exhibit A1: Key overall assumptions

3rd Level	4th/5th Level	Value	Source	Commentary
Total economic costs of COVID-19	Total annual COVID-19 infections	19,809,716	The Institute for Health Metrics and Evaluation (IHME) (released November 18, 2022)	• August 2022 annualized • Note: IFR ratio is 0.06% (2x that of Australia). IHME corrects to ensure reported deaths reflect actual deaths due to COVID-19
	Total COVID-19 cases	8,628,255		
	Total COVID-19 deaths	11,844		

Exhibit A2: Key direct cost assumptions

3rd Level	4th/5th Level	Parameter Name	Value	Source	Commentary
Inpatient		Hospitalization rate	0.39%	• Institute for Health Metrics and Evaluation	• Oct 2022 hospitalizations / total # infections
		Number of admissions	77,258	• Calculation	• Total infections (~19.8m) 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	11 days	• NHI Annual Statistical Report, 2021	• Average LOS in public hospitals in 2021
		Ward bed day cost	NT$9,308	• NHI Annual Statistical Report, 2021	• Cost of total stay divided by average length of stay for public hospitals; includes co-payment
	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	7 days	• NHI Annual Statistical Report 2021	• Average ICU LOS in public hospitals in 2021
		ICU bed day cost	NT$11,243	• Taipei Veterans General Hospital	• Average ICU bed day cost in 2021; includes co-payment
	Severe (cont.)	Proportion of ICU admissions requiring subacute care	50%	• Institute for Health Metrics and Evaluation	• Modelled number of required ICU beds as proportion of required hospital beds
		Subacute length of stay	24 days	• NHI Annual Statistical Report 2021	• Average LOS for all subacute respiratory admissions = 24 days
		Subacute bed day cost	NT$10,243	• Taipei Veterans General Hospital • NHI Annual Statistical Report 2021	• Mid-point between ward and ICU bed day costs, reflecting same ratio as comparable markets; includes co-payment

Exhibit A2: Key direct cost assumptions (continued)

3rd Level	4th/5th Level	Parameter Name	Value	Source	Commentary
Outpatient	Acute	Number of acute outpatient infections	19,732,458	Calculation	• Total infections (~19.8 mn) minus number of hospital admissions
		Number of visits to the ECU per 1,000 infections (~500 reported infections)	1	Taiwan NHI; Australian Institute of Health and Welfare report on the impact of COVID-19 on 2020 emergency department activity	• Taiwanese data triangulated with Australian data; frequency of ED use is roughly equivalent
		Number of ECU visits per year for COVID	20,900	Calculation	• Number of acute outpatient infections multiplied by (~1/1000)
		Cost per Emergency Department visit	NT$4,314	NHI	• Includes cost to NHI (~70%) and co-payment (~30%)
		Proportion of total infections that visit a primary care clinic	3-12%	Journal of Primary Care and Community Health Calculation based on known volumes of OAV prescriptions	• Study of visits to ~1,200 primary care centers across the US in 2020 for treatment of COVID illness; divided by number of infections
		Cost per Clinic visit	NT$1,347	NHI	• Includes cost to NHI (~55%) and co-payment (~45%)
		Proportion of infections prescribed OAV	3.3%	Internal MSD - Taiwan team	• Calculated using known Lagevrio prescription volume and market share
		Number of infections prescribed medication	657,091	Calculation	• Number of acute outpatient infections multiplied by 3.3%

Exhibit A2: Key direct cost assumptions (continued)

3rd Level	4th/5th Level	Parameter Name	Value	Source	Commentary
Outpatient	Chronic	Incidence of Long COVID	5%	• Australian National University Evidence from the COVID-19 Impact Monitoring Survey Series, August 2022	• Taiwan-specific data not available; gives estimate of Long COVID incidence in comparable markets of ~5%; implies ~1m annual cases
				• South Korean Long COVID study published in BMC Infectious Diseases	• Gives further estimate of Long COVID incidence of 5% in comparable market
		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	Infected working-age		67%	• National Centre for High Performance Computing (NCHC) COVID-19 Global Epidemic Map (2021)	• Proportion of cases assumed as proxy for proportion of infections (2021 represents period of more frequent testing / detection) • Similar to Australia and South Korea
	Pediatric carers		21%		
	Elderly		12%		
Cross-cutting assumptions	Acute illness		100%		• Assume all COVID-19 infections experience short-term 'illness' which can be symptomatic or asymptomatic
	Long COVID		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
	Persistently asymptomatic		25%	• Magnitude of asymptomatic COVID-19 cases throughout the course of infection: A systematic review and meta-analysis (2021)	• March 2021 Systemic Review - 6071 cases, weighted pooled proportion of asymptomatic cases throughout course of infection was 25% (95% CI)
	Detected		44%	• The Institute for Health Metrics and Evaluation (IHME) (released November 18, 2022)	• Calculated based on cases divided by total infections
	Proportion of people who will isolate for fulltime period (5 days)		100%		• Assume 100% adherence to national mandate of 5-day isolation period (if detected and/or symptomatic)
Specific to working-age and elderly	Acute - well enough to work	Proportion of acute infections well enough to work	99.6%	• The Institute for Health Metrics and Evaluation (IHME)	• Modelled based on infection to hospitalization rate for August 2022 – 0.4% • Note: Taiwan has no HITH / home care

Exhibit A3: Key indirect cost assumptions (continued)

Parameter			Value	Source	Commentary
Specific to working-age and elderly	Acute - well enough to work	Proportion of people who can work from home	63%	• Taipei Times – poll of 1,210 employees (2022)	• ~63% of employees said they had experience working from home
		Duration of acute illness	12 days	• Medline (2022)	• 10-14 days for mild to moderate illness
		Average # of days taken as sick leave from work	2.4 days	• Health Awards Survey (2018) via Yahoo • Expedia 'Global Vacation Deprivation Report' (2020)	• In the 2018 Health Awards Survey, 42% of people have taken sick leave within a year, and the average number of days off is 2.4 days • This is 20% less than the ~3 days cited for Australia (and other markets) • According to Expedia's "2020 Global Vacation Deprivation Report", workers around the world took an average of 21.9 days off in 2019, while Taiwan ranked last in the world with only 14 days (30% less)
		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.
	Acute – too ill to work	Duration of acute debilitating (inpatient) illness	14.35 days	• See direct cost length of stay assumptions	• 11 days on ward (95%) and (5% severe) 18 ICU + Ward stepdown + 12 subacute (50% of severe for 24 days) = weighted average of ~11.95 days. • + Recovery time at home (off work) assumed to be ~2.4 days (same as outpatient) = ~14.35 days
	Long COVID – well enough to work	Average # of days taken as sick leave from work	7.2 days		• Based on same logic for acute illness, the number of days taken as sick leave has been reduced by 20% compared to the assumption made for Australia (~9 days / 10% of long COVID illness duration)

Exhibit A3: Key indirect cost assumptions (continued)

Parameter		Value	Source	Commentary
Specific to elderly	Proportion of elderly receiving / requiring care from a non-health professional working-age adult	98.5%	• National Development Council • National Statistics Survey (2020)	• ~1.5% (52,244) of total 65+ population live in institutions - nursing home and long-term care centers and therefore don't require full-time care form working-age adult while ill • Compared to 5% in Australia
	Proportion of elderly providing childcare while parents work	20%	• Impact of Caring for Grandchildren on the Health of Grandparents in Taiwan (2013)	• 79.7% of surveyed grandparents were non caregiver and the remaining 20.3% caregivers in MG, SG or NR households
	Proportion of elderly participating in the workforce	10%	• National Statistics Republic (2022)	• Average for 2022
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 • 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 p proxy and applicable across markets due to limited availability of data • 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)


MSD
INVENTING FOR LIFE