

Original Article

# Gallbladder-associated hospital admission and cholecystectomy rates across Australia and Aotearoa New Zealand (2004–2019): Are we over-intervening?

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**Backgrounds/Aims:** To investigate if the increase in the number of cholecystectomies is proportional to symptomatic gallbladder-associated hospital admissions in Australia and Aotearoa New Zealand (NZ).

**Methods:** National healthcare registries were used to obtain data on all episodes of cholecystectomies and hospital admissions for patients  $\geq 15$  years from public and private hospitals.

**Results:** Between 2004 and 2019, in Australia, there have been 1,074,747 hospital admissions and 779,917 cholecystectomies, 715,462 (91.7%) of which were laparoscopic, and 163,084 admissions and 98,294 cholecystectomies in NZ. The 15–54 years age group saw an increase in operative rates, +4.0% in Australia and +6.6% in NZ, and admissions, +3.7% and +5.8%, respectively. Hospital admissions decreased by –9.8% in Australia but the proportion of patients undergoing intervention increased by 10.8% (from 67.1% to 75.0% of hospital admissions). Procedural rates increased by +7.3% in NZ with no change in the intervention rate.

**Conclusions:** In Australia, there has been a decline in symptomatic gallbladder-associated hospital admissions and a rise in intervention rate. Admissions and interventions have increased proportionally in NZ. There are higher rates of cholecystectomy and admission amongst younger demographics, compared to historical cohorts. Future research should focus on identifying risk factors for increased disease and operative rates amongst younger populations.

**Key Words:** Gallbladder; Cholelithiasis; Cholecystectomy; Australia; New Zealand

## INTRODUCTION

Gallbladder disease disproportionately affects western nations [1] and accounts for a large proportion of healthcare burden and expenditure in these countries. In Australia, approxi-

mately A\$320 million was spent on gallbladder disease in 2019 alone [2]. Whilst the rates of laparoscopic cholecystectomy (LC) markedly increased soon after its introduction in Australia [3–5] and Aotearoa New Zealand (NZ) in 1990 [6] and 1991 [7] respectively, so far, there is no contemporary literature on this increase in respect to gallbladder-associated disease. Similarly, whilst there is a reported increase in cholecystectomy rates internationally [8–11], currently, there is no recent literature that has explored this in relation to the epidemiology of symptomatic gallbladder disease.

The operative and diagnostic incidence of symptomatic gallbladder disease also appear dichotomous in Australia and NZ. These two nations account for 71% of the total Oceanic population and share similar population characteristics in regards to age structure, presence of large minority indigenous popu-

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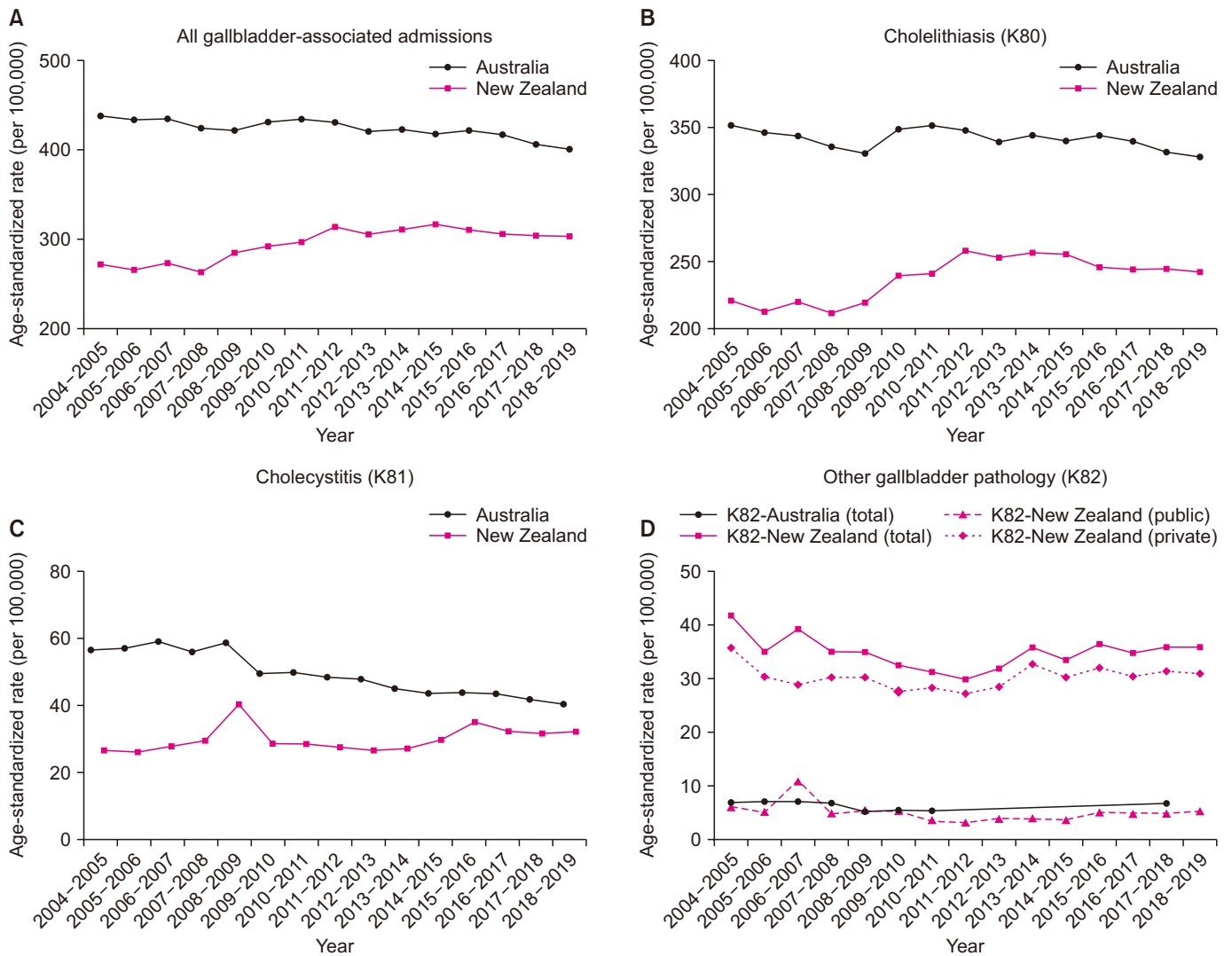
lations (Aboriginal and Torres Strait Islanders [ATSI] in Australia and Māori in NZ), body mass index (BMI) distributions, and universal healthcare coverage [12,13].

In this study, we aimed to describe the temporal trends in cholecystectomy and gallbladder-associated disease rates across Australia and NZ at a population level by analyzing data from public registry databases. We hypothesized that operative rates may have exceeded disease rates disproportionately over time. This study would be useful for both the surgeon to understand contemporary operative and admission trends, and provide the public healthcare practitioner with a snapshot of the at-risk populations for a disease with a significant healthcare burden.

## MATERIALS AND METHODS

We obtained data from national healthcare registries in Australia (Australian Institute of Health and Welfare [AIHW] [14]) and NZ (Ministry of Health New Zealand [MHNZ] [15]). We examined the incidence of cholecystectomy and symptomatic, benign, gallbladder-associated hospital admissions in Australia and NZ. The study included patients  $\geq 15$  years in both public and private healthcare institutions, from 2004 to 2019. While we aimed to include only adults (*i.e.*,  $\geq 18$  years) patients, this was not possible due to the nature of healthcare episodes- and population reporting at five-year intervals.

International Classification of Disease (tenth edition) (ICD-10) diagnostic codes (Supplementary Table 1) were used to determine the rates of gallbladder-associated hospital admissions.



**Fig. 1.** Hospital admissions due to gallbladder-associated disease in Australia and New Zealand per 100,000 age-standardized population  $\geq 15$  years old. (A) Combined gallbladder-associated admissions (ICD-10 Code K80 + K81 + K82), (B) cholelithiasis (ICD-10 Code K80), (C) cholecystitis (ICD-10 Code K81), and (D) other diseases of the gallbladder (ICD-10 Code K82) including New Zealand public and private sector data.

This included cholelithiasis (K80), cholecystitis (K81), and other diseases of the gallbladder (K82). K82 was analyzed separately due to suspected inconsistency in the NZ private sector. Biliary acute pancreatitis (K85.1) was excluded from analysis as NZ databases reported only '3-digit' ICD-10 codes rather than '4-digit' codes. Total cholecystectomies were reported by both the AIHW and MHNZ but 'open' or 'laparoscopic' differentiation was only reported by the AIHW. AIHW reported data from private and public hospitals collectively and not separately, unlike the MHNZ. Intervention rate was calculated by comparing the number of admissions with that of cholecystectomies providing a crude estimate of the percentage of admitted patients undergoing intervention.

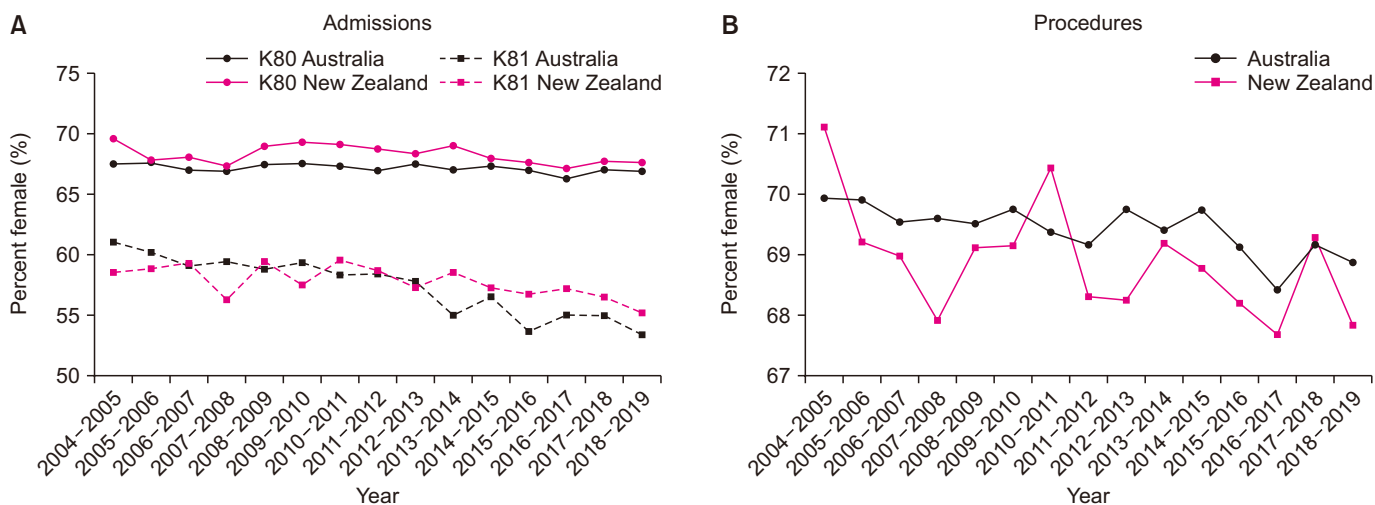
### Statistical analysis

Annual population estimates by sex and age were obtained from the Australian Bureau of Statistics [16] and Statistics New Zealand [17]. Patients were separated into eight age brackets (15–24, 25–34, 35–44, 45–54, 55–64, 65–74, 75–84, and  $\geq 85$  years) to calculate direct age-standardized rates (ASRs) [18] per 100,000 persons using the 2001 population as the standard. Incidence is reported as per 100,000 age-standardized population  $\geq 15$  years old. To assess statistical significance for changing trends (increase, decrease, or stable) we utilized joinpoint regression analysis [19]. Significance was defined as a  $p$ -value  $< 0.05$ . Statistical analysis was completed using GraphPad Prism v8.4 (GraphPad Software Inc., San Diego, CA, USA) and Joinpoint Trend Analysis Software v4.9 (Statistical Research and Applications Branch; National Cancer Institute, Bethesda, MD, USA).

## RESULTS

Over 15 years (2004–2019) in Australia, there were 1,074,747 hospital admissions from symptomatic gallbladder-associated disease and 779,917 cholecystectomies, 715,462 (91.7%) of which were laparoscopic. Over the same time period, there were 163,084 admissions and 98,294 cholecystectomies in NZ. On a 15-year average, this equated to 197 cholecystectomies per 100,000 population in Australia compared to 118 per 100,000 in NZ. The estimated overall intervention rate of all gallbladder-associated admissions on a 15-year average in Australia was 72.6%, versus 60.3% in NZ.

Hospital admissions and cholecystectomy rates are presented in Supplementary Table 2. Over the last 15 years, symptomatic gallbladder admissions have decreased by  $-9.8\%$  in Australia and risen by  $+7.3\%$  in NZ (Fig. 1A). Cholelithiasis has remained the most common gallbladder-associated complaint in Australia and NZ, accounting for 931,300 (86.7%) of all admissions in Australia, and 127,774 (78.5%) in NZ. In Australia, there was an initial increase in cholelithiasis admissions between 2007 and 2011 before a steady decline, an overall  $-6.6\%$  reduction between 2004 and 2019 ( $p < 0.001$ ). Conversely, during the same period, rates increased by  $+9.7\%$  in NZ ( $p < 0.001$ ) (Fig. 1B). Cholecystitis was the second most prevalent diagnosis, representing 134,542 (12.5%) of admissions in Australia and 16,164 (10.0%) in NZ. Incidence declined markedly by  $-28.2\%$  in Australia ( $p < 0.001$ ) but rose by  $+21.4\%$  ( $p = 0.39$ ) in NZ. The rise in NZ was not statistically significant, suggesting that cholecystitis rates have remained stable (Fig. 1C). Females made up 67.5% of hospital admissions in Australia and 67.9% in NZ, on average, although this has slightly declined over time (Fig. 2A). In Australia, the largest decline was observed in females with cholecystitis by  $-15.4\%$  ( $p < 0.01$ ).



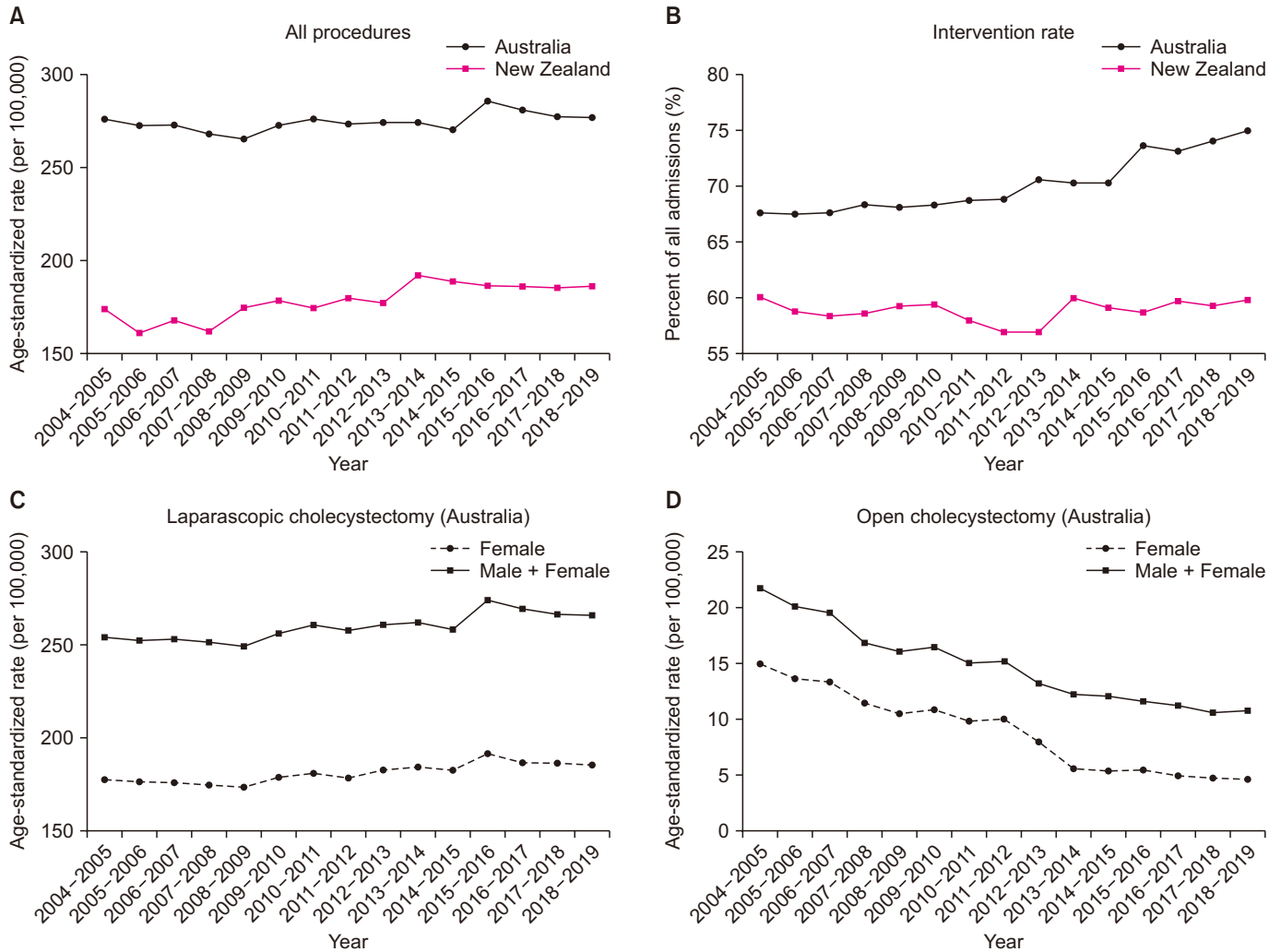
**Fig. 2.** The proportion of female patients being admitted or undergoing surgery in Australia and New Zealand. (A) Percentage of hospital admissions due to cholelithiasis (ICD-10 Code K80) or cholecystitis (ICD-10 Code K81) for female patients, and (B) percentage of cholecystectomies for female patients.

ICD-10 code K82, ‘other diseases of the biliary tract’, accounted for 0.83% of all hospital admissions in Australia until 2011 after which it was no longer recorded (except in 2018). Conversely, K82 accounted for 11.5% of admissions in NZ between 2004 and 2019. This variation arose primarily from coding in the NZ private sector which accounted for 85.4% of all K82 diagnoses in NZ (Fig. 1D). With NZ K82 private sector data excluded and only public sector data considered, K82 accounted for 1.9% of all hospital admissions in NZ (Australia 0.83%), cholelithiasis 87.1% (Australia 86.7%), and cholecystitis 11.0% (Australia 12.5%), more closely comparable to Australian data. Overall, K82 in the NZ public sector demonstrated no statistically significant change however, there was a -2.4% decline after 2006 in Australia ( $p = 0.028$ ).

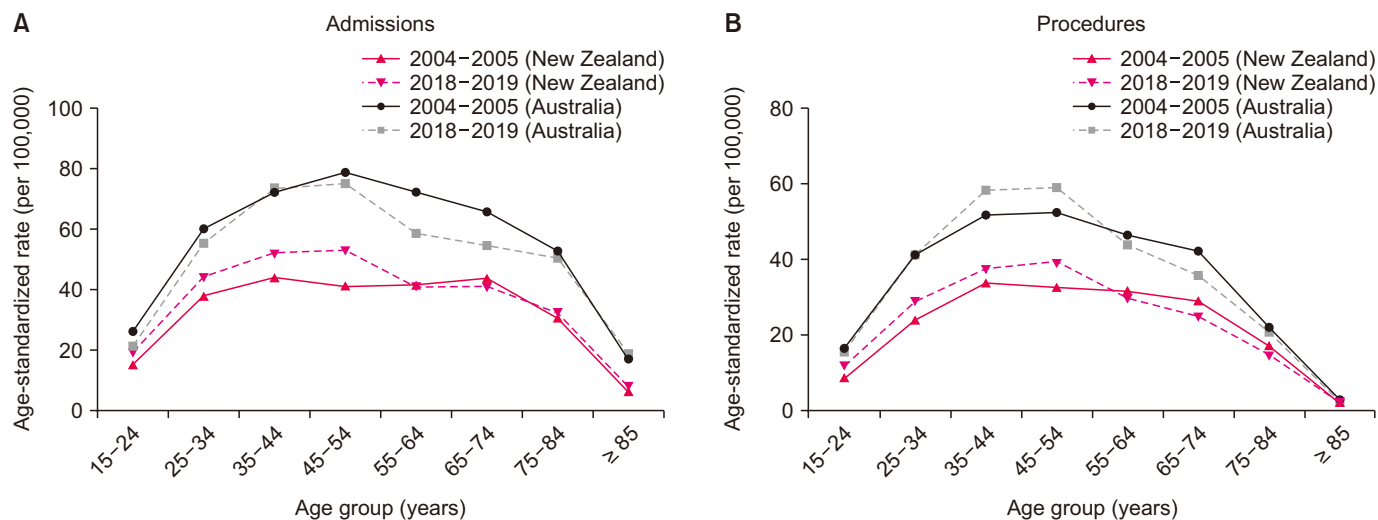
Despite a reduction in overall gallbladder-associated hospital admissions in Australia, operative rates have remained stable,

changing by +0.24% since 2004 (Fig. 3A). The estimated operative intervention (*i.e.*, the proportion of all gallbladder-associated hospital admissions receiving intervention) has increased from 67.7% to 75.0%, a 10.8% increase (Fig. 3B), over the last 15 years. Operative rates have steadily risen in NZ, by +6.8% (Fig. 3A), but the intervention rate has remained stable from 60.2% to 59.9%, a -0.30% change. Notably, in Australia, open cholecystectomies constituted 7.9% of procedures in 2004 and has since shrunk to 3.9% (Fig. 3D) with laparoscopic procedures in 2019 now making up 96.1% (Fig. 3C) of all procedures. On average, females made up 69.4% of cholecystectomies in Australia and 68.9% in NZ (Fig. 2B), slightly declining over time (Australia -1.3%, NZ -4.6%).

In both nations, the age demographic over the study period skewed towards younger patients undergoing hospital admission and subsequent surgical intervention when compared to



**Fig. 3.** All public and private inpatient cholecystectomy procedures per 100,000 age-standardised population ≥ 15 years old. (A) Combined procedure rates in Australia and New Zealand, (B) proportion of admitted patients undergoing intervention, *i.e.*, “intervention rate” for ICD-10 Code K80, K81, and Australian cholecystectomy rates by laparoscopic (C) and open procedures (D).



**Fig. 4.** Age demographics of patients per 100,000 age-standardized population  $\geq 15$  years old amongst two cohorts (2004–2005 and 2018–2019). (A) Admitted to hospital with gallbladder-associated disease (ICD-10 Code K80–82) and (B) undergoing cholecystectomy.

cohorts from 2004. Compared to this cohort, hospital admissions increased in the 15–54 years age group (+3.7% in Australia and +5.8% in NZ) and dropped in the 55–85 years age group (–4.1% in Australia, –5.9% in NZ). Both countries also demonstrated a slight increase in admissions amongst patients  $> 85$  years (+0.8% in Australia, +0.3% in NZ; Fig. 4A) over the 15-years study period. Operative rates in the 15–54 years age group also saw an increase (+4.0% in Australia and +6.6% in NZ) with a compensatory –3.0% drop in the 65–74 years age group in both countries (Fig. 4B).

## DISCUSSION

Our study has provided a temporal snapshot of the incidence of gallbladder-associated hospital admissions and cholecystectomy rates across Australia and NZ over the last 15 years. In particular, it has identified that whilst Australian gallbladder-associated hospital admissions have declined by 9.8% over the last 15 years, the proportion of patients undergoing intervention has increased by 10.8%. This is a trend that was not mirrored in NZ, which comparatively saw a 7.3% increase in hospital admissions with a proportional rise in the number of procedures, and a subsequent steady rise in intervention rate. Pertinently, the estimated operative rates in Australia were almost one-third higher compared to NZ (197 versus 118 per 100,000 population). Also of note is the progressive rise in the number of admissions and interventions in the younger age groups (15–54 years) in both Australia and NZ over the last 15 years.

The current study has identified a rise in the intervention rate in Australia, 67.7% to 75.0% of admissions between 2004 and 2019. It has long been established that cholecystectomy rates increased after the introduction of the LC [8–11] but it is

not yet clear if this increase was proportional to disease rates. This raises the question of whether we are over-intervening in Australia. Whilst this may be the case, the intervention rate reported in this study is only an estimate and is limited by the inability to link episodes of hospital admissions to an operative outcome using our databases. Further, it is probable, although not recently studied, that over time, there has been a preferential shift from inpatient to outpatient ambulatory cholecystectomy, particularly after ambulatory LC was first audited in Australia in 2001 [20]. Studies from the United States [21] and the United Kingdom [22] have suggested that the rate of ambulatory LC is between 79%–87% of all cholecystectomies. A growing model of outpatient care [23] may also be reflected in the overall drop in gallbladder-associated hospital admissions observed in our study in Australia over the last 15 years. Patient admissions due to both cholelithiasis and cholecystitis saw a significant decrease in Australia, whilst both have risen in NZ. The approximate 7% rise in admissions and intervention in NZ, without a change in the estimated intervention rate, could reflect practice differences between the two nations. What needs to be explored is whether shifting demographics and risk factors may explain these results, as we also observed a progressively younger population being admitted and undergoing an operation in both nations in our study.

In both Australia and NZ, there has been an observed increase in cholecystectomies and symptomatic gallbladder disease in the 15–54 years age group, with a resultant drop in the 55–85 years age groups. This may be related to the modern pervasiveness of stone risk factors such as obesity, lithogenic diet, metabolic syndrome, computed tomography scanning becoming ever-more commonplace, and improved hospital access [24] for those with symptomatic disease. Pertinently, obesity, a known risk factor for gallstones, has been increasing

among younger Australians since 1995 [25] and in NZ since at least 2004 [26]. The proportion of Australians considered 'overweight or obese' defined as a BMI  $\geq 25$  kg/m<sup>2</sup> has increased from 59.8% in 2000–2001 to 67.0% in 2017–2018 [27]. NZ has reported 34.3% of its overall population, and 50.8% of the Māori population, as obese [28]. This does not establish causality but associations between high rates of cholelithiasis and obesity have been reported in populations similar to those in our study [29]. A strong association between metabolically abnormal obesity and metabolic syndrome with the formation of gallstones has also been suggested [30]. Early-onset type 2 diabetes mellitus (T2DM) has increased in the Australian population from 3.3% to 4.4% over the 15-year study period [31]. In NZ, approximately 5% of the total population had T2DM with prevalence two to three times higher in adults aged 25–39 years of Māori descent [32]. Similarly, T2DM prevalence was 2.9 times higher amongst ATSI populations in Australia [31]. Despite the ATSI people only making up approximately 3% of the Australian population and the Māori people approximately 14% of the NZ population, they both share higher mortality, lower life expectancy, and higher rates of cancer (including gallbladder cancer [33] amongst ATSI) than the remaining population [34]. The Māori population also appears to be over-represented in cholelithiasis and cholecystectomy in the pediatric population [35]. Overall, surgical access continues to be a challenge for these minority indigenous populations [36,37].

There is also a potential relationship between gallbladder disease and high serum cholesterol levels. Previous literature has established that females are more likely to develop cholesterol gallstones than male, especially during their reproductive years, with the difference largely attributable to oestrogen increasing biliary cholesterol secretion [38]. Over our study period, the proportion of females who were admitted and had surgery remained consistently higher than that of males (between 67%–70%), despite a slight decline over time. In Australia, there is no clear evidence to suggest high serum cholesterol levels amongst younger populations, and levels seems to be stable since 2007, but it has been reported that obese adults are more than twice as likely to have high cholesterol [26,39] and similar findings have been reported in NZ [40]. Regardless, this suggests that there may be a causal link that warrants further investigation. The reduced cholelithiasis-related admissions in the older population could also be linked to the fact that cholesterol can be solubilized and replaced by calcium salts of carbonate, phosphate or bilirubinate with age [41], potentially resulting in less symptomatic disease. However, the chemical composition of stones from Australian or NZ patients has not been studied yet.

Of note was the high reporting of 'K82, other diseases of the gallbladder' in the NZ private sector compared to the NZ public sector, and Australian population. 'K82' diagnoses comprised 0.83% of all Australian admissions, compared to 11.5% in NZ, 85% of which were from the private sector. In NZ, K82

was first reported in 2003 where diagnoses remained relatively consistent in the public sector, 1.9% per year (compared to 0.83% in Australia) but high in the private sector, 10% per year. It is unclear why this is the case; we speculate that this difference may be due to disparities in compensation of K82 compared to other codes, or intricacies related to private health insurance claims in NZ. The healthcare systems in Australia and NZ are largely comparable with universal, public insurance for basic healthcare coverage, and private insurance that can be purchased by individuals as an add-on to public insurance [42]. Therefore, the reasons for these differences are speculative and no definitive publication could be found to substantiate these hypotheses. Simply, ICD-10 codes could be utilized differently in the Australian and NZ institutions or reported differently by the AIHW and MHNZ, in addition to procedural codes. Although we were unable to report on private hospital rates separately in our study, recent Australian data by Mui et al. [43] has done so. They noted 120 procedures per 100,000 in 2019 in the Australian private sector which would account for approximately 43% of total Australian cholecystectomies in 2019, compared to 23% in NZ. One possible reason for this difference may stem from the steady increase in cholecystitis diagnoses in NZ over time, which would presumably result in higher admissions or referrals to public centers with better emergency department access and acute level support. Further, the proportion of individuals with private hospital cover is higher in Australia, 46% compared to 33% [13] in NZ.

This study has provided the most recent and comprehensive overview of trends in gallbladder disease and cholecystectomy rates in Australia and NZ. However, our study should be considered in the context of the following limitations. We used hospital admission data as a surrogate marker for incidence of gallbladder disease which may under-report the overall, population-level incidence. Furthermore, we were unable to formally assess risk factors known to influence gallbladder disease including BMI, diabetes, serum cholesterol, smoking, ethnicity including indigenous status, and socio-economic status. Despite these limitations, our study provides a valuable perspective on the state of gallbladder disease and cholecystectomy in Australia and NZ, and lays a foundation for further epidemiological study into this field where contemporary literature is lacking. The use of the AIHW and MHNZ currently provides the best available insight into disease rate and intervention at a population level. The use of national databases in the assessment of gallbladder disease and cholecystectomy rates has also been previously validated in Australian [33], Canadian [9], and English [44] studies.

In conclusion, over the last 15 years, there has been a decline in gallbladder-associated hospital admissions in Australia and a subsequent increase in estimated intervention rate. NZ has seen a rise in both admissions and procedures with a stable intervention rate. Pertinently, there has been a shift in both admissions and interventions amongst the 15–54 years old, and

whilst females continue to contribute to the majority of admissions and interventions, this trend has been declining. The shifting incidence amongst younger Australian and NZ populations warrants further epidemiological investigation. Future research should focus on identifying risk factors contributing to increased disease and operative interventions amongst younger demographics.

## SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://doi.org/10.14701/ahbps.22-007>.

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## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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## AUTHOR CONTRIBUTIONS

Conceptualization: TM, KRQ. Data curation: TM, MC, HC. Methodology: TM, KRQ. Visualization: TM. Writing - original draft: TM. Writing - review & editing: All authors.

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