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Age at diagnosis and the surgical management of small renal carcinomas: findings from a cross-sectional population-based study.

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Abstract

Objectives:

To describe the use of partial nephrectomy (PN) for patients with stage T1a renal cell carcinoma (RCC) by age group (<65 and ≥65 years) in two Australian states.

Materials and Methods

All adults diagnosed with RCC in 2012 and 2013 were identified through population-based cancer registries in the Australian states of Queensland and Victoria. For each patient, research assistants extracted patient, tumour and treatment data from medical records. Percentages treated by PN were determined for the two age groups. Multivariable logistic regression analyses examined factors associated with PN. Clinicians treating RCC were sent surveys to assess attitudes towards PN.

Results

Data were collected on 956 patients (Victoria: n=548; Queensland: n=404) with stage T1a RCC. Of those having surgery (n=865) PN was more common for those aged <65 (61%) than ≥65 years (44%), with this difference significant after adjusting for patient, tumour (OR=0.50, 95%CI: 0.36, 0.70). There were significant interactions between age and treatment centre volume (p<.05) and residential state (p<.05). PN was less likely for younger patients treated at lower volume hospitals(<24 patients a year) but hospital volume was not associated with PN for older patients. PN was less likely for older patients in Queensland than Victoria. In multivariable analyses, age was not related to laparoscopic surgery. Queensland clinicians were less likely than those from Victoria to agree that PN was the treatment of choice for most T1aN0M0 tumours (p<.001).

Conclusions:

In Australia, patients aged over 65 years with small renal cancers are less likely to be treated by PN than younger patients. The variation in the surgical procedure used to treat older T1a RCC patients by state and hospital volume indicates better evidence is needed to direct practice in this area.

Key words

Renal Cancer, Surgical treatment, older age, Population-based, patterns of care, Nephron Sparing Surgery

Introduction

Treatment guidelines for the management of renal cell carcinoma (RCC) in Europe(1) and the United States(2)(U.S.), published in 2010 and 2009 respectively, recommend that, where possible, partial nephrectomy (PN) should be used for the surgical treatment of tumours less than 4 cm in diameter. These recommendations are based on evidence suggesting equivalent oncological outcomes for PN and radical nephrectomy (RN)(3, 4), and some studies showing that RN is associated with increased all-cause mortality and a greater likelihood of stage IV chronic kidney disease (CKD)(5). However, as the superiority of PN to RN for survival and cardiovascular and kidney outcomes has not been shown in all studies(6), patient

and clinician choice are likely to play a role in determining treatment approach for small renal cancers.

Several studies have noted that older patients (generally defined as 65 years and over) are less likely to be treated by PN than younger patients(7-11). This may reflect a lack of randomised controlled trials specifically examining the best treatment approach for older patients. Also, some consider that for older patients with shorter life expectancy, the renal function benefits of PN compared with RN are unlikely to offset the potential increased risk of peri-operative complications of PN(12, 13). Increased use of laparoscopic surgery may also influence surgical decisions for older patients. Laparoscopic RN has been found to have similar oncologic outcomes to open RN with fewer surgical complications and less time in hospital(14). However, there is some evidence from patient cohort studies and matched-control studies that PN may be beneficial in terms of survival and kidney function for older patients(15-17). A study matching PN- and RN-treated patients with stage 1 tumours on age, sex and a range of clinical factors including tumour size, showed significantly longer overall survival for older patients (aged over 65 years) treated with PN compared with RN(18). Another study taking a similar methodological approach did not find a statistically significant difference in overall survival for a PN- compared with a RN-treated group(19). While tumour factors including size, growth pattern and location are known to influence the use of PN or RN for small tumors(8, 20-22), characteristics of the treating clinician also play a role(23, 24). A U.S. study found 22% of the variance in PN use for small tumours in older patients, could be apportioned to surgeon factors although it did not attempt to identify what these factors were(23). A survey of urologists in the U.S. found those working at academic centres, those with high renal cancer caseloads and those more frequently using PN were less likely to report that patient age, tumour size, tumour location or comorbidities influenced their clinical management of small RCC tumours(24).

Despite recognition of the lower PN use in patients over 65 years, few population-based studies have reported treatment practices for T1a tumours post release of both U.S. or European guidelines . Indeed we could find only seven population-based studies, all from the U.S., that have reported the proportion of older patients with small tumours (<4cm) treated by PN (Table 1). All papers report a rate averaged over multiple years with most studies including more years prior to

guideline release than post-guideline release. Whether patterns of PN use for older patients in the post-guideline era are similar outside the U.S. is not known.

. In the current paper we investigate whether PN use differs for older (65 years and over) and younger patients with small (< 4 cm) renal tumours in Australia in the post-guideline period. As greater use of laparoscopic surgery may explain differences in use of PN for older and younger patients, we also examine whether age influences choice of laparoscopic surgery. Finally, given the potential influence of clinician factors on PN use, we report data examining Australian clinicians' attitudes towards PN use for renal cancer.

Patients and Methods

Procedure

This study is part of a broader examination of the patterns of care for newly diagnosed RCC patients in the Australian states of Queensland and Victoria. Identical procedures for case identification and data collection were followed in both states. Population-based cancer registries in each state identified all adult cases of renal cell carcinoma (RCC) (ICD-10 code C649) diagnosed between 1 January 2012 and 31 December 2013 along with their treating hospital and clinician. Permission was sought from treating hospitals to access the medical records for each patient attending their service for treatment. If a hospital refused participation, we asked clinicians involved in the care of that patient to provide treatment data. Trained data managers attended each treatment site to extract relevant data by retrospective review of clinical records. When a patient attended multiple treatment sites for their cancer care, treatment details were sought from each site. We obtained approval to access medical records without patient consent under the Queensland Public Health Act and through ethical approvals in Victoria. The study had ethical approval from the QIMR Berghofer and the Cancer Council Victoria Human Research Ethics Committees (HREC). Ethics approval from other institutions was obtained as needed. Patients' privacy was protected at all times. Access to data was restricted at a personnel and computer level and all clinical data was stored separately from any identifying data.

For each case, we extracted the following data from medical records or cancer registry: mode of presentation; diagnostic and staging investigations; clinical, histological and pathological details of the disease including stage; discussion at a multidisciplinary team (MDT) meeting and first-line treatment (i.e. surgery procedure (PN vs RN) and surgical approach (laparoscopic vs open). Comorbidity was assessed using information recorded in the medical record and a Charlson comorbidity index (low (0), medium (1), high (2+)) was calculated (renal cancer excluded from the score). We categorised pre-operative estimated Glomerular Filtration Rate (eGFR) as normal (90 mL/min/1.73m^2 or higher), mildly decreased (60-89 mL/min/1.73m^2) and low (under 60 mL/min/1.73m^2). Tumour growth pattern was taken from imaging reports and classified as endophytic, exophytic or missing/not reported. Post-operative complications recorded in the medical record were extracted. Patients' residential postcode was used to determine their socio-economic status (SES) via the area-based Index of Relative Socio-Economic Disadvantage (IRSD)(26) that ranks postcodes from most disadvantaged to least disadvantaged. Postcodes were classified into tertile SES groups. Patient residency and hospital rurality were also categorised using postcode data into 'major city', 'inner regional', 'outer regional' and rural/remote using the Australian Statistical Geography Standard for Remoteness Structure (ASGS)(27). . Hospitals were classified as public (universal access, not fee based) or private (fee-based). Using data we obtained, the number of RCC cases treated at each hospital in each year was determined. We classified annual hospital volume into four groups reflecting the treatment of: 1 to 11, 12-23, 24-59 and 60+ cases per year, translating into average patient volumes of: i) < 1 case/month; ii) 1 to <2 cases/month; and iii) 2 to <5 cases/month; and iv) ≥5 cases/month.

Tumour stage was determined from clinical and pathological tumour (T) stage, nodal (N) and metastatic (M) disease status. Across the entire data set pathological data were not available for 162 patients. For these patients, case notes were reviewed to identify indication of metastatic disease. When metastatic disease was evident, patients were assigned a M1 classification (N=115). For the current paper, we focus on patients with stage 1a tumours classified as T1N0M0 (<4cm in size) according to the American Joint Committee on Cancer (AJCC) staging system(28). For the current study, clinical T (cT) stage was used to determine tumour size, with pathological T stage used when this information was missing. Patients with

metastatic disease or nodal involvement were excluded from analyses regardless of cTstage.

Clinician Survey: Clinicians treating a RCC case included in the medical record review study were mailed a survey regarding management of RCC. We sent reminders to those not responding to our survey request within four weeks with phone follow-up to confirm that they had received the survey request. The survey assessed factors influencing decisions regarding surgical procedure for RCC (15 items), attitudes towards PN (7 items) and attitudes towards treatment of metastatic RCC (7 items) using Likert-type response options. We focus on responses to questions relating to surgical procedure decisions and attitudes towards PN. Clinicians provided an estimate of their annual caseload and this was classified into high (24+/patients/year; i.e. 2/month) or low (≤23 patients/year).

Data analysis

Age at diagnosis was obtained from the cancer registries and patients were classified into two groups (<65 years and ≥65 years).

We compared the demographic, tumour and treatment centre characteristics of older and young patients using chi-squared tests for proportions and ANOVA techniques for means. Multivariable logistic regression examined the association between age group and PN and laparoscopic surgery after adjusting for patient and tumour characteristics for patients treated by surgery. In these analyses, Wald statistics provided an assessment of the overall significance of the variable. If age group was significant we examined multivariable associations between the different patient, tumour and health-service characteristics and PN and laparoscopic surgery after stratifying by age group. In the stratified analyses, a linear indicator of age was included as a predictor variable and diagnosis year was included as a control variable. In stratified analyses when PN was the outcome, two models were tested: Model 1 included patient, tumour characteristics and state, with Model 2 also including the health-service variables. When Laparoscopic surgery was the outcome, Model 1 included patient, tumour and health-service characteristics, with Model 2 also including surgical procedure (PN or RN). For clinician survey data, chi-square tests examined differences in the distribution of responses between clinicians from Queensland and Victoria and for clinicians with high and low caseload. All analyses were conducted using Stata V15 and significance level was set at $P<.05$.

Results

Patients

In Victoria, 1380 primary RCC tumours were diagnosed during the period 1/1/2012 to 31/12/2013 and data were collected on 1337 patients (completion rate: 97%). In Queensland, data was collected on all 986 patients diagnosed with a primary RCC during the study period. T1a tumours, the focus of this analysis, were diagnosed in 956 patients across the two states making up 41% of RCCs. Of T1a tumours, 54 cases had no information regarding treatment and another 37 were not treated surgically.

Older patients (8%) were more likely than younger patients (1%) to not have surgery ($p<.001$) or have missing treatment data ($p<.001$) (Figure 1). Procedure type varied with age ($p<.001$) for those having surgery, with PN more likely for younger patients (60%) and RN more common in older patients (56%). A similar proportion of people in the two age groups had laparoscopic surgery (Figure 1). Subsequent analyses are restricted to those having surgical treatment.

Characteristics of surgically treated T1a patients and tumours by age group

The distribution of gender, SES and residential location was similar between the older and younger age groups (Table 1); but fewer (46%) older patients had no comorbidities than younger patients (63%), and more older (39%) than younger (18%) patients had an eGFR of < 60mL/min per 1.73m^2 (Table 1). There was no difference in tumour characteristics between older and younger patients, except older patients were more likely to have missing information about the tumour's growth pattern ($P<.01$). A greater proportion of younger patients treated in public hospitals ($p=.02$) and in hospitals treating 24-59 cases a year (Table 1).

Multivariable associations between age and PN (PN):

After adjusting for patient and tumour factors, fewer older patients (44%) had PN than younger patients (61%) (AOR=0.50 (95% CI:0.36, 0.70)).

When stratified by age group (Table 2), when health-service characteristics were excluded, the odds of having PN were lower for younger patients from midlevel SES groups ($p<.01$), from regional areas ($p<.05$), for those with larger tumours ($p<.001$),

and for those with endophytic tumours or those missing this information (p<.001) (Table 2). Younger patients with tumours located at the kidney poles were more likely to have PN (p<.01). For older patients, increasing age (p=0.012), residing in a regional area (p=.02), larger tumours (p<.001) and having tumours with an endophytic growth pattern (p=.014) reduced the odds of having PN (Table 2). Pre-operative kidney function was marginally associated with PN (p=0.056), with patients having an eFGR 60-89mL/min per 1.73m^2 slightly less likely to have PN (OR=0.54, 95%CI:0.27-1.07) than those with an eGFR 90+mL/min per 1.73m^2. In addition, older patients from the state of Queensland (33%) had significantly lower odds of having PN than those from Victoria (53%) (p<.001). For both age groups, including health-service characteristics changed the association between PN and residential location, with the significant association between residential location and PN becoming non-significant for young patients (OR=0.72 95%CI:0.45-1.16, p=.18) and marginally non-significant for older patients (OR=0.57, 95%CI:0.32-1.04, p=.065). Hospital caseload was significantly associated with PN for younger but not older patients with younger patients attending lower volume hospitals have lower odds of having PN compared to those attending high caseload hospitals (P<.001) (Table 2).

Combining data across the two age groups and repeating analyses that included health-service characteristics produced significant interactions between age and state (p=.01) and between age and hospital volume (treated as a linear variable) (p=.02) confirming the differential effect of these variables on use of PN for older and younger patients.

Evidence of MDT meeting discussion varied substantially between Victoria (40%) and Queensland (2%). In Victoria older patients discussed at MDT meetings were as likely to have PN (62%) as younger patients (66%) (p=.563). However among patients not discussed at an MDT, those who were older were less likely than younger patients to have PN (49% vs 63%, p=0.02).

Use of Laparoscopic surgical approach:

Table 3 shows the associations between laparoscopic surgery and different patient, tumour, health-service centre factors and state with (Model 2) and without (Model 1) the inclusion of surgical procedure (PN or RN). In Model 1, older patients, women, those with larger (p<.01), endophytic tumours (p<.05) and those treated at hospitals

treating fewer than 60 RCC cases/year (P<.01) had higher odds of having laparoscopic surgery, while patients with a greater number of comorbidities (p=.01) had lower odds of having laparoscopic surgery (Table 3, Model 1). When surgical procedure was included in the model, women had greater odds of having laparoscopic surgery than men (p=0.02), while the odds of having laparoscopic surgery were lower for those with a greater number of combordities (p<.05) and those having PN (p<0.001). Patients attending hospitals with the second highest volume were more likely to have laparoscopic surgery than those attending the highest volume hospitals (p=0.01). When stratified by surgical procedure, age was not associated with laparoscopic surgery for those treated by PN or RN.

Post-surgical Complications and age:

For patients treated by PN, post-operative complications did not differ by age group (Table 4). There was also no difference in the proportion of younger and older patients having laparoscopic surgery experiencing post-operative complications (Table 4).

Clinician survey:

Given the differential association between patient state, treatment centre volume and PN for older and younger patients, clinician attitudes towards use of PN for small renal tumours were examined stratified by state and annual caseload (Table 5). Of the 108 surgeons approached to complete the survey in Victoria only 41 responded (response rate: 38%), while in Queensland 32 of the 57 (56%) approached responded. In both states, around 95% of respondents were urologists, with the remaining participants indicating they were surgeons. Victorian clinicians were more likely to treat patients from the capital city (93% of patients) than were Queensland clinicians (79% of patients) (p=0.02), reflecting the geographic spread of people in the two states. The median number of reported RCC patients treated per year by Victorian clinicians was 18.5 (range:3-50), with a median of 15 (range:1-100) for Queensland clinicians. Clinicians treating 24 or more cases a year (≥2/month) were classified as having a high caseload (34% of respondents).

While the small sample size precludes statistical significance for anything other than large differences, the pattern of difference in clinician responses in Table 5 are in line with findings presented above. A greater percentage of clinicians in Victoria (95%)

compared with Queensland (77%) agreed that PN was the treatment of choice for most T1aN0M0 tumours (p=0.026). However, within strata of caseload (high or low) levels of agreement were similar (Table 5). While not statistically significant, more Victorian (27%) than Queensland (17%) clinicians indicated that patient age influenced their surgical approach a great deal, while the proportion of clinicians agreeing or strongly agreeing that the evidence to use PN for T1 RCC was insufficient was greater in Queensland than Victoria. High and low caseload clinicians were similar in their attitudes (Table 5).

Discussion

Using population-based data from two Australian states, we examined use of PN in the treatment of small renal tumours (<4cm) for older and younger RCC patients diagnosed in 2012 and 2013. Overall, older patients were less likely to be treated by PN; however, this pattern varied by state and treatment centre volume.. While PN rates were similar for younger patients in the two states, for older patients, rates were lower in Queensland compared to Victoria.The tumour characteristics influencing PN did not differ by age group, with larger tumours and those with an endophytic growth pattern less likely to be removed by PN. While our survey of clinicians did not identify state differences in attitudes regarding the influence of age on treatment decisions, clinicians from Queensland were less likely to agree that PN is the treatment of choice for most T1a tumours.

Despite European(1) and U.S. guidelines(2) recommending PN in the surgical management of small (<4cm) renal tumours, only one randomised controlled trial has examined whether outcomes for small tumours treated by PN or RN differ(6). Findings from this trial show equivalent oncologic outcomes from the two procedures, with the incidence of advanced kidney disease and kidney failure also similar across the two treatment arms(6). Survival analyses that focused on data only for RCC cases, found no difference between treatment arms(6). Findings from observational studies and matched case-control studies have suggested greater benefits of PN both in terms of kidney function(29) and survival(18, 30). However, concerns regarding the quality of the RCT(31, 32) and the non-randomised nature of observational studies(33), have created some controversy regarding the role of PN in the treatment of small renal tumours(12, 34). Queensland clinicians' lower

endorsement of PN as the treatment of choice for all T1a tumours may reflect the lack of certainty regarding the benefits of PN, particularly for older patients.

Evidence regarding the benefits of PN for patients aged ≥65 years comes from observational studies rather than RCTs. A study stratifying patients with T1 tumours into three age groups (<55; 55-64; 65+) then using propensity scores to match patients having PN or RN within each age group, found for the oldest patients better overall survival for those treated by PN compared to RN, with no survival differences for the other two age groups(18). Another study also using propensity scores to match older patients (≥65 years) treated by PN or RN, found no overall 5-year survival benefit for PN compared with RN, although renal function was better for PN treated patients(19). A smaller sample size and a difference of nine-months in median follow-up period between PN and RN groups in the latter study may have influenced findings. Additionally, while propensity score matching attempts to reduce bias by controlling for factors known to influence surgical treatment, these analyses did not adjust for surgeon, health-service characteristics or other factors that may also influence treatment choice. A U.S. study examining outcomes for older patients diagnosed between 1992 and 2007 found improved overall survival for patients treated by PN compared with RN, although kidney cancer-specific survival did not differ by surgery type(15). The conflicting nature of the evidence and the possibility of confounding in the propensity matching studies, means the benefits of PN for older patients remains uncertain. We found that around 57% of surgically treated patients aged ≥65 years in Victoria were treated by PN compared to a third (33%) in Queensland. We could only find US studies that have reported population-based data on the use of PN in the treatment of older patients with small tumors (Table 1). In the current study, in Victoria, 63% of patients aged 60-69 years and 46% of those aged 70-79 years were treated by PN, with estimates for Queensland patients at 55% and 27% respectively. Our findings at least for Victoria indicate that in the post-guideline era, PN rates for older patients with small tumours may be higher than previously reported in US population-based studies. Further research examining patterns of treatment for older patients using only data for those diagnosed post-guideline release is required to determine whether similar patterns are now occurring in other countries.

In the U.S. differences in the use of PN for T1 tumours in different regions in the US reduced considerably and were no longer significant after the release of the 2009 guidelines, although this study did not examine the influence of patient age on these trends(35). Our study found state differences still existed regarding the use of PN, with this difference due to differences in the treatment of older patients. As PN is a more complex surgical procedure than RN and is associated with greater perioperative risks(12), clinician perceptions and assessments regarding whether the benefits of PN outweigh any risks likely influences treatment decisions. We did not find greater rates of complications for older patients treated by PN. This is in line with other studies that suggest for elderly patients having kidney cancer surgery, post-operative complications are not related to the surgical procedure per se(13, 36). However, we note there is likely to be some selection regarding which elderly patients have surgery. The two states in our study differ substantially in their size (Queensland makes up 23% of Australia's landmass compared with Victoria's 3%), density of population (Queensland: 2.9 people/km^2 vs Victoria 27.8/km^2) and the proportion of population that lives outside the state capital (Queensland 52%; Victoria 24%)(37). These differences are likely to influence access to large tertiary hospitals with Intensive Care Units, which in turn may influence the likelihood of surgeons opting to treat older patients with PN. Our finding that health-service characteristics mediated the association between residential location and PN for both older and younger patients, suggests access to higher volume hospitals may be important in determining whether regional patients are treated by PN.

There is a growing call for treatment decisions to be based on quantitative measures of surgical risk(38) determined using risk calculators such as those produced by American College of Surgeons(39). When post-operative complication risks are high, RN may be the right option for small renal tumours(38). Differences in surgeons' assessment and tolerance of potential post-operative risks for elderly patients between the two states in our study, as well as differences in assessment of benefit of PN for older patients may contribute to the differences we found.

The recording of MDT meeting discussion differed substantially between the two states. In Victoria older patients discussed at a MDT were as likely to have PN as younger patients. Studies have shown that discussion at a MDT meeting can change treatment of urological cancers in up to 32% of cases discussed(40) and it may be

that discussion of older patients with kidney cancer increases the likelihood of PN by reducing or addressing any age bias that might be influencing clinical decisions. MDT meetings have been recognized as best practice care in Australia for over 20 years(41). While it is possible that the low levels of MDT meetings in Queensland may be an artefact of our data collection method, if the difference we found is real, it suggests substantial practice difference between the states which may contribute, in part, to the differential use of PN for older patients.

Strengths of our study include its population-based approach that enabled us to gather treatment data on the majority of patients diagnosed with renal cancer in two Australian states. This meant we could assess community-wide practice patterns rather than treatment delivered at a specific treatment centre. Our study assessed treatment through review of medical records. While this meant we could gather unbiased information on the treatment patients actually received, it relied on all the required information being present and accessible in the medical records. Differences in the documentation of information between hospitals and the extent data collectors in each state were able to access all relevant medical records may have influenced findings. The small number of patients aged ≥65 years in each state, reduced the study's statistical power to identify small differences. As we did not gather identifying information on the clinicians treating patients in one state, we could not use clinician RCC volume in analyses and instead examined the association between treatment centre volume and surgical treatment. Associations may have been different had we been able to use clinician caseload in analyses. While the response we achieved for our clinician survey was acceptable for the population surveyed, the low numbers in our analyses reduced statistical power to identify significant differences and may also mean that the responses do not represent the views of the wider clinician population, particularly in Victoria. Finally we note that robotic surgery techniques were not assessed in this paper. It is likely that the increased use of this technology will make the use of PN even for complex cases more likely(42) and this needs to be assessed in the future.

Despite these limitations, our study provides novel information on the use of PN for small renal tumours for older and young Australian RCC patients in a post-guideline era. The variation in the surgical procedure used to treat older RCC patients indicates that better evidence and clinician education is needed to direct practice in

this area. While ideally this evidence would come from an RCT, conducting such a trial may be difficult given the uptake of PN for older patients in some regions. Other strategies may be needed to determine the effectiveness or otherwise of PN for older patients. In the meantime, the effect of the use of RN or PN for older RCC patients on long-term health outcomes should be monitored to determine whether the negative impacts reported in some studies are evidenced at the population level in Australia.

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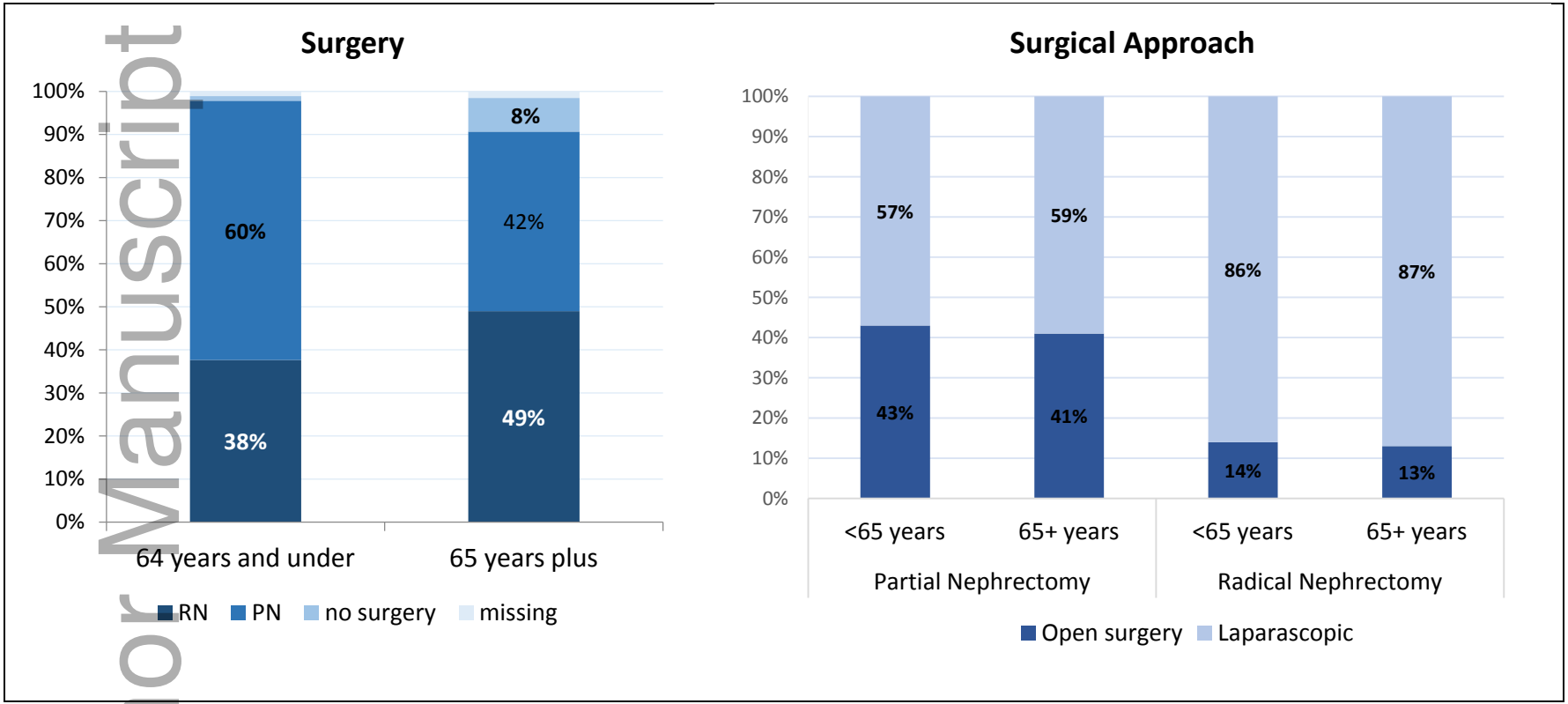

Figure 1: For all older (65 years and over) and younger (64 years and under) patients, proportion having different surgical procedures (left) and for those having surgery, surgical approach (right) (patients not having surgery included in analyses).

PN=partial nephrectomy, RN= radical nephrectomy; Lap=laparoscopic surgery; Open= open surgery.

Table 1: Proportion of surgically treated, older patients with T1a (<4cm) tumours treated by PN identified through population-based studies.

First author (Country)	Publication date	Year of diagnosis	Total N				
				60-69	**70-79**	**80+**	**≥66**
				%	**%**	**%**	**%**
Bandini et al (43) (USA)	2018	2004-2011	37121	52	43	30	
Bjurkin et al(44) (USA)	2017	2002-2011	8933				35
Tan et al(7)^ (USA)	2015	2000-2010	34599	40	31	20	
Bianchi et al (25)(USA)	2013	1998-2005	6024	20	14	5	
Becker et al(9) (USA)	2013	1998-2008	26468	28	17	3	
Sun et al(45) (USA)	2012	1998-2008	26468	-	16	3	
Dolabon et al	2010	1996-2006	11870	36	31	29	

(10) (USA)							

^Tan(7) number of patients having surgery and proportion of surgical patients having PN calculated from data in the paper.

Table 2: Demographic, tumour and health-service characteristics for surgically treated patients with T1a tumours by age group

	Age			
	<65 N (%)	65+ N (%)	Total N (%)	p-value for difference between age groups
Total	530 (61)	335 (39)	865 (100)	
Patient characteristics				
Sex				
Male	327 (62)	216 (64)	543 (63)	*0.410*
Female	203 (38)	119 (36)	322 (37)	
Socio-economic group-				
Low	124 (23)	83 (25)	207(24)	*0.648*

Mid	168 (32)	96 (29)	264 (31)	
high	238 (45)	155 (46)	393 (45)	
Area of residence				
Urban	357 (67)	219 (66)	576 (67)	*0.587*
Regional	173 (33)	115 (34)	288 (33)	
Charlson Co-morbidities				
Low (0)	331 (63)	155 (46)	486 (56)	*<0.001*
Medium (1)	107 (20)	81 (24)	188 (22)	
High (≥2)	92 (17)	99 (30)	191 (22)	
eGFR				
< 60	98 (18)	129 (39)	227 (26)	*<0.001*
60-<89	141 (27)	125 (37)	266 (31)	
90-hi	273 (52)	70 (21)	343 (40)	
missing	18 (3)	11 (3)	29 (3)	
Residential State				
Victoria	289 (55)	181 (54)	470 (54)	0.886
Queensland	241 (45)	154 (46)	395 (46)	

Tumour characteristics				
Diagnosis mode: incidental	350 (66)	220 (66)	570 (66)	*0.912*
Histology: clear cell	373 (70)	219 (65)	592 (68)	*0.123*
Clinical Size: mean cm (SD)	2.77 (0.78)	2.87 (0.76)	2.81 (0.78)	*0.96*
<2cm	71 (13)	33 (10)	104 (12)	*0.171*
2-<3cm	203 (38)	122 (36)	325 (38)	
3-4 cm	256 (48)	180(54)	436 (50)	
Growth pattern from imaging:				
Exophytic	230 (43)	111 (33)	341 (39)	*.253*[#]
Endophytic	24 (5)	17 (5)	41 (5)	
No imaging/not recorded	276 (52)	207 (62)	483 (56)	*0.011*[##]
Tumour polarity				
Central	172 (32)	96 (29)	268 (31)	
Poles only	303 (57)	203 (61)	506 (59)	*0.498*

Not known	55 (10)	36 (11)	91 (11)	
Health-service characteristics				
Hospital Type				
Public hospital	304 (55)	175 (47)	479 (52)	*0.017*
Private hospital	250 (45)	198 (53)	448 (49)	
Treatment centre RCC volume				
60 or more /year	61 (12)	50 (15)	111 (13)	*0.011*
24 -59 / year	283 (53)	142 (42)	425 (49)	
12-23 / year	122 (23)	86 (26)	208 (24)	
1-11/year	64 (13)	57 (17)	121 (14)	

chi-square test excludes cases with missing information for this variable

chi-square test comparing proportion of cases in the three groups (exophytic, endophytic, missing)

Table 3: Multivariable associations (Adjusted Odds Ratio (AOR) and 95% Confidence Intervals (95%CI)) for partial nephrectomy (PN) for older (65+ years) and younger (<65 years) patients with T1a renal tumours. Model 1 adjusts for patient characteristics, tumour factors, diagnosis year and state; Model 2 adjust for all variables in Model 1 and health-service characteristics. (NB: Patients not treated by surgery excluded from analyses).

	Age					
	64 years and under (n=530)			65 years and over (n=334)		
Characteristic	**% PN**	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)	**% PN**	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)
	Patient Characteristics					
Age (mean years)	(52.7)	1.00 (0.97-1.02)	1.00 (0.97-1.02)	(71.9)	0.94 (0.89,0.99)	0.94 (0.89,0.99)
Sex						
Male	62.9		1	45.1	**1**	1
Female	58.9	0.88 (0.58,1.34)	0.91 (0.59,1.40)	41.2	0.85 (0.50, 1.44)	0.85 (0.50,1.44)
Co morbidities						
None (0)	62.3	1	1	46.5	1	1
Low (1)	60.4	0.95 (0.56, 1.59)	1.16 (0.67, 2.01)	42.0	0.90 (0.48, 1.67)	0.94 (0.50, 1.76)

Medium or more (2+)	58.8	0.55 (0.31, 0.98)	0.59 (0.33,1.07)	40.8	0.86 (0.47,1.59)	0.91 (0.48,1.70)
Socio-economic group						
High	70.6	1	1	47.1	1	1
Mid	54.8	0.54 (0.34, 0.88)	0.59 (0.36, 0.98)	41.7	0.93 (0.51, 1.69)	0.99 (0.53,1.86)
Low	52.8	0.60 (0.35,1.02)	0.58 (0.33, 1.02)	39.8	0.85 (0.44, 1.66)	0.85 (0.42,1.71)
Urban/rural residence						
Urban	65.4	1	1	48.4	1	1
Regional	53.2	0.62 (0.39,0.98)	0.72 (0.45, 1.16)	34.8	0.50 (0.28, 0.90)	0.57 (0.32, 1.04)
eGFR						
90-high	60.9	1	1	51.4	1	1
60-<89	59.9	1.02 (0.63,1.67)	0.90 (0.54, 1.51)	37.6	0.54 (0.27, 1.07)	0.53 (0.26, 1.07)
< 60	63.9	2.48 (0.83,2.64)	1.39 (0.76, 2.52)	45.3	1.19 (0.59, 2.39)	1.17 (0.57, 2.39)
missing	66.7	1.82 (0.56,5.85)	1.87 (0.57, 6.17)	45.5	0.66 (0.16, 2.74)	0.73 (0.17, 3.13)
	Tumour characteristics					

Tumour size						
<2cm	81.7	1	1	69.7		1
2-<3cm	74.8	0.68 (0.33,1.42)	0.72 (0.34,1.51)	53.3	0.39 (0.16, 0.96)	0.36 (0.14, 0.89)
3-4cm	46.0	0.17 (0.08, 0.34)	0.16 (0.08,0.33)	32.4	0.14 (0.06, 0.34)	0.13 (0.05,0.32)
Tumour location						
Central/entire kidney	58.2	1	1	43.7	1	1
Affecting poles only	65.6	1.45 (0.93,2.27)	1.58 (1.00, 2.50)	48.4	1.54 (0.87, 2.71)	1.53 (0.86, 2.74)
Not known	48.2	1.10 (0.53,2.25)	1.11 (0.53, 2.36)	41.0	0.74 (0.30, 1.82)	0.76 (0.30, 1.91)
Growth Pattern from Imaging						
Exophytic	77.2	1	1	51.8	1	1
Endophytic	37.5	0.17 (0.06,0.48)	0.18 (0.06, 0.53)	17.6	1.17 (0.04, 0.70)	0.15 (0.03, 0.62)
No image/not described	50.4	0.30 (0.19,0.46)	0.29 (0.18, 0.46)	41.5	0.75 (0.44, 1.29)	0.70 (0.40, 1.21)
	Health-service Characteristics					

Hospital type						
Public	58.8	-	1	43.2	-	1
Private	64.6	-	1.34 (0.82, 2.19)	44.1	-	1.30 (0.71, 2.37)
Treatment centre RCC volume						
60 or more /year	73.8	-	1	40.0	-	1
24 -59 / year	66.6	-	0.85 (0.38,1.92)	51.1	-	1.87 (0.79, 4.44)
12-23 / year	52.5	-	0.33 (0.14,0.76)	39.5	-	1.15 (0.47, 2.80)
1-11/year	42.9	-	0.31 (0.13, 0.76)	35.2	-	0.89 (0.34, 2.35)
	State					
Victoria	64.4	1	1	53.0	1	1
Queensland	57.7	0.72 (0.47, 1.09)	0.71 (0.46,1.10)	32.5	0.32 (0.19, 0.56)	0.32 (0.18, 0.57)

AOR Adjusted Odds Ratio: ORs adjusted for all variables in the table.

Diagnosis year included in analyses as a covariate.

Table 4: Multivariable associations (Adjusted Odds Ratio (AOR) and 95% Confidence Intervals (95%CI)) with having laparoscopic surgery and Model 1: patient, tumour, health-service characteristics; Model 2: patient, tumour, health-service characteristics and type of surgical procedure for patients with T1a renal tumours treated by surgery.

		Surgical approach		
		Laparoscopic surgery		
Characteristic	N for each group	N (%)	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)
Patient Characteristics				
Age				
Under 65 years	530	362 (68.3)	1	1
65 years and over	335	249 (74.3)	1.41 (1.01,1.99)	1.17 (0.82,1.68)
Sex				
Male	543	368 (67.8)	1	1
Female	322	243 (75.5)	1.59 (1.14,2.21)	1.52 (1.08,2.15)
Co morbidities				
None (0)	486	358 (73.7)	1	1
Low (1)	188	124 (66.0)	0.59 (0.40, 0.87)	0.57 (0.38, 0.86)

Medium or more (2+)	191	129 (67.5)	0.72 (0.49, 1.07)	0.65 (0.43,0.98)
Socio-economic group				
high	393	282 (71.8)	1	1
Mid	264	175 (66.3)	0.74 (0.51,1.07)	0.66 (0.44,0.97)
low	207	154 (74.4)	1.06 (0.69,1.63)	0.98 (0.62,1.55)
Urban/rural residence				
Urban	576	406 (70.5)	1	1
Regional	288	205 (71.2)	1.09 (0.76, 1.55)	0.97 (0.66, 1.41)
eGFR				
90-high	343	241 (70.3)	1	1
60-<89	266	192 (72.2)	1.06 (0.72,1.55)	0.98 (0.65, 1.46)
< 60	227	158 (69.6)	0.87 (0.58,1.30)	0.90 (0.59, 1.38)
missing	29	20 (69.0)	0.69, (0.29,1.65)	0.74 (0.30, 1.84)
Tumour characteristics				
<2 cm	104	61 (58.7)	1	1
2-<3 cm	325	212 (65.2)	1.27 (0.79, 2.02)	1.09 (0.67, 1.77)

3-<4cm	436	338 (77.5)	2.29 (1.44, 3.65)	1.40 (0.85, 2.30)
Tumour location				
Central tumour	268	190 (71.9)	1	1
Affecting poles only	506	357 (70.6)	0.98 (0.70, 1.38)	1.09 (0.76, 1.57)
Not known	91	64 (70.3)	0.87 (0.50, 1.51)	0.85 (0.47, 1.53)
Growth Pattern from Imaging				
Exophytic	341	222 (65.1)	1	1
Endophytic	41	34 (82.9)	2.69 (1.09, 6.15)	1.61 (0.65, 4.98)
No image/not described	483	355 (73.5)	1.34 (0.97,1.86)	1.05 (0.75, 1.48)
Health-Service Characteristics				
Hospital type				
Public	449	312 (69.5)	1	1
Private	416	299 (71.9)	1.30 (0.89, 1.88)	1.40 (0.95, 2.07)
Treatment centre RCC volume				
60 or more /year	111	68 (61.3)	1	1
24 -59 / year	425	309 (72.7)	2.26 (1.32, 3.86)	2.51 (1.44, 4.37)

12-23 / year	208	144 (69.2)	1.89 (1.09, 3.29)	1.66 (0.92, 2.96)
1-11/year	121	90 (74.4)	2.21 (1.20,4.05)	1.91 (1.00, 3.62)
State				
Victoria	470	338 (71.9)	1	1
Queensland	395	273 (69.1)	1.02 (0.74, 1.40)	0.85 (0.60, 1.19)
Type of Surgical procedure				
Radical Nephrectomy	394	340 (86.3)	-	1
Partial Nephrectomy	471	271 (57.5)	-	0.20 (0.13, 0.29)

AOR Adjusted Odds Ratio: ORs adjusted for all variables in the table.

Diagnosis year included in analyses as a covariate.

Table 5: Proportion of older and younger surgical patients with documented post-operative complications for those having partial nephrectomy, those having laparoscopic surgery and all surgical patients.

	Surgery characteristics				**All surgical patients**		
	Partial Nephrectomy		**Laparoscopic surgery**				
Post operative complication	<65 years	65+ Years	<65 years	65+ years	<65 years	65+ years	Total

	%	%	%	%	%	%	%
Deep vein thrombosis	0	0.7	0.	0.4	0	0.8	0.3
Wound infection	1.5	1.4	2.8	0.8	2.8	1.4	2.2
Post operative pneumonia	2.1	3.0	1.1	0.8	1.5	1.7	1.6
Haemorrhage requiring transfusion	3.3	3.6	2.2	3.2	2.8	3.3	3.0
Unplanned return to theatre	1.5	1.2	1.7	0.8	1.3	0.8	1.1
Unplanned ICU^	4.8	6.7	3.9	6.4	4.6	7.0	5.5

^ ICU. Intensive Care Unit

Table 6: Number (percent) of clinicians treating RCC agreeing (strongly agree/agree) or disagreeing (strongly disagree /disagree) to statements regarding partial nephrectomy for stage 1 renal cancer and the extent patient age, renal function and health influence treatment decisions by clinician state and caseload[#].

	There is insufficient evidence to use partial nephrectomy in T1RCC				PN treatment of choice for most T1aN0M0 tumours				For most T1N0M0 tumours, laparoscopic radical nephrectomy is a better option than partial nephrectomy			
	State		Caseload		State		Caseload		State		Caseload	
	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)
Disagree	33 (83)	21 (68)	35 (78)	18 (75)	2 (5)	7 (23)	6 (14)	3 (13)	27 (75)	23 (82)	33 (79)	17 (77)
Agree	7 (18)	10 (33)	10 (22)	6 (25)	37 (95)	23 (77)	38 (86)	21 (87)	9 (25)	5 (18)	9 (21)	5 (23)
P-value	*0.148*		*.795*		*0.026*		*0.895*		*0.49*		*0.905*	
How much do the following issues influence the type of surgical procedure you recommend to patients with RCC												
	Patient's age?				Patient's renal function?				Patient's general health?			
	State		Caseload		State		Caseload		State		Caseload	
	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)
A great	11	5	10	6	32	28	37	22	33	22	33	20

deal	(27)	(17)	(21)	(25)	(78)	(88)	(79)	(92)	(81)	(69)	(70)	(83)
To some extent/ A little/ not at all	30 (73)	24 (83)	37 (79)	18 (75)	9 (22)	4 (12)	10 (21)	2 (8)	8 (19)	10 (31)	14 (30)	4 (17)
P-value	*0.251*		*.722*		*0.295*		*0.169*		*0.248*		*0.229*	

[#] Treating 24+ cases of renal cancer a year (2+ patients a month) classified as high caseload. Clinicians treating fewer than this were classified as low caseload.

Table 1: Proportion of surgically treated, older patients with T1a (<4cm) tumours treated by PN identified through population-based studies.

First author (Country)	Publication date	Year of diagnosis	Total N				
				60-69	**70-79**	**80+**	**≥66**
				%	**%**	**%**	**%**
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Sun et al(45) (USA)	2012	1998-2008	26468	-	16	3	
Dolabon et al	2010	1996-2006	11870	36	31	29	

(10) (USA)							

^Tan(7) number of patients having surgery and proportion of surgical patients having PN calculated from data included in paper.

Table 2: Demographic, tumour and health-service characteristics for surgically treated patients with T1a tumours by age group

	Age			
	<65 N (%)	65+ N (%)	Total N (%)	p-value for difference between age groups
Total	530 (61)	335 (39)	865 (100)	
Patient characteristics				
Sex				
Male	327 (62)	216 (64)	543 (63)	*0.410*
Female	203 (38)	119 (36)	322 (37)	
Socio-economic group-				
Low	124 (23)	83 (25)	207(24)	*0.648*

Mid	168 (32)	96 (29)	264 (31)	
high	238 (45)	155 (46)	393 (45)	
Area of residence				
Urban	357 (67)	219 (66)	576 (67)	*0.587*
Regional	173 (33)	115 (34)	288 (33)	
Charlson Co-morbidities				
Low (0)	331 (63)	155 (46)	486 (56)	*<0.001*
Medium (1)	107 (20)	81 (24)	188 (22)	
High (≥2)	92 (17)	99 (30)	191 (22)	
eGFR				
< 60	98 (18)	129 (39)	227 (26)	*<0.001*
60-<89	141 (27)	125 (37)	266 (31)	
90-hi	273 (52)	70 (21)	343 (40)	
missing	18 (3)	11 (3)	29 (3)	
Residential State				
Victoria	289 (55)	181 (54)	470 (54)	0.886
Queensland	241 (45)	154 (46)	395 (46)	

Tumour characteristics				
Diagnosis mode: incidental	350 (66)	220 (66)	570 (66)	*0.912*
Histology: clear cell	373 (70)	219 (65)	592 (68)	*0.123*
Clinical Size: mean cm (SD)	2.77 (0.78)	2.87 (0.76)	2.81 (0.78)	*0.96*
<2cm	71 (13)	33 (10)	104 (12)	*0.171*
2-<3cm	203 (38)	122 (36)	325 (38)	
3-4 cm	256 (48)	180(54)	436 (50)	
Growth pattern from imaging:				
Exophytic	230 (43)	111 (33)	341 (39)	*.253*[#]
Endophytic	24 (5)	17 (5)	41 (5)	
No imaging/not recorded	276 (52)	207 (62)	483 (56)	*0.011*[##]
Tumour polarity				
Central	172 (32)	96 (29)	268 (31)	
Poles only	303 (57)	203 (61)	506 (59)	*0.498*

Not known	55 (10)	36 (11)	91 (11)	
Health-service characteristics				
Hospital Type				
Public hospital	304 (55)	175 (47)	479 (52)	*0.017*
Private hospital	250 (45)	198 (53)	448 (49)	
Treatment centre RCC volume				
60 or more /year	61 (12)	50 (15)	111 (13)	*0.011*
24 -59 / year	283 (53)	142 (42)	425 (49)	
12-23 / year	122 (23)	86 (26)	208 (24)	
1-11/year	64 (13)	57 (17)	121 (14)	

chi-square test excludes cases with missing information for this variable

chi-square test comparing proportion of cases in the three groups (exophytic, endophytic, missing)

Table 3: Multivariable associations (Adjusted Odds Ratio (AOR) and 95% Confidence Intervals (95%CI)) for partial nephrectomy (PN) for older (65+ years) and younger (<65 years) patients with T1a renal tumours. Model 1 adjusts for patient characteristics, tumour factors, diagnosis year and state; Model 2 adjust for all variables in Model 1 and health-service characteristics. (NB: Patients not treated by surgery excluded from analyses).

	Age					
	64 years and under (n=530)			65 years and over (n=334)		
Characteristic	**% PN**	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)	**% PN**	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)
	Patient Characteristics					
Age (mean years)	(52.7)	1.00 (0.97-1.02)	1.00 (0.97-1.02)	(71.9)	0.94 (0.89,0.99)	0.94 (0.89,0.99)
Sex						
Male	62.9		1	45.1	**1**	1
Female	58.9	0.88 (0.58,1.34)	0.91 (0.59,1.40)	41.2	0.85 (0.50, 1.44)	0.85 (0.50,1.44)
Co morbidities						
None (0)	62.3	1	1	46.5	1	1

Low (1)	60.4	0.95 (0.56, 1.59)	1.16 (0.67, 2.01)	42.0	0.90 (0.48, 1.67)	0.94 (0.50, 1.76)
Medium or more (2+)	58.8	0.55 (0.31, 0.98)	0.59 (0.33,1.07)	40.8	0.86 (0.47,1.59)	0.91 (0.48,1.70)
Socio-economic group						
High	70.6	1	1	47.1	1	1
Mid	54.8	0.54 (0.34, 0.88)	0.59 (0.36, 0.98)	41.7	0.93 (0.51, 1.69)	0.99 (0.53,1.86)
Low	52.8	0.60 (0.35,1.02)	0.58 (0.33, 1.02)	39.8	0.85 (0.44, 1.66)	0.85 (0.42,1.71)
Urban/rural residence						
Urban	65.4	1	1	48.4	1	1
Regional	53.2	0.62 (0.39,0.98)	0.72 (0.45, 1.16)	34.8	0.50 (0.28, 0.90)	0.57 (0.32, 1.04)
eGFR						
90-high	60.9	1	1	51.4	1	1
60-<89	59.9	1.02 (0.63,1.67)	0.90 (0.54, 1.51)	37.6	0.54 (0.27, 1.07)	0.53 (0.26, 1.07)
< 60	63.9	2.48 (0.83,2.64)	1.39 (0.76, 2.52)	45.3	1.19 (0.59, 2.39)	1.17 (0.57, 2.39)
missing	66.7	1.82 (0.56,5.85)	1.87 (0.57, 6.17)	45.5	0.66 (0.16, 2.74)	0.73 (0.17, 3.13)

	Tumour characteristics					
Tumour size						
<2cm	81.7	1	1	69.7		1
2-<3cm	74.8	0.68 (0.33,1.42)	0.72 (0.34,1.51)	53.3	0.39 (0.16, 0.96)	0.36 (0.14, 0.89)
3-4cm	46.0	0.17 (0.08, 0.34)	0.16 (0.08,0.33)	32.4	0.14 (0.06, 0.34)	0.13 (0.05,0.32)
Tumour location						
Central/entire kidney	58.2	1	1	43.7	1	1
Affecting poles only	65.6	1.45 (0.93,2.27)	1.58 (1.00, 2.50)	48.4	1.54 (0.87, 2.71)	1.53 (0.86, 2.74)
Not known	48.2	1.10 (0.53,2.25)	1.11 (0.53, 2.36)	41.0	0.74 (0.30, 1.82)	0.76 (0.30, 1.91)
Growth Pattern from Imaging						
Exophytic	77.2	1	1	51.8	1	1
Endophytic	37.5	0.17 (0.06,0.48)	0.18 (0.06, 0.53)	17.6	1.17 (0.04, 0.70)	0.15 (0.03, 0.62)
No image/not described	50.4	0.30 (0.19,0.46)	0.29 (0.18, 0.46)	41.5	0.75 (0.44, 1.29)	0.70 (0.40, 1.21)

	Health-service Characteristics					
Hospital type						
Public	58.8	-	1	43.2	-	1
Private	64.6	-	1.34 (0.82, 2.19)	44.1	-	1.30 (0.71, 2.37)
Treatment centre RCC volume						
60 or more /year	73.8	-	1	40.0	-	1
24 -59 / year	66.6	-	0.85 (0.38,1.92)	51.1	-	1.87 (0.79, 4.44)
12-23 / year	52.5	-	0.33 (0.14,0.76)	39.5	-	1.15 (0.47, 2.80)
1-11/year	42.9	-	0.31 (0.13, 0.76)	35.2	-	0.89 (0.34, 2.35)
	State					
Victoria	64.4	1	1	53.0	1	1
Queensland	57.7	0.72 (0.47, 1.09)	0.71 (0.46,1.10)	32.5	0.32 (0.19, 0.56)	0.32 (0.18, 0.57)

AOR Adjusted Odds Ratio: ORs adjusted for all variables in the table.

Diagnosis year included in analyses as a covariate.

Table 4: Multivariable associations (Adjusted Odds Ratio (AOR) and 95% Confidence Intervals (95%CI)) with having laparoscopic surgery and Model 1: patient, tumour, health-service characteristics; Model 2: patient, tumour, health-service characteristics and type of surgical procedure for patients with T1a renal tumours treated by surgery.

		Surgical approach		
		Laparoscopic surgery		
Characteristic	N for each group	N (%)	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)
Patient Characteristics				
Age				
Under 65 years	530	362 (68.3)	1	1
65 years and over	335	249 (74.3)	1.41 (1.01,1.99)	1.17 (0.82,1.68)
Sex				
Male	543	368 (67.8)	1	1
Female	322	243 (75.5)	1.59 (1.14,2.21)	1.52 (1.08,2.15)
Co morbidities				

None (0)	486	358 (73.7)	1	1
Low (1)	188	124 (66.0)	0.59 (0.40, 0.87)	0.57 (0.38, 0.86)
Medium or more (2+)	191	129 (67.5)	0.72 (0.49, 1.07)	0.65 (0.43,0.98)
Socio-economic group				
high	393	282 (71.8)	1	1
Mid	264	175 (66.3)	0.74 (0.51,1.07)	0.66 (0.44,0.97)
low	207	154 (74.4)	1.06 (0.69,1.63)	0.98 (0.62,1.55)
Urban/rural residence				
Urban	576	406 (70.5)	1	1
Regional	288	205 (71.2)	1.09 (0.76, 1.55)	0.97 (0.66, 1.41)
eGFR				
90-high	343	241 (70.3)	1	1
60-<89	266	192 (72.2)	1.06 (0.72,1.55)	0.98 (0.65, 1.46)
< 60	227	158 (69.6)	0.87 (0.58,1.30)	0.90 (0.59, 1.38)
missing	29	20 (69.0)	0.69, (0.29,1.65)	0.74 (0.30, 1.84)
Tumour characteristics				

<2 cm	104	61 (58.7)	1	1
2-<3 cm	325	212 (65.2)	1.27 (0.79, 2.02)	1.09 (0.67, 1.77)
3-<4cm	436	338 (77.5)	2.29 (1.44, 3.65)	1.40 (0.85, 2.30)
Tumour location				
Central tumour	268	190 (71.9)	1	1
Affecting poles only	506	357 (70.6)	0.98 (0.70, 1.38)	1.09 (0.76, 1.57)
Not known	91	64 (70.3)	0.87 (0.50, 1.51)	0.85 (0.47, 1.53)
Growth Pattern from Imaging				
Exophytic	341	222 (65.1)	1	1
Endophytic	41	34 (82.9)	2.69 (1.09, 6.15)	1.61 (0.65, 4.98)
No image/not described	483	355 (73.5)	1.34 (0.97,1.86)	1.05 (0.75, 1.48)
Health-Service Characteristics				
Hospital type				
Public	449	312 (69.5)	1	1
Private	416	299 (71.9)	1.30 (0.89, 1.88)	1.40 (0.95, 2.07)
Treatment centre RCC volume				

60 or more /year	111	68 (61.3)	1	1
24 -59 / year	425	309 (72.7)	2.26 (1.32, 3.86)	2.51 (1.44, 4.37)
12-23 / year	208	144 (69.2)	1.89 (1.09, 3.29)	1.66 (0.92, 2.96)
1-11/year	121	90 (74.4)	2.21 (1.20,4.05)	1.91 (1.00, 3.62)
State				
Victoria	470	338 (71.9)	1	1
Queensland	395	273 (69.1)	1.02 (0.74, 1.40)	0.85 (0.60, 1.19)
Type of Surgical procedure				
Radical Nephrectomy	394	340 (86.3)	-	1
Partial Nephrectomy	471	271 (57.5)	-	0.20 (0.13, 0.29)

AOR Adjusted Odds Ratio: ORs adjusted for all variables in the table.

Diagnosis year included in analyses as a covariate.

Table 5: Proportion of older and younger surgical patients with documented post-operative complications for those having partial nephrectomy, those having laparoscopic surgery and all surgical patients.

	Surgery characteristics	All surgical patients

	Partial Nephrectomy		Laparoscopic surgery				
Post operative complication	<65 years %	65+ Years %	<65 years %	65+ years %	<65 years %	65+ years %	Total %
Deep vein thrombosis	0	0.7	0.	0.4	0	0.8	0.3
Wound infection	1.5	1.4	2.8	0.8	2.8	1.4	2.2
Post operative pneumonia	2.1	3.0	1.1	0.8	1.5	1.7	1.6
Haemorrhage requiring transfusion	3.3	3.6	2.2	3.2	2.8	3.3	3.0
Unplanned return to theatre	1.5	1.2	1.7	0.8	1.3	0.8	1.1
Unplanned ICU^	4.8	6.7	3.9	6.4	4.6	7.0	5.5

^ ICU: Intensive Care Unit

Table 6: Number (percent) of clinicians treating RCC agreeing (strongly agree/agree) or disagreeing (strongly disagree /disagree) to statements regarding partial nephrectomy for stage 1 renal cancer and the extent patient age, renal function and health influence treatment decisions by clinician state and caseload[#].

	There is insufficient evidence to use partial nephrectomy in T1RCC				PN treatment of choice for most T1aN0M0 tumours				For most T1N0M0 tumours, laparoscopic radical nephrectomy is a better option than partial nephrectomy			
	State		Caseload		State		Caseload		State		Caseload	
	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)
Disagree	33 (83)	21 (68)	35 (78)	18 (75)	2 (5)	7 (23)	6 (14)	3 (13)	27 (75)	23 (82)	33 (79)	17 (77)
Agree	7 (18)	10 (33)	10 (22)	6 (25)	37 (95)	23 (77)	38 (86)	21 (87)	9 (25)	5 (18)	9 (21)	5 (23)
P-value	*0.148*		*.795*		*0.026*		*0.895*		*0.49*		*0.905*	
How much do the following issues influence the type of surgical procedure you recommend to patients with RCC												
	Patient's age?				Patient's renal function?				Patient's general health?			
	State		Caseload		State		Caseload		State		Caseload	
	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)
A great	11	5	10	6	32	28	37	22	33	22	33	20

deal	(27)	(17)	(21)	(25)	(78)	(88)	(79)	(92)	(81)	(69)	(70)	(83)
To some extent/ A little/ not at all	30 (73)	24 (83)	37 (79)	18 (75)	9 (22)	4 (12)	10 (21)	2 (8)	8 (19)	10 (31)	14 (30)	4 (17)
P-value	*0.251*		*.722*		*0.295*		*0.169*		*0.248*		*0.229*	

[#] Treating 24+ cases of renal cancer a year (2+ patients a month) classified as high caseload. Clinicians treating fewer than this were classified as low caseload.

Table 1: Proportion of surgically treated, older patients with T1a (<4cm) tumours treated by PN identified through population-based studies.

First author (Country)	Publication date	Year of diagnosis	Total N				
				60-69	**70-79**	**80+**	**≥66**
				%	**%**	**%**	**%**
Bandini et al (42) (USA)	2018	2004-2011	37121	52	43	30	
Bjurkin et al(43) (USA)	2017	2002-2011	8933				35
Tan et al(7)^ (USA)	2015	2000-2010	34599	40	31	20	
Bianchi et al (44)(USA)	2013	1998-2005	6024	20	14	5	
Becker et al(9) (USA)	2013	1998-2008	26468	28	17	3	
Sun et al(45) (USA)	2012	1998-2008	26468	-	16	3	
Dolabon et al (10) (USA)	2010	1996-2006	11870	36	31	29	

^Tan(7) number of patients having surgery and proportion of surgical patients having PN calculated from data included in paper.

Table 2: Demographic, tumour and health-service characteristics for surgically treated patients with T1a tumours by age group

	Age			
	<65 N (%)	65+ N (%)	Total N (%)	p-value for difference between age groups
Total	530 (61)	335 (39)	865 (100)	
Patient characteristics				
Sex				
Male	327 (62)	216 (64)	543 (63)	*0.410*
Female	203 (38)	119 (36)	322 (37)	
Socio-economic group-				
Low	124 (23)	83 (25)	207(24)	*0.648*
Mid	168 (32)	96 (29)	264 (31)	
high	238 (45)	155 (46)	393 (45)	
Area of residence				
Urban	357 (67)	219 (66)	576 (67)	*0.587*
Regional	173 (33)	115 (34)	288 (33)	
Charlson Co-morbidities				
Low (0)	331 (63)	155 (46)	486 (56)	*<0.001*

Medium (1)	107 (20)	81 (24)	188 (22)	
High (≥2)	92 (17)	99 (30)	191 (22)	
eGFR				
< 60	98 (18)	129 (39)	227 (26)	*<0.001*
60-<89	141 (27)	125 (37)	266 (31)	
90-hi	273 (52)	70 (21)	343 (40)	
missing	18 (3)	11 (3)	29 (3)	
Residential State				
Victoria	289 (55)	181 (54)	470 (54)	0.886
Queensland	241 (45)	154 (46)	395 (46)	
Tumour characteristics				
Diagnosis mode: incidental	350 (66)	220 (66)	570 (66)	*0.912*
Histology: clear cell	373 (70)	219 (65)	592 (68)	*0.123*
Clinical Size: mean cm (SD)	2.77 (0.78)	2.87 (0.76)	2.81 (0.78)	*0.96*
<2cm	71 (13)	33 (10)	104 (12)	*0.171*
2-<3cm	203 (38)	122 (36)	325 (38)	

3-4 cm	256 (48)	180(54)	436 (50)	
Growth pattern from imaging:				
Exophytic	230 (43)	111 (33)	341 (39)	*.253*[#]
Endophytic	24 (5)	17 (5)	41 (5)	
No imaging/not recorded	276 (52)	207 (62)	483 (56)	*0.011*[##]
Tumour polarity				
Central	172 (32)	96 (29)	268 (31)	
Poles only	303 (57)	203 (61)	506 (59)	*0.498*
Not known	55 (10)	36 (11)	91 (11)	
Health-service characteristics				
Hospital Type				
Public hospital	304 (55)	175 (47)	479 (52)	*0.017*
Private hospital	250 (45)	198 (53)	448 (49)	
Treatment centre RCC volume				
60 or more /year	61 (12)	50 (15)	111 (13)	*0.011*
24 -59 / year	283 (53)	142 (42)	425 (49)	
12-23 / year	122 (23)	86 (26)	208 (24)	
1-11/year	64 (13)	57 (17)	121 (14)	

chi-square test excludes cases with missing information for this variable

chi-square test comparing proportion of cases in the three groups (exophytic, endophytic, missing)

Table 3: Multivariable associations (Adjusted Odds Ratio (AOR) and 95% Confidence Intervals (95%CI)) for partial nephrectomy (PN) for older (65+ years) and younger (<65 years) patients with T1a renal tumours. Model 1 adjusts for patient characteristics, tumour factors, diagnosis year and state; Model 2 adjust for all variables in Model 1 and health-service characteristics. (NB: Patients not treated by surgery excluded from analyses).

	Age					
	64 years and under (n=530)			65 years and over (n=334)		
Characteristic	**% PN**	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)	**% PN**	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)
	Patient Characteristics					
Age (mean years)	(52.7)	1.00 (0.97-1.02)	1.00 (0.97-1.02)	(71.9)	0.94 (0.89,0.99)	0.94 (0.89,0.99)
Sex						
Male	62.9		1	45.1	**1**	1
Female	58.9	0.88 (0.58,1.34)	0.91 (0.59,1.40)	41.2	0.85 (0.50, 1.44)	0.85 (0.50,1.44)
Co morbidities						
None (0)	62.3	1	1	46.5	1	1
Low (1)	60.4	0.95 (0.56, 1.59)	1.16 (0.67, 2.01)	42.0	0.90 (0.48, 1.67)	0.94 (0.50, 1.76)
Medium or more (2+)	58.8	0.55 (0.31, 0.98)	0.59 (0.33,1.07)	40.8	0.86 (0.47,1.59)	0.91 (0.48,1.70)
Socio-economic						

group						
High	70.6	1	1	47.1	1	1
Mid	54.8	0.54 (0.34, 0.88)	0.59 (0.36, 0.98)	41.7	0.93 (0.51, 1.69)	0.99 (0.53,1.86)
Low	52.8	0.60 (0.35,1.02)	0.58 (0.33, 1.02)	39.8	0.85 (0.44, 1.66)	0.85 (0.42,1.71)
Urban/rural residence						
Urban	65.4	1	1	48.4	1	1
Regional	53.2	0.62 (0.39,0.98)	0.72 (0.45, 1.16)	34.8	0.50 (0.28, 0.90)	0.57 (0.32, 1.04)
eGFR						
90-high	60.9	1	1	51.4	1	1
60-<89	59.9	1.02 (0.63,1.67)	0.90 (0.54, 1.51)	37.6	0.54 (0.27, 1.07)	0.53 (0.26, 1.07)
< 60	63.9	2.48 (0.83,2.64)	1.39 (0.76, 2.52)	45.3	1.19 (0.59, 2.39)	1.17 (0.57, 2.39)
missing	66.7	1.82 (0.56,5.85)	1.87 (0.57, 6.17)	45.5	0.66 (0.16, 2.74)	0.73 (0.17, 3.13)
	Tumour characteristics					
Tumour size						
<2cm	81.7	1	1	69.7		1
2-<3cm	74.8	0.68 (0.33,1.42)	0.72 (0.34,1.51)	53.3	0.39 (0.16, 0.96)	0.36 (0.14, 0.89)
3-4cm	46.0	0.17 (0.08, 0.34)	0.16 (0.08,0.33)	32.4	0.14 (0.06, 0.34)	0.13 (0.05,0.32)

Tumour location						
Central/entire kidney	58.2	1	1	43.7	1	1
Affecting poles only	65.6	1.45 (0.93,2.27)	1.58 (1.00, 2.50)	48.4	1.54 (0.87, 2.71)	1.53 (0.86, 2.74)
Not known	48.2	1.10 (0.53,2.25)	1.11 (0.53, 2.36)	41.0	0.74 (0.30, 1.82)	0.76 (0.30, 1.91)
Growth Pattern from Imaging						
Exophytic	77.2	1	1	51.8	1	1
Endophytic	37.5	0.17 (0.06,0.48)	0.18 (0.06, 0.53)	17.6	1.17 (0.04, 0.70)	0.15 (0.03, 0.62)
No image/not described	50.4	0.30 (0.19,0.46)	0.29 (0.18, 0.46)	41.5	0.75 (0.44, 1.29)	0.70 (0.40, 1.21)
	Health-service Characteristics					
Hospital type						
Public	58.8	-	1	43.2	-	1
Private	64.6	-	1.34 (0.82, 2.19)	44.1	-	1.30 (0.71, 2.37)
Treatment centre RCC volume						

60 or more /year	73.8	-	1	40.0	-	1
24 -59 / year	66.6	-	0.85 (0.38,1.92)	51.1	-	1.87 (0.79, 4.44)
12-23 / year	52.5	-	0.33 (0.14,0.76)	39.5	-	1.15 (0.47, 2.80)
1-11/year	42.9	-	0.31 (0.13, 0.76)	35.2	-	0.89 (0.34, 2.35)
	State					
Victoria	64.4	1	1	53.0	1	1
Queensland	57.7	0.72 (0.47, 1.09)	0.71 (0.46,1.10)	32.5	0.32 (0.19, 0.56)	0.32 (0.18, 0.57)

AOR Adjusted Odds Ratio: ORs adjusted for all variables in the table.

Diagnosis year included in analyses as a covariate.

Table 4: Multivariable associations (Adjusted Odds Ratio (AOR) and 95% Confidence Intervals (95%CI)) with having laparoscopic surgery and Model 1: patient, tumour, health-service characteristics; Model 2: patient, tumour, health-service characteristics and type of surgical procedure for patients with T1a renal tumours treated by surgery.

		Surgical approach		
		Laparoscopic surgery		
Characteristic	N for each group	N (%)	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)
Patient Characteristics				
Age				
Under 65 years	530	362 (68.3)	1	1
65 years and over	335	249 (74.3)	1.41 (1.01,1.99)	1.17 (0.82,1.68)
Sex				
Male	543	368 (67.8)	1	1
Female	322	243 (75.5)	1.59 (1.14,2.21)	1.52 (1.08,2.15)
Co morbidities				
None (0)	486	358 (73.7)	1	1
Low (1)	188	124 (66.0)	0.59 (0.40, 0.87)	0.57 (0.38, 0.86)
Medium or more (2+)	191	129 (67.5)	0.72 (0.49, 1.07)	0.65 (0.43,0.98)

Socio-economic group				
high	393	282 (71.8)	1	1
Mid	264	175 (66.3)	0.74 (0.51,1.07)	0.66 (0.44,0.97)
low	207	154 (74.4)	1.06 (0.69,1.63)	0.98 (0.62,1.55)
Urban/rural residence				
Urban	576	406 (70.5)	1	1
Regional	288	205 (71.2)	1.09 (0.76, 1.55)	0.97 (0.66, 1.41)
eGFR				
90-high	343	241 (70.3)	1	1
60-<89	266	192 (72.2)	1.06 (0.72,1.55)	0.98 (0.65, 1.46)
< 60	227	158 (69.6)	0.87 (0.58,1.30)	0.90 (0.59, 1.38)
missing	29	20 (69.0)	0.69, (0.29,1.65)	0.74 (0.30, 1.84)
Tumour characteristics				
<2 cm	104	61 (58.7)	1	1
2-<3 cm	325	212 (65.2)	1.27 (0.79, 2.02)	1.09 (0.67, 1.77)
3-<4cm	436	338 (77.5)	2.29 (1.44, 3.65)	1.40 (0.85, 2.30)
Tumour location				
Central tumour	268	190 (71.9)	1	1

Affecting poles only	506	357 (70.6)	0.98 (0.70, 1.38)	1.09 (0.76, 1.57)
Not known	91	64 (70.3)	0.87 (0.50, 1.51)	0.85 (0.47, 1.53)
Growth Pattern from Imaging				
Exophytic	341	222 (65.1)	1	1
Endophytic	41	34 (82.9)	2.69 (1.09, 6.15)	1.61 (0.65, 4.98)
No image/not described	483	355 (73.5)	1.34 (0.97,1.86)	1.05 (0.75, 1.48)
Health-Service Characteristics				
Hospital type				
Public	449	312 (69.5)	1	1
Private	416	299 (71.9)	1.30 (0.89, 1.88)	1.40 (0.95, 2.07)
Treatment centre RCC volume				
60 or more /year	111	68 (61.3)	1	1
24 -59 / year	425	309 (72.7)	2.26 (1.32, 3.86)	2.51 (1.44, 4.37)
12-23 / year	208	144 (69.2)	1.89 (1.09, 3.29)	1.66 (0.92, 2.96)
1-11/year	121	90 (74.4)	2.21 (1.20,4.05)	1.91 (1.00, 3.62)
State				
Victoria	470	338 (71.9)	1	1

Queensland	395	273 (69.1)	1.02 (0.74, 1.40)	0.85 (0.60, 1.19)
Type of Surgical procedure				
Radical Nephrectomy	394	340 (86.3)	-	1
Partial Nephrectomy	471	271 (57.5)	-	0.20 (0.13, 0.29)

AOR Adjusted Odds Ratio: ORs adjusted for all variables in the table.

Diagnosis year included in analyses as a covariate.

Table 5: Proportion of older and younger surgical patients with documented post-operative complications for those having partial nephrectomy, those having laparoscopic surgery and all surgical patients.

	Surgery characteristics				All surgical patients		
	Partial Nephrectomy		Laparoscopic surgery				
Post operative complication	<65 years %	65+ Years %	<65 years %	65+ years %	<65 years %	65+ years %	Total %
Deep vein thrombosis	0	0.7	0.	0.4	0	0.8	0.3
Wound infection	1.5	1.4	2.8	0.8	2.8	1.4	2.2
Post operative pneumonia	2.1	3.0	1.1	0.8	1.5	1.7	1.6
Haemorrhage requiring transfusion	3.3	3.6	2.2	3.2	2.8	3.3	3.0
Unplanned return to theatre	1.5	1.2	1.7	0.8	1.3	0.8	1.1
Unplanned ICU^	4.8	6.7	3.9	6.4	4.6	7.0	5.5

^ ICU. Intensive Care Unit

Table 6: Number (percent) of clinicians treating RCC agreeing (strongly agree/agree) or disagreeing (strongly disagree /disagree) to statements regarding partial nephrectomy for stage 1 renal cancer and the extent patient age, renal function and health influence treatment decisions by clinician state and caseload[#].

	There is insufficient evidence to use partial nephrectomy in T1RCC				PN treatment of choice for most T1aN0M0 tumours				For most T1N0M0 tumours, laparoscopic radical nephrectomy is a better option than partial nephrectomy			
	State		Caseload		State		Caseload		State		Caseload	
	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)
Disagree	33 (83)	21 (68)	35 (78)	18 (75)	2 (5)	7 (23)	6 (14)	3 (13)	27 (75)	23 (82)	33 (79)	17 (77)
Agree	7 (18)	10 (33)	10 (22)	6 (25)	37 (95)	23 (77)	38 (86)	21 (87)	9 (25)	5 (18)	9 (21)	5 (23)
P-value	*0.148*		*.795*		*0.026*		*0.895*		*0.49*		*0.905*	
How much do the following issues influence the type of surgical procedure you recommend to patients with RCC												
	Patient's age?				Patient's renal function?				Patient's general health?			
	State		Caseload		State		Caseload		State		Caseload	
	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)	Vic N (%)	Qld N (%)	Low 1-23/yr N (%)	High 24+/yr N (%)
A great	11	5	10	6	32	28	37	22	33	22	33	20

deal	(27)	(17)	(21)	(25)	(78)	(88)	(79)	(92)	(81)	(69)	(70)	(83)
To some extent/ A little/ not at all	30 (73)	24 (83)	37 (79)	18 (75)	9 (22)	4 (12)	10 (21)	2 (8)	8 (19)	10 (31)	14 (30)	4 (17)
P-value	*0.251*		*.722*		*0.295*		*0.169*		*0.248*		*0.229*	

[#] Treating 24+ cases of renal cancer a year (2+ patients a month) classified as high caseload. Clinicians treating fewer than this were classified as low caseload.

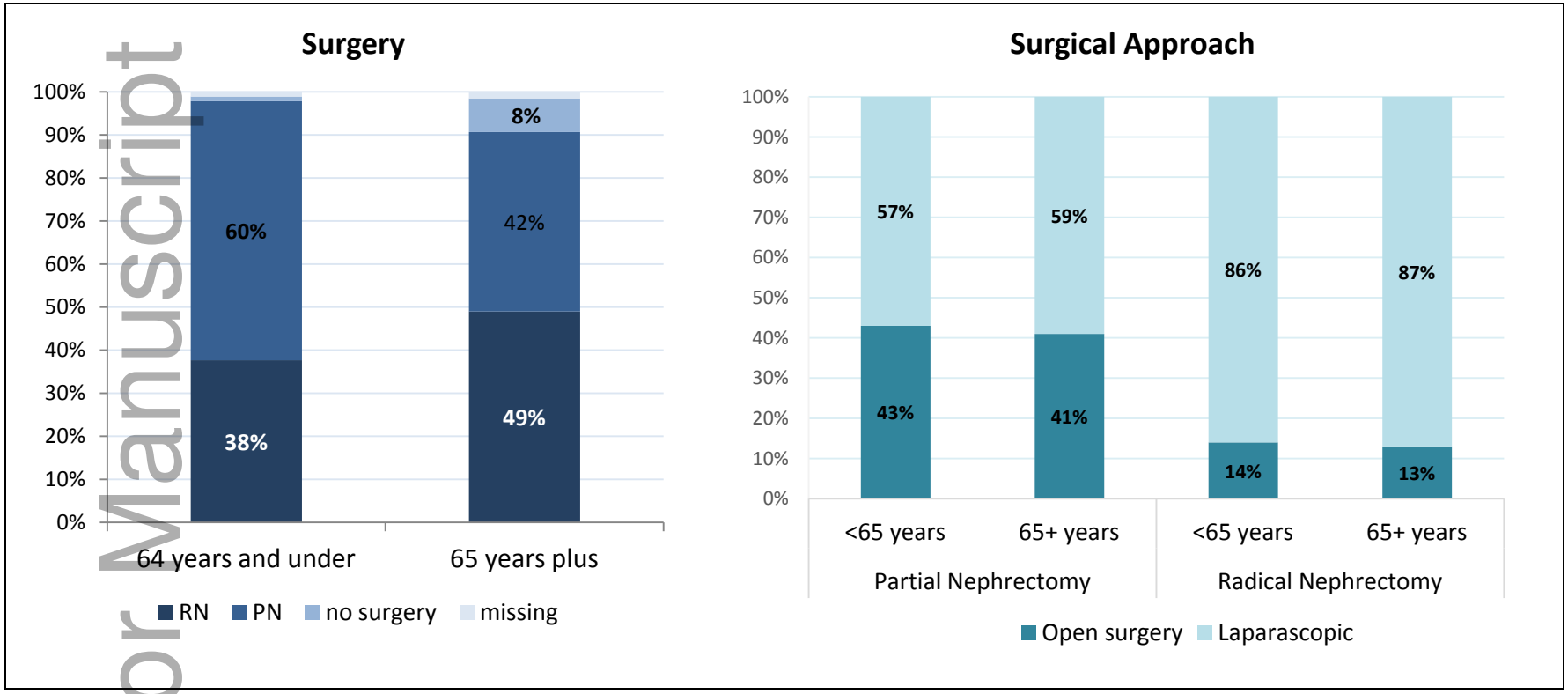

Figure 1: For all older (65 years and over) and younger (64 years and under) patients, proportion having different surgical procedures (left) and for those having surgery, surgical approach (right) (patients not having surgery included in analyses).

PN=partial nephrectomy, RN= radical nephrectomy; Lap=laparoscopic surgery; Open= open surgery.