

# Years of life lost due to COVID-19 and other causes of death in Australia, 2019-2022

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## Research Article

**Keywords:**

**Posted Date:** May 20th, 2024

**DOI:** <https://doi.org/10.21203/rs.3.rs-4315896/v1>

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**Additional Declarations:** No competing interests reported.

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# Abstract

## Background

Years of life lost (YLL) is a measure of fatal burden, quantifying the toll associated with premature death. YLL is an important and useful metric for assessing the mortality impacts of the COVID-19 pandemic. In this study, we calculated the fatal burden associated with COVID-19 and other causes of death in Australia from 2019 to 2022.

## Methods

The analysis was conducted using demographic and death data contained within the Person Level Integrated Data Asset. The study population included all deaths which occurred between 2019 to 2022 in Australia that were received and registered by the Australian Bureau of Statistic (ABS) by 31 March 2023. We calculated YLL using the 2019–2021 Australian life tables published by the ABS, which provided more contemporary single-age and gender breakdowns of aspirational life expectancy than standard reference life tables found in the Global Burden of Disease studies.

## Results

Between 2019 and 2022, the fatal burden in Australia increased from an age-standardised YLL of 74.14 per 1,000 population in 2019 to 80.88 per 1,000 population in 2022, an increase of 9.1%. However, this increase was not linear, with a slight decrease observed in 2020, followed by a rise to baseline in 2021 and a continued increase in 2022. Throughout the four-year period, the YLL per 1,000 population in males was consistently around 1.5 times that observed for females, though females experienced a higher proportional increase in total fatal burden between 2019 and 2022 (10.1% in females compared to 8.8% in males). Fatal burden from COVID-19 increased considerably between 2020 to 2022. In 2022, based on age-standardised YLL per death, COVID-19 was the third leading cause of fatal burden in Australia, following cerebrovascular diseases and 'other cardiac conditions' (cardiac disease that is not coronary artery disease). The only conditions which showed a reduction in fatal burden in 2022 compared to 2019 were influenza and pneumonia and chronic lower respiratory diseases.

## Conclusions

Our findings contribute to improving our understanding of the mortality impacts of the COVID-19 pandemic in Australia and how these have evolved over time. The results highlight areas of health where COVID-19 has had a disproportionate impact, which can support the implementation of more targeted and nuanced public health measures.

# Introduction

The COVID-19 pandemic has had a profound impact on global health, causing significant disruption to communities and loss of life around the world. In the four years since the start of the pandemic in 2020 through to 14 January 2024, there have been more than 11 million cases and more than 24,000 COVID-19 associated deaths reported nationally [1]. Beyond the immediate toll of COVID-19 associated deaths, it is important to consider the broader impacts on population health including the years of life lost (YLL) as a measure of fatal burden and premature mortality.

As estimates of YLL account for both the frequency of deaths and the age at which they occur, YLL can be used to quantify social and economic loss owing to premature death [2]. It is arguably an improved measure on the impact of the pandemic than crude death tolls, accounting for the greater impact of deaths at younger ages on the health of a population [3]. When the methods used are consistent, it also facilitates comparisons of outcomes across domestic and international regions and over time. Higher YLL can result from deaths of younger people, a higher number of overall deaths, or a combination of these two factors [4]. Knowing which risk factors and health conditions contribute most heavily to YLL can help understand their relationships and guide targeted public health interventions.

Several studies have examined the fatal burden experienced by different countries during the pandemic, noting that differences in methods across these studies may yield differences in the estimated YLL. In the United States, there was an estimated 9.7 million YLL due to COVID-19 in the first two years of the pandemic [5]. In England and Wales, during the first year of the pandemic, between 7 March and 25 December 2020, there was an estimated 763,550 excess YLL, representing a 15% increase in YLL compared to the equivalent period in 2019 [6]. This pattern of higher YLL during the pandemic is consistent across many other countries, with a total of 20.5 million YLL due to COVID-19 estimated across 81 countries during the first year of the pandemic [7].

As was the trend globally, most deaths associated with COVID-19 reported in Australia have been among older people [8, 9]. However, a considerable number of deaths have also occurred among younger people, particularly since the widespread increase in COVID-19 cases across Australia associated with the highly transmissible Omicron variant from late 2021 [10]. Aside from deaths due to COVID-19, disruption to health services may have resulted in increased burden due to other illnesses among the population. In line with the global experience, disruptions to Australian health care services as a result of the COVID-19 pandemic have resulted in delays to preventive care, care utilisation, diagnosis and treatment. Disruption to cancer-screening, chronic disease management, hospital treatment services and access to medications can widen inequalities in fatal burden – particularly for those with multi-morbidities – and contribute to significant immediate and delayed impacts on individual and health system outcomes [11–13].

Nevertheless, Australia's profile of fatal burden is likely to have differed significantly across pandemic years as well as in comparison to other countries. Australia's geographical isolation and swift implementation of public health and social measures (PHSM) meant that Australia experienced low

COVID-19 infections until late 2021 [14]. Gradual domestic and international border re-openings from December 2021, along with widespread circulation of the Omicron variant, resulted in substantial numbers of COVID-19 infections and deaths in Australia during 2022 [9]. As such, Australia's profile of fatal burden is expected to vary significantly across the pandemic years. Furthermore, prior to rising COVID-19 infections in 2022, there were high levels of vaccine-acquired immunity against COVID-19 in Australia with more than 90% of Australians aged 16 years and above having completed a primary course of immunisation as at 23 December 2021 [15]. This was in contrast with other high-income countries, which had relatively limited vaccine protection and PHSM earlier in the pandemic.

Despite the unique epidemiology of COVID-19 in Australia, the fatal burden over the course of the pandemic has not been evaluated. Additionally, few studies have quantified the impact of the COVID-19 pandemic on the fatal burden of non-COVID-19 diseases over time, notwithstanding the myriad of research demonstrating that those with multi-morbidities have been disproportionately negatively impacted [16, 17]. Finally, no studies have examined the effects of associated conditions – conditions which contributed to a death but were not themselves the underlying cause of death – on disease-specific fatal burden over time across the COVID-19 pandemic.

To address these gaps, we estimate YLL in Australia due to all causes, COVID-19, and specific conditions between 2019 to 2022 using linked administrative data. Owing to global evidence suggesting differences in the experience of fatal burden over the COVID-19 pandemic by sex [7], we also examine sex differences in YLL over time within the Australian context. Lastly, to better understand the risk factors associated with select conditions, we identify each condition's top three individual associated conditions or causes of death which, together with the condition, contribute to the highest YLL. Understanding these many-faceted impacts of the COVID-19 pandemic on fatal burden will allow policy makers and researchers to better evaluate Australia's experience over the pandemic and identify groups who continue to be adversely affected.

## Methods

### Study population and data source

The analysis was conducted using the Person-level Integrated Data Asset (PLIDA) maintained by the Australia Bureau of Statistics (ABS). Using a unique person-linkage spine, PLIDA securely links together Australia's population data over time at the person-level, combining information on individuals' health, education, social security, employment, migration, deaths and demographics.

For fact and cause of death, the study used deaths registrations data in PLIDA which contains the date of death as well as the associated and underlying causes of death coded according to the World Health Organization's International Classification of Diseases version 10 (ICD-10). The study population included all deaths which occurred between 1 January 2019 to 31 December 2022 in Australia that were

received and registered by the ABS by 31 March 2023. The selected conditions of interest along with their associated ICD-10 codes are presented in Supplementary Materials Table 1.

Instead of using the age at death described directly on the death registration data, we used a bespoke demographics data file in PLIDA which provided higher quality individual-level demographic information such as date of birth and sex. Using majority agreement, the combined demographics file synthesises information from multiple data sources including Medicare (Australia’s universal health insurance scheme), social security, taxation, deaths and Census to yield a “best option” for various demographic fields. Age at death was calculated using individual date of birth from the combined demographics file and date of death from the deaths data.

## Analysis

The study broadly adopted the approach used in the Australian Institute of Health and Welfare’s (AIHW) 2022 Australian Burden of Disease Study [18]. However, some modifications were made using the individual-level data available in PLIDA. For calculating YLL, the Australian Burden of Disease Study used the standard reference life tables found in the Global Burden of Disease (GBD) studies of 2010 and 2013 which assume the same aspirational life expectancy for both males and females [19]. As we were not primarily focused on generating world-wide comparative estimates of YLL, we used the most recent 2019–2021 Australian life tables published by the ABS which provided more contemporary single-age and gender breakdowns of aspirational life expectancy [20].

As the 2019–2021 Australian life tables only contain life expectancy data up to age 100, the aspirational life expectancies for ages greater than 100 years were assumed to be the same as those for age 100 years. The granularity afforded by single-age and sex allowed for a more detailed investigation into factors and conditions associated with high fatal burden. Importantly, since Australian life tables have lower aspirational life expectancies at all ages compared to GBD life tables, this study’s estimate of YLL will consistently be lower than those in the Australian Burden of Disease Study.

Total fatal burden in YLL was calculated as:

$$YLL = \sum_{a,s,i} D_{a,s,i} \times W_{a,s}$$

Where  $a$  represents age,  $i$  represents disease or cause of death and  $s$  represents sex.  $D_{a,s,i}$  represents the total number of deaths for sex  $s$  with disease  $i$  at age  $a$ .  $W_a$  represents the aspirational life expectancy for sex  $s$  at age  $a$ .  $\sum_{a,s,i}$  represents the sum across all ages, sexes and diseases.

The analysis included all deaths in Australia that occurred between 2019 to 2022. The fatal burden for the general population each year is expressed as YLL per 1,000 population using the Estimated Residential Population (ERP) as at 30 June each year. The ERP is Australia’s official measure of residential population derived from the Census, and modified according to registers of births, deaths,

and net overseas migration. It includes all people usually residing in the country regardless of nationality or citizenship [21].

The total YLL for a particular condition was calculated using the population whose underlying cause of death was that condition as identified through their death registration. The causes of death presented in this study were chosen in line with those published in the Provisional Mortality Statistics by the ABS, which are based on their status as leading causes of death in Australia, and the proportion of doctor certified deaths [22]. Where the prevalence of health conditions was unknown, fatal burden is expressed as YLL per death. Associated conditions were identified from individuals' associated causes of death as documented on their death registration. To assist with comparability of fatal burden across years and diseases, direct age-standardisation by five-year age groups up to 100 years and greater was performed. The 2001 ERP was used as the reference population, as recommended by the ABS [23].

This study was undertaken under the Australian Government's evaluation of the COVID-19 vaccination program and no ethics approvals were required. All data was de-identified and analytical outputs were modified according to PLIDA output rules to protect data privacy and reduce disclosure risk through re-identification [24]. All counts were perturbed randomly up or down to the nearest five. Cells with numbers lower than 10 were suppressed. As such, rows and columns may not sum up to the total provided. Data preparation and analyses were conducted using Python version 3.9.12.

## Results

Between 2019 and 2022, the total fatal burden of the Australian population increased by 10.0% from 2,157,130 YLL in 2019 to 2,372,260 in 2022 (Table 1). This change can also be expressed as an increase of 9.1% in age-standardised YLL (AS-YLL), from 74.14 per 1,000 population in 2019 to 80.88 per 1,000 population in 2022 (Fig. 1).

Table 1

Total YLL, count of deaths, population estimates, crude and age-standardised YLL per 1,000 population, Australia, 2019–2022

Statistics type	2019	2020	2021	2022
Total YLL	2,157,130	2,146,720	2,213,810	2,372,260
Count of deaths	161,480	160,410	169,570	187,065
ERP population	25,340,215	25,655,290	25,688,080	25,996,145
Crude YLL per 1,000 population	85.13	83.68	86.18	91.25
Age-standardised YLL per 1,000 population	74.14	73.81	75.79	80.88

Over the four-year study period, among those aged 0 to 17 years, there was an overall 28% decrease in YLL, from 11.50 YLL per 1,000 population in 2019 to 8.29 YLL per 1,000 population in 2022 (Supplementary Materials Table 2). YLL per 1,000 population remained relatively stable among those

aged 18 to 44 years. Among those aged 45 years and over, the initial decrease in fatal burden per 1,000 population in 2020 was followed by minor, sub-baseline rebounds in 2021 and a notable increase in 2022, beyond the pre-pandemic baselines in 2019. This increase was greatest among those aged 90 years and over where the YLL per 1,000 population in 2022 was 9.4% higher than 2019. Together, 63.9% and 67.3% of the total YLL in 2019 and 2022 respectively were attributable to deaths of individuals aged 60 years and over.

Males experienced higher total and per population fatal burden than females across all four years between 2019 to 2022 (Supplementary Materials Table 3). There was an increasing trend in fatal burden for both sexes over the pandemic. For males, the AS-YLL per 1,000 population increased from 88.3 in 2019 to 96.0 in 2022, representing an 8.8% increase. We observed a similar trend among females where the AS-YLL per 1,000 population from 60.3 in 2019 to 66.3 in 2022, representing a 10.1% increase (Fig. 2). While females experienced a higher proportional increase in fatal burden per population between 2019 and 2022 than males, YLL per population among males were consistently around 1.5 times those observed for females throughout the four-year period.

Among the selected conditions (Fig. 3), the five leading causes of fatal burden in 2019 were: other cardiac conditions (48.4 AS-YLL per death); influenza and pneumonia (48.3 AS-YLL per death); cancer (48.3 AS-YLL per death); cerebrovascular diseases (48.2 AS-YLL per death); and chronic lower respiratory diseases (48.1 AS-YLL per death). In 2022, cerebrovascular diseases (48.8 AS-YLL per death), other cardiac conditions (48.7 AS-YLL per death) and cancer (48.4 AS-YLL per death) remained in the top five. Influenza and pneumonia, and chronic lower respiratory were replaced by COVID-19 (48.5 AS-YLL per death) and all other causes (47.9 AS-YLL per death).

There was a considerable increase in the fatal burden per death from COVID-19 during the pandemic. In 2020, the AS-YLL per death from COVID-19 was 12.5 years. This increased to 32.7 years in 2021 and 48.5 years in 2022. Of the selected conditions, the only conditions which showed improvements in fatal burden per death over the pandemic were influenza and pneumonia (43.4 AS-YLL in 2022 vs. 48.3 AS-YLL in 2019) and chronic lower respiratory diseases (43.0 AS-YLL in 2022 vs. 48.1 AS-YLL in 2019). Refer to Supplementary Materials Table 4 for details on all selected conditions.

The top three conditions associated with COVID-19 deaths which contributed to the greatest fatal burden per death were influenza and pneumonia, other cardiac conditions, and chronic lower respiratory diseases. However, COVID-19 was not among the top three associated conditions with the highest fatal burden per death for influenza and pneumonia, other cardiac conditions, and chronic lower respiratory diseases. COVID-19 as an associated condition in deaths due to cancer, ischaemic heart diseases, diabetes and dementia contributed to high levels of fatal burden. Results for other selected causes of death and their associated conditions with the highest AS-YLL per death can be found in Supplementary Materials Table 5.

## Discussion



The total fatal burden among the Australian population increased from 74 AS-YLL per 1,000 population in 2019 to 81 AS-YLL per 1,000 population in 2022, representing an increase of 9% between 2019 and 2022. We observed the largest proportional increases in YLL among females and older age groups. Males consistently experienced 1.5 times the AS-YLL of females, and 67.3% of total YLL in 2022 were attributable to deaths from individuals aged 60 and over. The Australian experience presented here is comparable to the global experience where 60.8% of total YLL were attributable to deaths from individuals aged 55 years and over, and males on average lost 44% more years of life than females [7].

YLL due to COVID-19 increased steadily over the course of the pandemic, culminating in over 91,000 total YLL and 48.5 AS-YLL per death in 2022 compared to 7,230 total YLL and 12.5 AS-YLL per death in 2020. This is likely due to a considerable increase in the number of COVID-19 infections and COVID-19-associated deaths occurring in 2022 compared to earlier years. Australia experienced low levels of transmission in the first 18 months of pandemic, during which most cases were acquired overseas and any sustained levels of transmission primarily occurred in localised outbreaks in particular settings and geographic locations [14]. In late 2021, the high transmissibility of the Omicron variant led to unprecedented levels of local transmission in Australia, peaking at over 450,000 cases reported per week during the BA1 wave in January 2022 [25]. This wave was characterised by particularly high levels of transmission among young people. While the Omicron variant is not considered to be inherently more severe than the Delta variant, the sheer number of infections led to a higher number of COVID-19 associated deaths across all age groups in 2022 [9, 10].

During the first two years of the pandemic, there was an overall decrease in the fatal burden due to influenza and pneumonia, and chronic lower respiratory diseases. This may be explained by the drastic reduction in the incidence of influenza and other respiratory viruses in Australia across 2020 and 2021, which is likely attributable to closure of the international border and to COVID-19 PHSM such as mask wearing, social distancing and lockdowns [26, 27]. On the other hand, influenza and pneumonia and chronic lower respiratory diseases constitute two of the three associated conditions to COVID-19 which contribute to the highest fatal burden (Fig. 4), even though few deaths due to these two conditions had COVID-19 as an associated condition. When summing the number of deaths in 2020 and 2021 where influenza and pneumonia or chronic lower respiratory diseases was an underlying cause of death or an associated condition to a COVID-19 death, the result for each disease remains below their respective pre-pandemic baselines in 2019.

A main limitation of this study is the lack of adjustments for the impacts of comorbidities on COVID-19 and other deaths. It is well-documented that people with comorbidities experience higher risk of COVID-19 mortality [16, 17]. In this study, we adjusted for age using age standardisation which only partially accounts for comorbidities, recognising that older people typically have a higher number of underlying health conditions [28]. However, without explicit adjustment for comorbidities, our YLL estimates for COVID-19 may be inflated. Future studies should undertake more robust adjustments which considers the impact of comorbidities on the life expectancies for COVID-19 related deaths to provide a more accurate estimate of fatal burden associated with COVID-19. The identification of chronic health

conditions, particularly using administrative datasets as is available in Australia, is complex. There are proxies available such as medical service usage and medicine dispensing which can assist with the inference of underlying health conditions. However, these approaches face a range of challenges including multi-indications for medications and service use. Nevertheless, some international studies have modelled the impact of long-term health conditions on YLL for COVID-19 associated deaths [29]. Finally, while not necessarily a limitation, it is important to note that our study has an explicit focus on the Australian context with the use of Australia-specific life tables. Thus, care should be taken when comparing our results against international findings.

In Australia, as in many other countries, the pandemic had a disproportional impact on vulnerable populations. Future analyses of fatal burden can focus on high-risk cohorts including individuals residing in residential aged care homes, people living with a disability and First Nations people to better understand the drivers of disparities and disadvantages sustained by these groups [30–32]. In the same vein, analyses of fatal burden can also assist with the evaluation of COVID-19 policy responses in relation to a variety of priority cohorts. Additionally, further analyses can include COVID-19 vaccination status as cohorts of interest or as part of model adjustment. In Australia, during the initial stages of the COVID-19 vaccine rollout, a staggered approach was undertaken where elderly individuals and those with underlying medical conditions were prioritised for the primary course of vaccination, as well as booster doses [33]. While Australia currently has very high primary course vaccination coverage, above 95% among those aged 16 or greater, a smaller proportion received a booster dose in 2022 (72.4%) [34]. As at 10 May 2023, only a minority received a 2023 booster with the vast majority of the population having their last vaccination six or more months ago [35]. Numerous studies have demonstrated the waning effectiveness of COVID-19 vaccines against mortality over time, especially after six months [36–38]. Analysing fatal burden in relation to COVID-19 vaccination status, including time since last dose, can provide further evidence base for the importance of keeping “up-to-date” with COVID-19 vaccinations.

## Conclusion

As an alternative to mortality counts, YLL accounts for both the number of deaths and the age at which they occur, highlighting the disproportional societal impacts of deaths at younger ages. Thus, YLL provides a more robust measure of the impacts of the pandemic owing to premature death. We found that age-standardised YLL in Australia increased by 9.1% between 2019 and 2022, noting that this increase was not linear, with the fatal burden initially decreasing slightly in 2020 and subsequently increasing in 2021 and 2022. The initial increase observed in 2021 is likely due to the Delta wave of COVID-19 transmission (June to December 2021), which was the first significant level of transmission that occurred in Australia. While males consistently experienced around 1.5 times the YLL per 1,000 population compared to females, females experienced a greater proportional increase in YLL between 2019 and 2022. We also found that fatal burden due to COVID-19 increased considerably between 2020 and 2022 and became the third leading cause of fatal burden in 2022 (based on age-standardised YLL per death). Across the pandemic, influenza and pneumonia, and chronic lower respiratory diseases showed decreases in fatal burden compared to their respective 2019 pre-pandemic baselines, most

likely as a result of reduced infections from influenza and respiratory viruses due to implementation of COVID-19 public health and social measures. COVID-19 contributed to high levels of fatal burden as an associated cause of death to deaths from cancer, ischaemic heart diseases, diabetes and dementia. Our results highlight the ongoing need for effective public health responses to COVID-19. A deeper understanding of fatal burden over the pandemic across the many facets of health can help policymakers and researchers identify areas of continued disadvantage and formulate strategies to address these disparities.

## **Declarations**

## **Ethics approval and consent to participate**

This study was undertaken under the Australian Government's evaluation of the COVID-19 vaccination program and no ethics approvals were required. No participants were recruited for this study and all the data used was de-identified, primarily collected for government services administration. It was therefore not feasible to seek individual consent, nor to inform participants about the use of data in this study.

## **Consent for publication**

No participants were recruited for this study and all the data used was de-identified, primarily collected for government services administration. It was therefore not feasible to seek individual consent, nor to inform participants about the use of data in this study.

## **Availability of data and materials**

The data underlying the results presented in the study are from the Person Level Integrated Data Asset (PLIDA). Data from PLIDA are available for approved projects: <https://www.abs.gov.au/about/data-services/data-integration/access-and-services>

## **Competing interests**

None.

## **Funding**

The authors received no specific funding for this work.

## **Authors' contributions**

Conceptualisation of the study: PMK, PG, KJ, CS. Conceptualisation of the manuscript: AFI, AL, BH, CS. Formal analysis: AL. Project administration: AFI, AL, BH, CS. Interpretation of data: AFI, AL, BH, CS, GMH, MA. Writing – original draft: AFI, AL, BH, CS, GMH, MA. Writing – review and editing: AFI, AL, BH, CS, GMH, MA, MDK, KJ, PMK, PG. All authors read and approved the final manuscript.

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## Figures

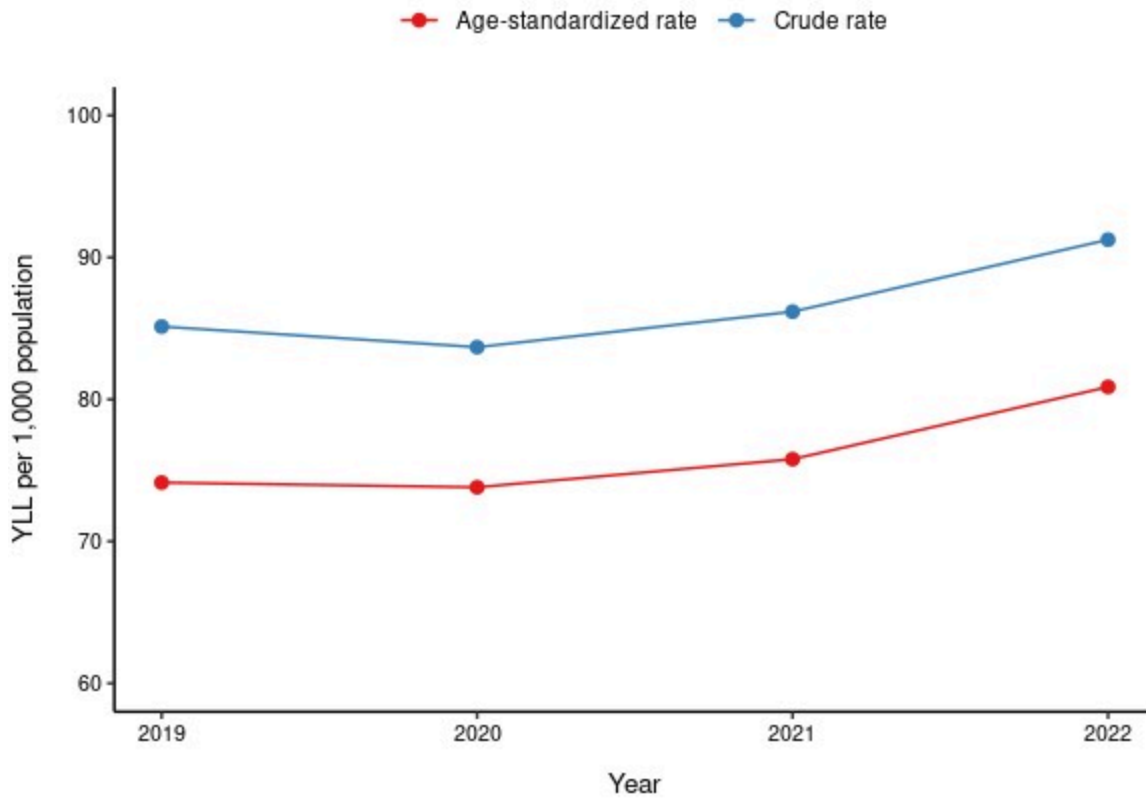


Figure 1

Crude and age-standardised YLL per 1,000 population, Australia, 2019-2022

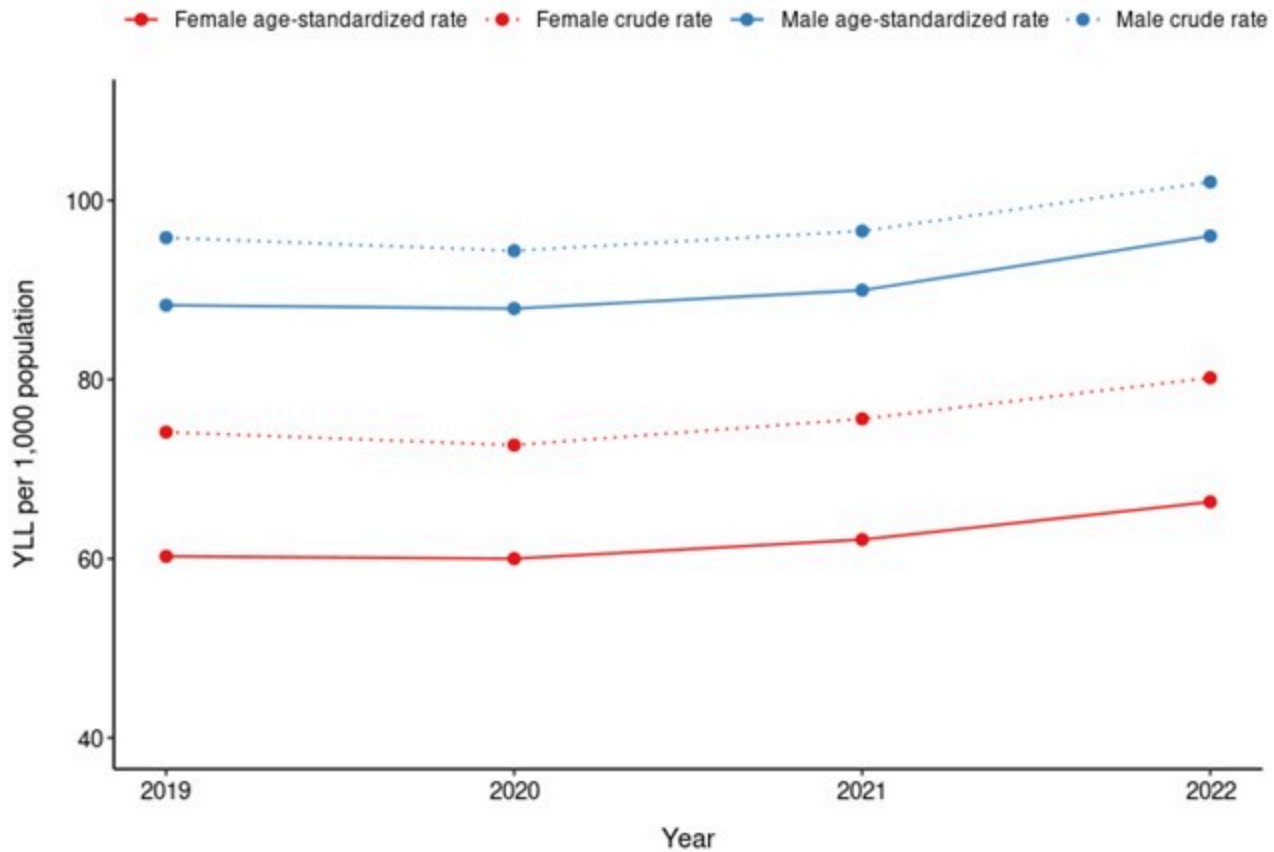


Figure 2

Crude and age-standardised YLL per 1,000 population by sex, Australia, 2019-2022

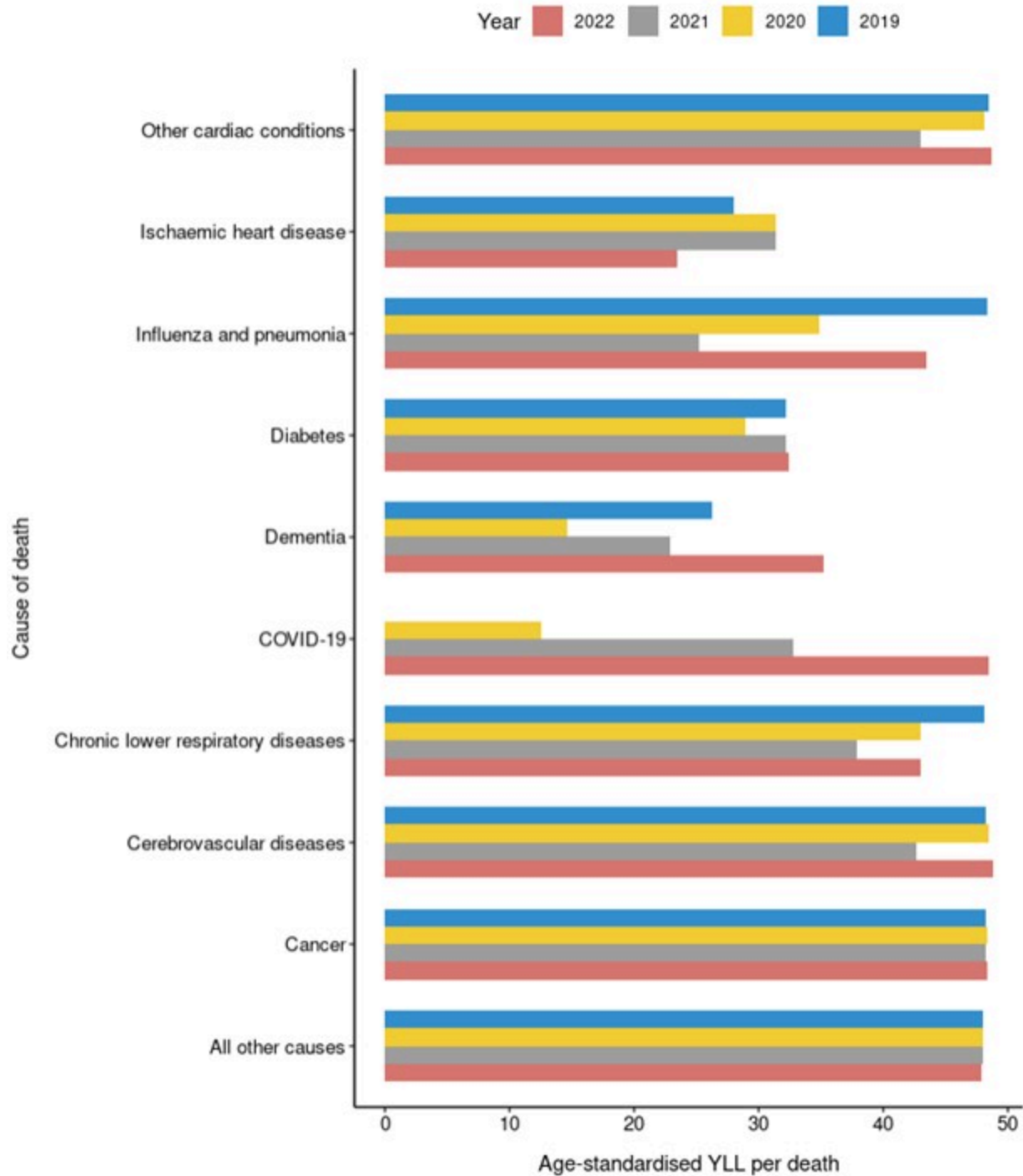


Figure 3

Age-standardised YLL per death by underlying cause of death, Australia, 2019-2022



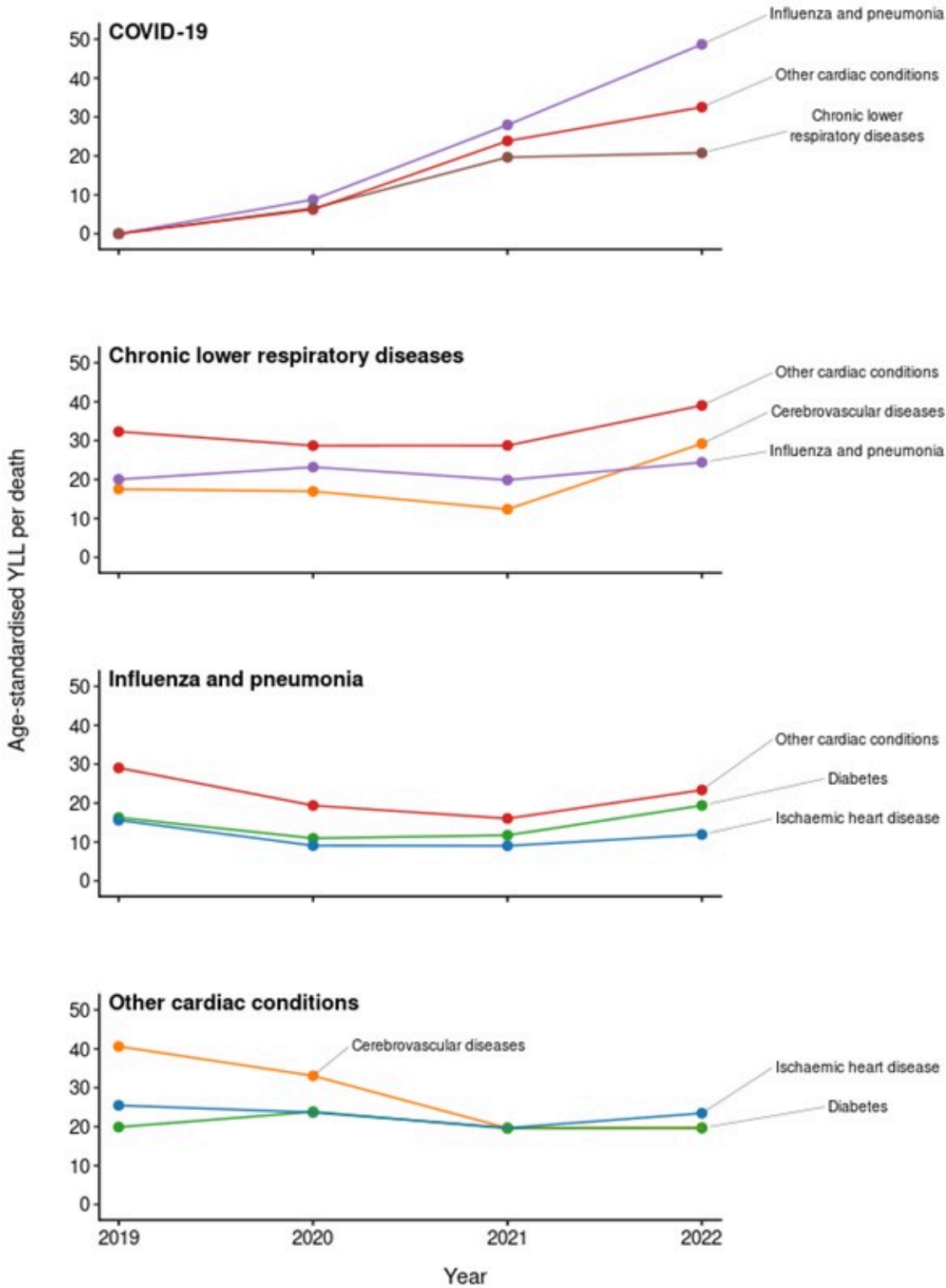


Figure 4

Age-standardised YLL per death by cause of death and its top three associated conditions, Australia, 2019-2022

## Supplementary Files

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- [YearsoflifelostinAustralia20192022SupplementaryMaterialsfinalforsubmissionApril2024.docx](#)