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Population estimates and characteristics of Australians potentially eligible for bariatric surgery: findings from the 2011–13 Australian Health Survey

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Abstract

Objective. The aim of the present study was to determine the potential demand for publicly and privately funded bariatric surgery in Australia.

Methods. Nationally representative data from the 2011–13 Australian Health Survey were used to estimate the numbers and characteristics of Australians meeting specific eligibility criteria as recommended in National Health and Medical Research Council guidelines for the management of overweight and obesity.

Results. Of the 3 352 037 adult Australians (aged 18–65 years) estimated to be obese in 2011–13, 882 441 (26.3%; 95% confidence interval (CI) 23.0–29.6) were potentially eligible for bariatric surgery (accounting for 6.2% (95% CI 5.4–7.1) of the adult population aged 18–65 years (n = 14 122 020)). Of these, 396 856 (45.0%; 95% CI 40.4–49.5) had Class 3 obesity (body mass index (BMI) $\geq$40 kg m^{-2}), 470 945 (53.4%; 95% CI 49.0–57.7) had Class 2 obesity (BMI 35–39.9 kg m^{-2}) with obesity-related comorbidities or risk factors and 14 640 (1.7%; 95% CI 0.6–2.7) had Class 1 obesity (BMI 30–34.9 kg m^{-2}) with poorly controlled type 2 diabetes and increased cardiovascular risk; 458 869 (52.0%; 95% CI 46.4–57.6) were female, 404 594 (45.8%; 95% CI 37.3–54.4) had no private health insurance and 309 983 (35.1%; 95% CI 28.8–41.4) resided outside a major city.

Conclusion. Even if only 5% of Australian adults estimated to be eligible for bariatric surgery sought this intervention, the demand, particularly in the public health system and outside major cities, would far outstrip current capacity. Better guidance on patient prioritisation and greater resourcing of public surgery are needed.

What is known about this topic? In the period 2011–13, 4 million Australian adults were estimated to be obese, with obesity disproportionately more prevalent in areas of socioeconomic disadvantage. Bariatric surgery is considered to be cost-effective and the most effective treatment for adults with obesity, but is mainly privately funded in Australia (>90%), with 16 650 primary privately funded procedures performed in 2015. The extent to which the supply of bariatric surgery is falling short of demand in Australia is unknown.

What does this paper add? The present study provides important information for health service planners. For the first time, population estimates and characteristics of those potentially eligible for bariatric surgery in Australia have been described based on the best available evidence, using categories that best approximate the national recommended eligibility criteria.

What are the implications for practitioners? Even if only 5% of those estimated to be potentially eligible for bariatric surgery in Australia sought a surgical pathway (44 122 of 882 441), the potential demand, particularly in the public health system and outside major cities, would still far outstrip current capacity, underscoring the immediate need for better guidance on patient prioritisation. The findings of the present study provide a strong signal that more funding of public surgery and other effective interventions to assist this population group are necessary.

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Introduction

Bariatric surgery is more effective than conservative interventions to treat resistant obesity and is considered cost-effective.[1–3] Generally, bariatric surgery is recommended for those with resistant Class 3 obesity (body mass index (BMI) $\geq$40 kg m^{-2}) or resistant Class 2 obesity (BMI 35–39.9 kg m^{-2}) and obesity-related comorbidities.[2,4,5] In recent national guidelines for obesity management,[2,5] bariatric surgery has also been recommended for consideration for those with resistant Class 1 obesity (BMI 30–34.9 kg m^{-2}) and type 2 diabetes mellitus (T2DM). This is because of accumulating evidence that metabolic health improves after surgery.[3,6]

As in many other countries, significant numbers of Australians are overweight or obese. Four million adult Australians, or 27.2% of the adult population, were estimated to be obese in 2011–12, up from 19.1% in 1995.[7] Although obesity is more prevalent in areas of socioeconomic disadvantage[7] and surgical outcomes appear comparable by funding type,[8–10] >90% of bariatric surgery in Australia is privately funded (16 650 primary privately funded procedures were performed in 2015[11]), a funding pattern that appears similar to that in other countries, such as Mexico and the United Arab Emirates.[12] Not all Australian jurisdictions provide publicly funded bariatric surgery and where it is available the waiting period can be prolonged.[13–15] Of additional concern is that the wait for bariatric surgery may be associated with declining health.[16] The extent to which supply is falling short of potential demand in Australia and in many countries is unknown.[17] In one Canadian study, 23% of patients in a publicly funded weight management program and who were deemed eligible for bariatric surgery expressed interest in pursuing a surgical pathway.[18] Many individual, social and environmental factors (e.g. a patient's health status, recommendations made by health professionals, exposure to other recipients of bariatric surgery) can influence a preference for surgery.[19]

The objectives of the present study were to use national population survey data from the 2011–13 Australian Health Survey (AHS)[20] to: (1) estimate the number of Australians potentially eligible for bariatric surgery; (2) describe their demographic characteristics, health status and health service use; and (3) estimate the potential demand for surgery in the public and private health systems.

Methods

Data were extracted from the cross-sectional 2011–13 AHS conducted by the Australian Bureau of Statistics (n = 31 837).[20] The survey used a stratified multistage area sample of private dwellings to ensure a nationally representative sample. The AHS comprised two main surveys: the National Health Survey (NHS) and the National Nutrition and Physical Activity Survey (NNPAS). Participants completed only one survey. Common to both surveys was a core component that included questions and measures of sociodemographic characteristics (e.g. sex, age, geographical location) and physical and health characteristics (e.g. measured height, weight, blood pressure, self-rated health, health conditions, smoking status).

Participants from either the NHS or NNPAS were invited to complete the National Health Measures Survey (NHMS). The NHMS collected blood and urine samples and tested for chronic disease biomarkers, including fasting plasma glucose, blood lipids, albumin, creatinine and alanine aminotransferase (ALT). The sample for the present study was drawn from the NHMS.[20] In addition, we conducted a subanalysis using a sample that had completed both the NHMS and NHS, enabling analysis of private health insurance status and health service use. Only those with complete measured height and weight data were included in our analyses. The structure, response rates and sample sizes of the AHS are summarised in Fig. 1. Further details on the AHS can be found in the user's guide.[21]

Eligibility for surgery

Participants were classified as potentially eligible for bariatric surgery based on survey data that best approximated the 2013 Australian criteria for considering bariatric surgery,[2] that is for adults (aged 18–65 years) with resistant Class 3 obesity (BMI $\geq$40 kg/m^2), or Class 2 obesity (BMI 35–39.9 kg/m^2) with at least one obesity-related comorbidity (at risk of a cardiovascular (CV) event or mortality, or experiencing hypertension, T2DM, chronic kidney disease, non-alcoholic steatohepatitis (NASH) or gastro-oesophageal reflux disease (GORD)), or Class 1 obesity with poorly controlled T2DM and increased CV risk. A summary of the variables and classification criteria is given in Table 1. Our classifications were limited by the data available within the AHS and did not cover the range of factors considered when making a clinical judgement about eligibility for surgery (e.g. classifying resistant obesity, patient preference). Consequently, we make reference to potential eligibility only. Bariatric surgery may be recommended for those outside of the 18–65 years age range,[9] but our analysis was based on Australian guidelines only.

Other variables included in the analysis were: (1) the index of relative socioeconomic disadvantage, which ranks geographical areas of residence according to their social and economic status; (2) remoteness area category based on the location of a participant's residence and classified as major city, inner regional or outer regional; (3) private health insurance status reported by participants; (4) self-rated health reported by participants as excellent, very good, good, fair or poor; and (5) health service

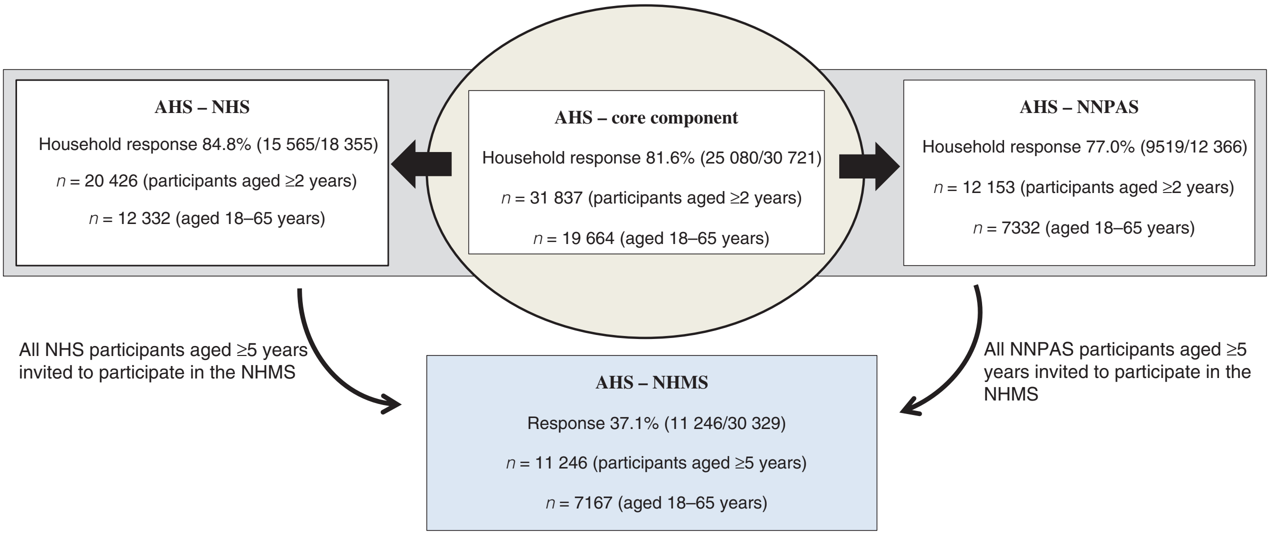

Fig. 1. Design of and response rates for the 2011–13 Australian Health Survey (AHS). AHS participants completed the National Health Survey (NHS) or the National Nutrition and Physical Activity Survey (NNPAS). The AHS core component was common to both surveys. Response proportions represent adequately or fully responding households, except for the National Health Measures Survey (NHMS) where the response proportion reflects the total number of participants relative to total number of participants in the core component of the AHS. The sample used in the present study was drawn from the NHMS. Adapted from the AHS users' guide.[21]

use reported by participants, including consultation with a general practitioner or specialist, having been admitted to hospital as an in-patient or visits to an emergency department or as an out-patient during the previous 2 weeks. Health service use and private health insurance status data were extracted from the NHS, whereas data for the remaining variables were extracted from the core component of the AHS (Fig. 1).

Statistical analysis

Summary data are presented as the mean for continuous variables and percentages for categorical variables. A weighted Poisson regression model was used to estimate associations with factors influencing health service use, including age, sex, socioeconomic status, remoteness area category and private health insurance. In all analyses, estimates were weighted with sampling weights provided by the ABS within the recommended survey weight module svr (N. Winter, Boston College Department of Economics, Chestnut Hill, MA, USA), and 95% confidence intervals (CIs) derived using replicate weights.[21]

Results

Population estimates were calculated based on a sample of 6804 adults (aged 18–65 years) with complete height and weight data who had completed the NHMS. Of the 3 352 037 Australians aged 18–65 years estimated to be obese, 882 441 (26.3%) were estimated to be potentially eligible for bariatric surgery. This was comprised mostly of those with Class 2 or 3 obesity (Table 2). There was variation between the states and territories: Queensland had the highest percentage of the population potentially eligible for bariatric surgery (7.5%) and Western Australia the lowest (5.1%; Table 3).

Table 4 compares the characteristics of those potentially eligible for bariatric surgery with those classified as ineligible for surgery, except for those potentially eligible with Class 1 obesity because of the small sample size ($n = 17$). Slightly more females were potentially eligible for surgery due to their higher prevalence of Class 3 obesity. Compared with the obese ineligible population, those in the potentially eligible population were more likely to be female, reside outside a major city, be of low socioeconomic position and rate their health as 'poor'. As a consequence of the selection criteria being dependent on comorbidity, those with Class 2 obesity potentially eligible for surgery had, on average, poorer obesity-related health and were older (by 4.9 years) than those with Class 3 obesity. Hypertension was the most common reason an individual with Class 2 obesity became potentially eligible for bariatric surgery. Potential eligibility for bariatric surgery was associated with more health service use independent of age, sex, remoteness area category, private health insurance and socioeconomic status (Table 5). As expected (due to the selection criteria), being potentially eligible for surgery with Class 2 obesity was associated with more medical appointments in the previous 2 weeks.

Of the total 882 441 Australians estimated to be potentially eligible for bariatric surgery, 45.8% (405 594) were without private health insurance (sample $n = 165$), of whom 54.5% (95% CI 42.5–66.6) were female. More of those potentially eligible for surgery (78.5%; 95% CI 69.5–87.4) reported that private health insurance was unaffordable than did the ineligible obese population (67.3%; 95% CI 60.0–74.5). Overall, the proportion of females and males potentially eligible for bariatric surgery with private health insurance was similar (48.9% female; 95% CI 38.6–59.1). However, there were differences between the sexes within the Class 2 and 3 obesity categories, in which the proportion of females with insurance was 39.3% (95% CI 25.4–53.2) and 67.3% (95% CI 54.5–80.0) respectively. Of

Table 1. Description of variables used to determine potential eligibility for bariatric surgery

ALT, alanine aminotransferase; ACR, albumin : creatinine ratio; AHS, Australian Health Survey; BMI, body mass index; BP, blood pressure; CKD, chronic kidney disease; Class 1 obesity, BMI 30–34.9 kg m^{-2}; Class 2 obesity, BMI 35–39.9 kg m^{-2}; Class 3 obesity, BMI $\geq$40 kg m^{-2}; CV, cardiovascular; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; HbA1c, Haemoglobin A1c; HDL-C, high-density lipoprotein cholesterol; HF, heart failure; N/A, not applicable; NASH, non-alcoholic steatohepatitis; NHS, National Health Survey; SBP, systolic blood pressure; T1DM, Type 1 diabetes mellitus; T2DM, Type 2 diabetes mellitus

Variable	Method[C] and description	Cut-off points used in the present study	Limitations
Age (years)	Self-reported	18–65	N/A
BMI (kg m^{-2})	Height measured with stadiometer in centimetres to one decimal point and repeated in 10% of randomly selected participants, and again if heights differed by >1 cm Weight measured once using digital scales recorded to nearest 100 g	Class 1 obesity, BMI 30–34.99 kg m^{-2} Class 2 obesity, BMI 35–39.99 kg m^{-2} Class 3 obesity, BMI $\geq$40 kg m^{-2}	Maximum weight limit of digital scales 150 kg No individuals in the sample weighing 150 kg were tall enough to be misclassified with Class 2 instead of Class 3 obesity Total no. with missing height or weight data excluded from our sample: 363
Class 1 obesity only[A]			
Poorly controlled T2DM	Included known diabetes defined as self-reported doctor- or nurse-diagnosed diabetes (T2DM or type unknown) and measured HbA1c $\geq$6.5 mmol/mol, or medicated for diabetes and measured HbA1c $\geq$6.5 mmol/mol; gestational diabetes excluded	HbA1c $\geq$6.5 mmol/mol	Diabetes was self-reported and may be prone to error Poorly controlled T2DM classified on the basis of a single high HbA1c, but clinically more results would be required Diabetes type 'unknown' classified as T2DM becauseit is unlikely that T1DM status would be unknown
Increased CV risk	CV risk score $\geq$15% calculated as per Australian guidelines[33] using Framingham risk equation Algorithm included age, diabetes (any type), HDL-C, sex, smoking status (current), SBP, total cholesterol[34] Participants with self-reported current and long-term angina, other ischaemic heart diseases, HF, other heart diseases, stroke or other cerebrovascular diseases also included Self-reported heart attack and oedema combined with HF were only available in the NHS and were included in the health insurance status subanalysis	5-year CV risk $\geq$15%	Limitations of diabetes and BP measures described below No data for quitting smoking in the past year as used in Framingham risk equation CV risk score affected by medications that were not reported in the core component of the AHS Possible self-report errors
Class 2 obesity only[B]			
At risk of CV event or mortality	Defined as per 'increased CV risk' above	5-year CV risk $\geq$15%	See 'increased CV risk'
CKD	Included participants with Stage 1–5 CKD (identified by combining measured eGFR with ACR) and those with self-reported current and long-term CKD	Stage 1–5: eGFR $\geq$90 mL min^{-1} 1.73 m^{-2} and albuminuria to eGFR <30 mL min^{-1} 1.73 m^{-2}	CKD classified on basis of single eGFR and ACR result; clinically, more results would be required Possible self-report errors
Hypertension (mmHg)	Automated BP machine used with three cuff sizes; preferred position seated, extended and relaxed left arm, forearm supinated Generally, two measures; second measure recorded in AHS output Another reading taken if the first and second readings differed by $\geq$10 mmHg; the average of the second and third reading then used unless difference $\geq$20 mmHg Invalid result recorded if all readings differed by $\geq$20 mmHg Participants with self-reported current and long-term high BP also included	SBP $\geq$140 mmHg or DBP $\geq$90 mmHg	Hypertension classified on the basis of a single elevated blood pressure reading; clinically, more results would be required Possible self-report errors

(*continued next page*)

Table 1. (*continued*)

Variable	Method[C] and description	Cut-off points used in the present study	Limitations
NASH	Measured abnormal ALT used as a surrogate indicator of NASH.	ALT >30 U/L for females and >40 U/L for males	NASH classified on basis of ALT results; clinically, more results would be required
T2DM	Included known diabetes defined as self-reported doctor- or nurse-diagnosed diabetes (T2DM or type unknown) or medicated for diabetes; and Included newly diagnosed diabetes (type undetermined) defined as HbA1c ≥6.5 mmol/mol and diabetes not previously diagnosed by doctor or nurse and no diabetes medication taken Gestational diabetes excluded	HbA1c ≥6.5 mmol/mol	Newly diagnosed diabetes classified as T2DM because unlikely the participant first diagnosed with T1DM through AHS and more than half of new T1DM cases diagnosed at <18 years[35] Newly diagnosed T2DM classified on the basis of a single high HbA1c, but clinically more results would be required Possible self-report errors

[A]Must have poorly controlled T2DM and increased CV risk to be potentially eligible for bariatric surgery.
[B]Must have one of the following obesity-related comorbidities to be potentially eligible for bariatric surgery.
[C]Blood samples taken at pathology centres or at home using standard protocols and analysed at a central laboratory using accredited equipment.

Table 2. Population estimates of adult Australians aged 18–65 years potentially eligible for bariatric surgery by obesity class; findings from the 2011–13 Australian Health Survey (AHS)

Eligibility criteria for bariatric surgery are as per National Health and Medical Research Council of Australia guidelines.[2] All estimates are for adults aged 18–65 years, with 95% confidence intervals in parentheses. Weights used for population estimates were determined by the Australian Bureau of Statistics at time of the survey in 2011–13.[20] The sample number refers to the size of the sample from which the estimates were made. Refer to Fig. 1 for the design of the AHS. Class 1 obesity, body mass index (BMI) 30–34.9 kg m^{-2}; Class 2 obesity, BMI 35–39.9 kg m^{-2}; Class 3 obesity, BMI ≥40 kg m^{-2}

	Total Australian population aged 18–65 years estimated to be potentially eligible for bariatric surgery	% Australian population aged 18–65 years (sample $n = 6804$; population estimate $n = 14\,122\,020$)	% Obese Australian population aged 18–65 years (sample $n = 1938$; population estimate $n = 335\,2037$)	% Total estimated to be potentially eligible for bariatric surgery
Eligible: all obesity classes (sample $n = 540$)	882 441	6.2 (5.4, 7.1)	26.3 (23.0, 29.6)	100.0
Eligible: Class 1 (sample $n = 17$)	14 640	0.1 (0.0, 0.2)	0.4 (0.2, 0.7)	1.7 (0.6, 2.7)
Eligible: Class 2 (sample $n = 286$)	470 945	3.3 (2.8, 3.8)	14.0 (12.1, 16.0)	53.4 (49.0, 57.7)
Eligible: Class 3 (sample $n = 237$)	396 856	2.8 (2.3, 3.3)	11.8 (9.8, 13.9)	45.0 (40.4, 49.5)

Table 3. Population estimates of adult Australians aged 18–65 years potentially eligible for bariatric surgery for each Australian jurisdiction; findings from the 2011–13 Australian Health Survey

Eligibility criteria for bariatric surgery are as per National Health and Medical Research Council of Australia guidelines.[2] All estimates are for adults aged 18–65 years with 95% confidence intervals (CIs) in parentheses. The sample number refers to the size of the sample from which the estimates were made

Australian state or territory	Total potentially eligible for bariatric surgery (sample n)	Total population aged 18–65 years	% Total population aged 18–65 years potentially eligible for bariatric surgery (95% CI)	Obese population aged 18–65 years (sample n)	% Obese population aged 18–65 years potentially eligible for bariatric surgery (95% CI)
Australian Capital Territory	18 568 (731)	250 252	7.4 (5.3, 9.5)	57 281 (193)	32.4 (25.5, 39.3)
New South Wales	280 524 (1148)	4 557 663	6.2 (4.5, 7.8)	1 081 415 (309)	25.9 (19.5, 32.4)
Northern Territory	8158 (526)	113 990	7.2 (4.7, 9.6)	25625 (103)	31.8 (20.7, 43.0)
Queensland	210 753 (1216)	2 823 636	7.5 (5.8, 9.1)	728 965 (341)	28.9 (23.7, 34.1)
South Australia	63 645 (889)	1 008 229	6.3 (4.7, 7.9)	265 642 (272)	24.0 (18.5, 29.4)
Tasmania	22 325 (806)	314 293	7.1 (5.0, 9.2)	83332 (226)	26.8 (20.5, 33.1)
Victoria	203 345 (963)	3 575 516	5.7 (3.9, 7.4)	725 697 (234)	28.0 (20.4, 35.6)
Western Australia	75 123 (988)	1 478 441	5.1 (3.6, 6.6)	384 081 (260)	19.6 (13.8, 25.3)

those potentially eligible for bariatric surgery with private health insurance (sample $n = 192$), 36.7% (95% CI 25.4–47.9) were of low socioeconomic position (at or below Quintile 2 (Q2), the most disadvantaged).

Sensitivity analysis

We assessed how sensitive our prevalence estimates were to possible misclassification of comorbidities for those with Class 2 obesity (see Table 1 for comorbidity definitions and their

Table 4. Characteristics of adult Australians aged 18–65 years potentially eligible for bariatric surgery; findings from the 2011–13 Australian Health Survey (AHS)

Eligibility criteria for bariatric surgery are as per National Health and Medical Research Council of Australia guidelines.[2] All estimates are for adults aged 18–65 years and, unless stated otherwise, show mean values with 95% confidence intervals in parentheses. Individuals with missing height or weight data are not included. The sample number refers to the size of the sample from which the estimates were made. Population estimates for Class 1 obesity were not reported because of low sample size. ALT, alanine aminotransferase; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; FPG, fasting plasma glucose; HbA1c, haemoglobin AIc

Characteristic	Potentially eligible for bariatric surgery			Ineligible for bariatric surgery	
	Class 2 (sample $n = 286$; population estimate $n = 470\,945$)	Class 3 (sample $n = 237$; population estimate $n = 396\,856$)	Total (sample $n = 540$; population estimate $n = 882\,441$)	All weight classes (sample $n = 6264$; population estimate $n = 13\,239\,579$)	Obese only (sample $n = 1398$; population estimate $n = 2\,469\,595$)
BMI (kg m^{-2})	37.1 (36.8, 37.4)	43.9 (43.3, 44.5)	40.1 (39.6, 40.6)	26.1 (25.9, 26.2)	32.8 (32.6, 32.9)
Age (years)	47.8 (45.6, 50.1)	42.9 (40.3, 45.6)	45.8 (44.2, 47.5)	39.7 (39.6, 39.9)	44.0 (43.0, 45.1)
Female sex (%)	42.1 (34.6, 49.5)	65.4 (56.5, 74.2)	52.0 (46.4, 57.6)	49.1 (48.7, 49.5)	45.6 (42.2, 49.0)
Remoteness area category (%)					
Major city	67.8 (60.1, 75.4)	61.4 (52.4, 70.4)	64.9 (58.6, 71.2)	74.5 (73.0, 76.1)	70.3 (66.9, 73.8)
Inner regional	22.0 (14.7, 29.3)	26.8 (18.0, 35.5)	23.9 (18.4, 29.4)	18.0 (16.0, 20.0)	21.9 (18.5, 25.2)
Outer regional	10.2 (6.5, 13.9)	11.8 (5.9, 17.8)	11.2 (7.7, 14.7)	7.4 (5.9, 9.0)	7.8 (6.1, 9.4)
Index of relative socioeconomic disadvantage (%)					
1 (most disadvantaged)	21.6 (15.1, 28.1)	26.5 (17.0, 35.9)	23.6 (17.6, 29.6)	15.6 (13.9, 17.3)	20.5 (17.5, 23.5)
2	28.9 (21.1, 36.7)	29.6 (20.5, 38.7)	29.1 (22.8, 35.5)	18.9 (16.6, 21.2)	23.2 (19.3, 27.1)
3	18.5 (12.7, 24.4)	17.2 (10.3, 24.2)	18.0 (14.0, 22.0)	20.7 (18.2, 23.3)	17.7 (14.6, 20.8)
4	15.3 (9.3, 21.3)	11.1 (5.6, 16.7)	13.7 (9.3, 18.2)	21.5 (18.5, 24.5)	19.5 (15.9, 23.2)
5 (least disadvantaged)	15.6 (6.6, 24.7)	15.5 (7.8, 23.3)	15.6 (8.9, 22.3)	23.3 (20.9, 25.7)	19.0 (15.6, 22.4)
Diabetes					
FPG (%)					
Known diabetes	10.5 (6.1, 14.9)	8.5 (4.2, 12.8)	10.7 (7.5, 14.0)	1.0 (0.7, 1.4)	2.0 (1.3, 2.8)
Newly diagnosed[A]	3.6 (0.7, 6.5)	6.4 (0.0, 12.7)	4.8 (1.6, 8.1)	0.3 (0.1, 0.4)	1.0 (0.3, 1.7)
HbA1c (%)					
Known diabetes	14.0 (9.4, 18.6)	11.0 (5.1, 16.9)	14.1 (10.1, 18.1)	1.3 (0.9, 1.6)	2.5 (1.7, 3.3)
Newly diagnosed[A]	5.4 (1.4, 9.4)	7.4 (1.0, 13.8)	6.2 (2.7, 9.7)	0.5 (0.3, 0.7)	1.1 (0.4, 1.8)
High blood pressure[B] (%)	62.5 (52.1, 72.9)	49.2 (39.7, 58.6)	56.7 (49.4, 64.0)	16.5 (15.4, 17.6)	28.6 (25.0, 32.1)
CVD, self-reported (%)	7.5 (4.0, 11.1)	4.9 (1.7, 8.1)	6.6 (4.3, 8.9)	2.1 (1.7, 2.5)	3.5 (2.2, 4.7)
CVD risk ≥15% (%)	7.6 (4.3, 10.9)	5.8 (0.0, 12.1)	7.9 (4.5, 11.4)	1.0 (0.8, 1.3)	1.5 (0.9, 2.2)
CKD (Stages 1–5; %)	13.7 (8.8, 18.7)	16.4 (8.4, 24.4)	15.4 (11.1, 19.7)	5.7 (4.9, 6.5)	4.6 (3.3, 5.9)
Abnormal liver function[C] (%)	46.6 (38.1, 55.1)	21.8 (14.0, 29.5)	34.8 (29.1, 40.5)	10.4 (9.3, 11.6)	17.4 (14.9, 19.9)
Self-rated health (%)					
Excellent	8.0 (2.6, 13.3)	3.7 (0.7, 6.6)	5.9 (2.9, 8.9)	21.1 (19.5, 22.7)	11.3 (8.8, 13.8)
Very good	22.6 (14.8, 30.4)	22.1 (15.5, 28.7)	22.0 (16.9, 27.1)	40.2 (38.0, 42.4)	34.1 (30.3, 37.9)
Good	44.9 (35.2, 54.5)	36.2 (27.2, 45.2)	40.8 (34.7, 46.9)	29.1 (27.1, 31.0)	38.7 (35.3, 42.2)
Fair	17.0 (10.8, 23.1)	30.1 (21.2, 39.0)	23.3 (17.5, 29.1)	7.5 (6.6, 8.4)	12.9 (10.5, 15.2)
Poor	7.6 (2.2, 13.0)	7.9 (3.4, 12.4)	8.0 (4.5, 11.5)	2.1 (1.6, 2.7)	3.0 (2.0, 4.1)

[A]Diabetes not known before the AHS.
[B]High blood pressure defined as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg.
[C]Abnormal liver function was defined as alanine aminotransferase >30 U/L in females and >40 U/L in males.

limitations). We considered our definition of NASH (elevated Alanine Aminotransferase (ALT)) to be the most error prone and removing this comorbidity reduced the total number estimated to be potentially eligible for surgery by 107 023 to 775 418. The number of individuals who became potentially eligible for bariatric surgery based solely on other specific criteria was as follows: risk of a CV event or mortality, $n = 4274$; existing chronic kidney disease, $n = 18\,550$; existing hypertension, $n = 125\,472$; and existing T2DM, $n = 16\,247$. A more conservative HbA1c cut-off point of ≥7.0 mmol/mol to indicate the presence of diabetes, instead of a cut-off point of ≥6.5 mmol/mol (as used in the AHS), reduced the population estimate by 5791.

Discussion

The findings of the present study provide compelling evidence that the potential need for bariatric surgery in Australia far outweighs availability, especially through the public health system, a situation also seen elsewhere (e.g. Canada[22,23]). Even if only 5% of those estimated to be potentially eligible for bariatric surgery in Australia sought this pathway (44 122/

Table 5. Risk and relative risk of using health services in the previous 2-week period for adult Australians aged 18–65 years by obesity category and potential eligibility for bariatric surgery; findings from the 2011–13 Australian Health Survey

The outcome 'medical appointments' refers to whether a participant had an appointment in the previous 2 weeks with a general practitioner or specialist or at a hospital out-patient facility or day clinic. Hospital visit refers to whether a participant visited hospital as an in-patient or attended an emergency facility. Model 1 was adjusted for age and sex. Model 2 was also adjusted for remoteness area category and socioeconomic and private health insurance status. The sample number refers to the size of the sample from which the estimates were made. RR, relative risk; CI, confidence interval; Class 1 obesity, body mass index (BMI) 30–34.9 kg m^{-2}; Class 2 obesity, BMI 35–39.9 kg m^{-2}; Class 3 obesity, BMI $\geq$40 kg m^{-2}

Eligibility status	Health service use									
	Proportion accessing medical appointments					Proportion visiting a hospital				
	%	*n*/*N*	Unadjusted RR (95% CI; sample *n* = 8694)	Model 1 adjusted RR (95% CI; sample *n* = 8694)	Model 2 adjusted RR (95% CI; sample *n* = 8668)	%	*n*/*N*	Unadjusted RR (95% CI; sample *n* = 8694)	Model 1 adjusted RR (95% CI; sample *n* = 8694)	Model 2 adjusted RR (95% CI; sample *n* = 8668)
All ineligible	22.4	1832/81 972	Reference	Reference	Reference	1.3	104/8093	Reference	Reference	Reference
All eligible	35.4	264/745	1.56 (1.36, 1.79)	1.43 (1.24, 1.65)	1.43 (1.24, 1.65)	2.6	19/745	2.21 (1.16, 4.23)	2.29 (1.15, 4.56)	2.20 (1.12, 4.31)
Eligible: Class 1 obesity	35.7	5/14	1.97 (0.45, 8.53)	1.77 (0.41, 7.63)	1.71 (0.40, 7.28)	0.0	0/14	0.00 (0.00, 2.00	0.00 (0.00, 0.13)	0.00 (0.00, 0.00)
Eligible: Class 2 obesity	37.9	139/367	1.76 (1.47, 2.12)	1.61 (1.32, 1.97)	1.63 (1.34, 1.99)	2.5	9/367	1.74 (0.77, 3.92)	1.87 (0.78,4.44)	1.82 (0.76, 4.32)
Eligible: Class 3 obesity	33.0	120/364	1.33 (1.12, 1.59)	1.23 (1.04, 1.47)	1.22 (1.03, 1.45)	2.8	10/364	2.80 (1.23, 6.35)	2.76 (1.21, 6.28)	2.61 (1.16, 5.88)

882 441), demand would still exceed current capacity. Further, approximately half those Australian adults potentially eligible for bariatric surgery would likely need to access this service through the public health system if they chose to seek this intervention. This finding highlights the immediate need for guidelines on the prioritisation of eligible patients for publicly funded bariatric surgery. In addition, the total number of individuals estimated to be potentially eligible for surgery provides a strong signal that more funding of public surgery and other effective interventions to assist this population group are necessary. Given the limitations in the supply of publicly funded bariatric surgery in Australia, health economic modelling is needed to determine prioritisation for the allocation of this limited resource.

Currently, there is inequitable access to bariatric surgery in Australia favouring those who can access this service through the private health system.[11,24] Further, recipients of bariatric surgery in Australia are more likely to be aged between 35 and 54 years, of middle socioeconomic status, living in a major city and female.[11] These characteristics are similar to those collectively identified in a recent systematic review of 12 retrospective cohort studies conducted in the US, UK, Canada and Australia.[17] That review reported that the average proportion of those eligible who received bariatric surgery ranged between 1% and 5%.[17] During the period July 2011 to June 2012, 11586 privately funded bariatric surgeries (excluding revisions and reversals) were performed in Australia (no published data were available for publicly funded bariatric surgery during this period). According to our results, this represents 1.3% of the population potentially eligible for surgery. Australian-based modelling estimated that increasing the provision of bariatric surgery in Australia through public funds by 30% per year over the 10-year period from 2015 to 2025 has the potential to reduce the number of people with obesity by 4400, resulting in a societal saving of A $170 million.[25]

The finding in the present study that significantly more females had Class 3 obesity (a pattern seen in other countries, such as Canada and the US[26]) and that females were more likely to have private health insurance within the same obesity class may explain, in part, why more females are having bariatric surgery.[11,12] However, more research is needed to understand sex differences in the uptake of surgery.[12]

We found that 36.7% (175 356/477 847) of those potentially eligible for surgery with private health insurance were of low socioeconomic position ($\leq$Q2). This has potential implications for the public health system because of the relatively common need for reoperative bariatric surgery. A recent systematic review demonstrated that, on average, 2.5–18.4% of bariatric surgery recipients required a reoperation and 13–25.2% required a subsequent reoperation.[27] Patients should be encouraged to maintain their health insurance, which may be more challenging for those experiencing socioeconomic disadvantage.

Ensuring equitable access to publicly funded bariatric surgery and determining the optimal number of surgeries to perform and who should get priority is difficult. Health economic modelling is needed to determine who should be prioritised for this limited resource, a process that will be aided by the recently initiated Australian Bariatric Surgery Registry. This registry will fill important knowledge gaps needed to inform an improved prioritisation system if sufficient numbers of surgeons and patients participate.[28]

Study limitations

The present study has several limitations, which may have introduced error in the estimates of the numbers and characteristics of those potentially eligible for bariatric surgery, with most summarised in Table 1. In addition, resistant obesity could not be classified from the AHS data, although we expect the effect of this limitation to be small because sustained weight loss is

Box 1. Key findings for health service planners

- 882 441 Australian adults between 2011 and 2013 were estimated to be potentially eligible for bariatric surgery, most of whom had Class 2 (53.4%; $n=470\,945$) or Class 3 obesity (45.0%; $n=396\,856$)
- 35.1% (309 983) of those potentially eligible for surgery lived outside a major city; this has implications for follow-up care, particularly for those types of bariatric surgery that often require more follow-up than others (e.g. laparoscopic adjustable gastric band)
- of those potentially eligible for bariatric surgery, 52.7% (465 296) were of low socioeconomic position (at or below Quintile 2) and 45.8% (404 594) were without private health insurance
- 36.7% (175 356/477 847) of those potentially eligible for surgery with private health insurance were of low socioeconomic position (at or below Quintile 2); the need for reoperative bariatric surgery is relatively common, therefore patients should be encouraged to maintain their private health insurance, which may be more challenging for those experiencing socioeconomic disadvantage
- providing access to bariatric surgery for those with Class 1 obesity and poorly controlled Type 2 diabetes mellitus and increased risk of cardiovascular disease may not unduly burden the health system if our categorisation of this group is clinically relevant
- potential eligibility for surgery was independently associated with more health service use

unlikely in this population group.[29] In the absence of other data, we used elevated ALT as a surrogate marker of NASH (gold standard for diagnosis is liver biopsy[30]), which may have misclassified some with Class 2 obesity as potentially eligible. ALT has been found to be an independent predictive marker of NASH, at least in those with a BMI $\geq$40 kg/m^2,[31] and a systematic review reported the estimated prevalence of NASH in the obese population to be between 10% and 56% (median 33%).[30] Of the total population we estimated to be potentially eligible for bariatric surgery, 12.1% had Class 2 obesity and became eligible only through high ALT levels. This figure appears reasonable given the NASH prevalence data available.[30] Elevated ALT can arise as a result of excess alcohol intake and, in a subanalysis using the NHS, we estimated that 25% of this group had alcohol intake exceeding 20 mL day^{-1}. However, this estimate was determined from a small sample ($n=24$) using 3-day self-report alcohol consumption data. Furthermore, there were no direct measures or surrogate indicators of GORD in the AHS. Using self-reported medication data in the NHS for the collective category 'GORD or peptic ulcers', we found that the sample size increased by only eight individuals or 2.2%. Therefore, the effect on our estimates from the AHS data is likely to be small. There was also the possibility of error in our estimates because of self-report inaccuracies related to disclosure of comorbidities and smoking status. Further, some participants in our sample may have already had bariatric surgery and, of those classified as potentially eligible, not all would want surgery and some may be unsuitable for reasons undetectable through the AHS (e.g. due to clinical contraindications).[2] Finally, although the AHS was a high-quality national health survey, there are limitations specific to the survey design that have been comprehensively described in the user's guide, for example those relating to sampling variability and non-sampling error.[21]

Study strengths

The findings of the present study were drawn from a large ($n=31\,837$), comprehensive and high-quality national health survey that included measured physical and biomedical characteristics. For the first time, population estimates and the characteristics of those potentially eligible for bariatric surgery in Australia have been quantified and described based on the best available evidence, using categories that best approximate the national recommended eligibility criteria.[2] The findings of the present study have important implications for health service planning, especially now that the inclusion of bariatric surgery in the treatment algorithm of T2DM has been widely endorsed.[32]

Key findings relevant to health service planners are summarised in Box 1.

Conclusion

Potential demand for bariatric surgery in Australia, particularly in the public health system and outside major cities, far exceeds current capacity, highlighting an immediate need for improved prioritisation guidelines for eligible patients. Further, the large number potentially eligible for bariatric surgery ($n=882441$) provides a strong signal that more funding for public surgery and other effective interventions are urgently needed for this population group.

Competing interests

Martin Hensher is an employee of the Department of Health and Human Services Tasmania and, as such, does not receive direct personal funding from any of the sources declared below. Martin Hensher has been involved in making policy decisions and funding allocations for the provision of bariatric surgery in Tasmanian public hospitals. All other authors declare they have no competing interests.

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