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In-hospital mortality following surgical lung biopsy for interstitial lung disease in the USA: 2000-2011

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JPH, AWF, TMM and RBH conceived and designed the study. JPH obtained, prepared and analysed the data, with assistance from TMM. JH wrote the first draft; all authors were involved in reviewing and shaping the manuscript, and all approved the final version prior to submission.

Running head: Mortality after lung biopsy for pulmonary fibrosis

Subject code: 9.23 – Interstitial lung disease

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Surgical lung biopsy for interstitial lung disease can help to clarify the diagnosis, but mortality has been reported to be high in some case series.

What This Study Adds to the Field

In a large national dataset, in-hospital mortality after elective lung biopsy was 1.7%, but significantly higher in non-elective procedures. Male sex, increasing age and co-morbidity were associated with increased risk.

This article has an online data supplement, which is accessible from this issue's table of content online at www.atsjournals.org

In-hospital mortality following surgical lung biopsy for interstitial lung disease in the USA: 2000-2011

John Hutchinson, Andrew Fogarty, Tricia McKeever, Richard Hubbard

Abstract

Rationale: Surgical lung biopsy can help to determine a specific diagnosis in interstitial lung disease, but has associated risks. Most currently available mortality data are derived from case series and may not be generalizable to broader populations.

Objectives: We aimed to assess in-hospital mortality following surgical lung biopsy for interstitial lung disease in a national secondary care dataset from the United States.

Methods: Data were obtained from the 2000-2011 Nationwide Inpatient Sample. Cases were identified using International Classification of Diseases (ICD-9-CM) codes for interstitial lung disease and surgical lung biopsies. Lung resections and cases of lung cancer were excluded. Weighted data were used to estimate numbers of biopsies nationwide and in-hospital mortality, and multivariable logistic regression was used to adjust for sex, age, geographic region, co-morbidity, type of operation and provisional diagnosis.

Measurements and Main Results: We estimated there to be around 12,000 surgical lung biopsies performed annually for interstitial lung disease in the United States, two-thirds of which were performed electively. In-hospital mortality was 1.7% for elective procedures, but significantly higher for non-elective procedures (16.0%). Male sex, increasing age, increasing co-morbidity, open surgery and a provisional diagnosis of idiopathic pulmonary fibrosis or connective tissue disease related interstitial lung disease were risk factors for increased mortality.

Conclusions: In-hospital mortality following elective surgical lung biopsy for interstitial lung disease is just under 2%, but significantly higher for non-elective procedures. Identified risk factors for death should be taken into account when counselling patients on whether to pursue a histological diagnosis.

Abstract word count: 248

Keywords: interstitial lung disease, mortality, surgery

Introduction

In a patient with characteristic clinical features, a confident diagnosis of idiopathic pulmonary fibrosis (IPF) can be made after excluding alternative causes of interstitial lung disease (ILD) and demonstrating typical features on high-resolution computed tomography (HRCT) of the lungs (1). In patients with atypical features on imaging or other cause for diagnostic uncertainty, a surgical lung biopsy may be required to confirm diagnosis. This may be important for management, as treatment options and prognosis differ greatly between the various types of ILD.

As patients with ILD often have impaired pulmonary function, the risks of thoracic surgery are an important consideration when contemplating surgical lung biopsy. Several case series have explored morbidity and mortality following the procedure, with 30-day mortality varying from 0-24% (2, 3).

This study aims to assess the risks of surgical lung biopsy for ILD in the United States using a national secondary care dataset.

Methods

We used the Nationwide Inpatient Sample (NIS), an anonymised stratified yearly sample of US community hospitals (4). Individual records represent discharges from hospital, and details are provided on diagnoses and procedures using coding based on the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). To preserve confidentiality, unique patient identifiers are unavailable. Further information on the NIS is available in the online supplement.

We used data from 2000-2011, and selected all records with the following ICD-9-CM codes for interstitial lung disease: 515 (post-inflammatory pulmonary fibrosis), 516.3 (idiopathic fibrosing alveolitis), 517.2 (lung involvement in systemic sclerosis), 714.81 (rheumatoid lung), 517.8 (lung involvement in diseases classified elsewhere), 495 (extrinsic allergic alveolitis), 500-505 (pneumoconiosis, including asbestosis) and 135 (sarcoidosis). Codes 517.2, 714.81 and 517.8 were

grouped together as connective tissue disease related ILD (CTD-ILD). Code 516.3 was labelled 'idiopathic pulmonary fibrosis clinical-syndrome' (IPS-CS) to reflect the fact that most of these cases would be IPF, but some would be other idiopathic interstitial pneumonias (5). We then selected those hospital stays involving a surgical lung biopsy using the following ICD-9-CM procedure codes: 33.28 (open biopsy of lung), 32.29 (other local excision or destruction of lesion or tissue of lung), 33.20 (thoracoscopic lung biopsy) and 32.20 (thoracoscopic excision of lesion or tissue of lung) – the latter two codes being introduced in October 2007. We considered the 'biopsy' codes (33.28 and 33.20) to be potentially more accurate than the 'excision' codes (32.29 and 32.20) and therefore also carried out a sensitivity analysis using these alone.

We excluded records with additional codes for segmental resection, lobectomy or pneumonectomy that implied a therapeutic rather than diagnostic procedure. We also excluded records with a diagnostic code for lung cancer to ensure that diagnostic procedures for malignancy were not included. We focussed on procedures coded as 'elective' or 'scheduled' (as opposed to 'non-elective' – 'urgent' or 'emergency'), as these would be most relevant to the clinician planning a biopsy in the office setting.

We used weighted data to estimate the frequency of biopsy procedures nationwide. Our primary outcome measure was in-hospital mortality. We assessed risk factors for mortality using multiple logistic regression, adjusting for age, gender, census region, type of operation (thoracoscopic vs open) and co-morbidity. Co-morbidity was assessed using the updated Charlson index (6, 7): scores were derived from additional diagnostic codes, and matched according to published guidance (8) (see online supplement for further details). As the specific diagnosis in the discharge record may not have been the final pathological diagnosis, we presumed this to be the working or provisional diagnosis, and assessed its effect on mortality in our multivariable model, excluding records with multiple ILD diagnoses for clarity.

We also assessed length of stay and presence of complications. Complications were derived from additional diagnostic codes and therefore only assessed for elective procedures to exclude problems occurring prior to unplanned inpatient surgery. We limited our assessment to conditions we were confident were acute post-operative complications (see online for further details).

Statistical analysis was performed using Stata, version 13.1 (StataCorp, USA). To account for the complex stratified sample design, estimates were calculated using the specialized survey commands, taking account of year and strata, and using weights to create national estimates (9).

Results

After exclusions, there were 32,022 records with a surgical lung biopsy for interstitial lung disease in the NIS between 2000-2011 (see Figure 1). Using weighted data, 66.3% of admissions were for elective procedures, 32.2% were for non-elective procedures, and for 1.5% the urgency of the operation was not clear. 48% of total records were male, with 61% below age 65 (Table 1: unweighted 'raw' data; Table E1A (online): weighted data). Total numbers of records by year are presented online (Table E1B), alongside demographics for both 'biopsy' and 'excision' codes (Tables E2-E3).

After applying weightings to adjust for sampling, we estimated there to be around 12,000 surgical lung biopsies performed for ILD each year in the United States (see Table E4, online). Numbers were relatively stable over time (Figure 2), although use of 'biopsy' codes decreased, and 'excision' codes became more prevalent (see Table E5-E6, online).

Biopsies were less commonly performed in the West census region (see Tables E7-9 online). The most commonly coded provisional diagnosis (excluding cases with more than one type of ILD coded) was post-inflammatory fibrosis (PIF, ICD-9-CM 515, 80% of the cohort), followed by IPF-CS (9.3%) and sarcoidosis (5.4%). 8.3% of records had codes for more than one type of ILD (excluded from the

multivariable analysis). The estimated number of biopsies for a suspected diagnosis of IPF-CS dropped noticeably around 2003 (Figure 3).

There were 2,051 deaths recorded prior to hospital discharge in our biopsy cohort. Nationally there were estimated to be 9,700 deaths (95% confidence intervals (CI) 9,209-10,192) following surgical lung biopsy for ILD (prior to hospital discharge) between 2000 and 2011, giving an overall in-hospital mortality of 6.4% (95% CI 6.1%-6.7%). This comprised 1,695 deaths following elective operations (95% CI 1,506-1,883), giving an in-hospital mortality of 1.7% (95% CI 1.5%-1.9%), and 7,796 deaths following non-elective operations (95% CI 7,361-8,230), giving an in-hospital mortality of 16.0% (95% CI 15.2%-18.8%). In-hospital mortality reduced over time (see Table 2, Figure 4).

Increasing mortality was associated with male sex, increasing age, higher co-morbidity scores, undergoing open rather than thoracoscopic surgery, and having a provisional diagnosis of IPF-CS or CTD-ILD (see Table 3 (elective patients), Tables E10-11 (overall and non-elective patients) – all weighted data). After adjusting for sex, age, co-morbidity, census region, type of operation and provisional diagnosis, the associations remained significant. There were some differences between regions but no clear trends for both elective and non-elective procedures. Repeating the analyses for records with 'biopsy' codes only made a small difference to the overall results: mortality increased to 2.6% in elective patients (9.4% overall, 20.0% non-elective patients), and most of the associations were strengthened slightly (see Tables E12-E14 – online).

Table 4 shows the risk of in-hospital mortality following elective surgical lung biopsy for ILD using the key demographic determinants of sex, age and co-morbidity level (6). Co-morbidity was classified into two categories: an Updated Charlson score of 0-1 (consistent with either no co-morbidity, or a single lower scoring condition such as chronic pulmonary disease, diabetes or renal disease), or an updated Charlson score 2 or greater (consistent with multiple co-morbidities, or a single higher-scoring condition such as liver disease, dementia, heart failure, or malignancy) – further details are

available online. This table demonstrates the significant increase in mortality with male sex, increasing age and increasing co-morbidity.

The median length of stay in our cohort of patients was 5 days**,** with a range of 0-308 days. 96% of records were for stays of 30 days or less. Excluding those remaining in hospital more than 30 days, in-hospital 30-day mortality was 5.4% (1.5% for elective patients, 14.2% for non-elective patients). Median length of stay was less for elective operations (3 days vs 12 days).

Possible complications were estimated to occur in 30% of elective records. The most common were post-operative pneumothorax (8.7%), pulmonary collapse (6.4%), pneumonia (5.8%), pleural effusion (3.2%), respiratory failure (3.1%), other respiratory complications (encompassing ventilator-associated pneumonia, chemical pneumonitis and transfusion-related acute lung injury) (2.0%), ventilator dependence (1.8%), acute kidney injury (1.7%), bleeding complications (accidental puncture, laceration, bleeding, haemorrhage or haematoma complicating the procedure) (1.7%), and surgical emphysema (1.1%).

Discussion

Our cohort of surgical lung biopsies for ILD from hospitals across the United States has shown in-hospital mortality of just under 2% for elective operations, but a significantly increased mortality (16%) for non-elective (urgent and emergency) procedures. There was a strong but unsurprising link of mortality risk with increasing age and co-morbidity, and also associations with male sex, open rather than thoracoscopic surgery, and a suspected diagnosis of IPF-CS or CTD-ILD.

The size of our cohort, at over 30,000 procedures, is the largest reported series of surgical lung biopsies for interstitial lung disease, and encompasses multiple centres from a large country. The NIS is the largest all-payer inpatient care database that is publically available in the US, including patients covered by Medicare, Medicaid, private insurance and the uninsured, and therefore is likely to be

representative of the wider patient population. We focussed on later years of the dataset (year 2000 onwards) that were likely to have higher data completeness, with weightings used to adjust for sampling techniques. Although there is no universally-agreed standard for assessing co-morbidity using large datasets, our use of a contemporaneous score and published coding guidance helped ensure that our measures of co-morbidity were reliable. We identified some differences between regions of the US, although it is unclear whether this reflects variation in clinical practice or disease incidence.

The main limitation with using the NIS was the lack of unique patient identifiers, which limited our ability to assess re-admissions, and raised the concern that a patient could be included more than once. However, it would be unusual for a patient to undergo a surgical lung biopsy on multiple occasions. A further limitation was the different diagnostic codes used for surgical lung biopsies, which in turn are dependent on clinical coders' interpretations of operation notes, however we used both broader and narrower terms to assess this impact. The large difference between elective and non-elective procedures could be affected by incorrect coding, however it would be expected that more urgent cases might have higher mortality due to the severity of their illness. Our exclusion of records with a code for lung cancer may have excluded some biopsy patients (who are likely to have been higher risk) but we felt this was necessary to prevent inclusion of those undergoing biopsies for their cancer. It is possible that some patients with suspected malignancy but no confirmed diagnostic code were included in the cohort inappropriately, but it is hoped these would be a small group. One disadvantage of using discharge records compared to a case series was the lack of a definitive histological diagnosis, and the popularity of the non-specific ICD-9-CM code for post-inflammatory fibrosis – a condition not widely recognised in updated guidelines – limited our ability to assess the impact of the type of ILD.

We were unable to assess 30-day or 90-day mortality, measures commonly used in other case series, and since the vast majority of our patients were discharged within 30 days it is likely that 30-day

mortality would be slightly higher than our estimate, to account for deaths at home and after re-admissions. Our analysis of co-morbidity codes was only able to include those mentioned on the admission record, and it is possible that having a longer baseline period would have captured further conditions – thereby putting patients into higher risk co-morbidity categories, and potentially lowering the mortality risk associated with higher co-morbidity – however it would be hoped that the more significant co-morbidities coded with the updated Charlson score would be highlighted on an inpatient admission. Finally, we lacked reliable data on medications such as corticosteroids, immunosuppression, anticoagulation and pre-operative oxygen requirements, all of which have been associated with adverse outcomes in surgical lung biopsy case series (10-12), and these should clearly be taken into account when counselling patients on risk. Nevertheless, our risk table (Table 6) gives a reasonable estimate of surgical risk that may be useful in the pre-operative consultation. The possibility that this may underestimate the true risks (due to exclusion of some higher risk patients and those dying after hospital discharge, and misclassification of some patients as 'non-elective') should be kept in mind.

We systematically reviewed the literature for studies reporting mortality after surgical lung biopsy for interstitial lung disease, and identified over 50 reports from at least 20 countries. Differences in research aims, case selection (IPF vs any ILD), type of surgery (open vs thoracoscopic) and reporting outcomes (30 day mortality vs 'post-operative' or other) limited comparison between studies, but mortality estimates ranged from 0-34%. Studies reporting higher mortality tended to highlight the presence of acute symptoms, older age, pre-operative respiratory failure or mechanical ventilation, and immunosuppression as associated with poor outcomes (3, 13-17), suggesting more careful case selection could improve outcomes. Supporting this, one US study specifically of patients undergoing biopsy during an acute exacerbation showed survival in only 1 of 7 patients (18). Few studies distinguished between elective and non-elective surgery, although many included patients who were acutely unwell and likely to have undergone an urgent procedure.

Our estimate of 1.7% for in-hospital mortality following elective surgery is comparable with other estimates. Nguyen and Meyer (19) quoted 'overall mortality' of 3.5% in their recent comprehensive review of studies (2.1% mortality for thoracoscopic surgery, 4.3% for open), although it was unclear how many of these were elective procedures. Kreider *et al* reviewed previous studies in 2007, and derived a composite postoperative mortality of 4.5% (10), noting a significantly increased mortality of 47% in those requiring pre-operative ventilation compared to 2.2% in those free from ventilation. Overall, our data supports the far higher risk of surgery in unplanned procedures. The fact that one in three patients in our dataset underwent a non-elective procedure suggests that these higher risk procedures are still being performed regularly. While it is impossible to state the contribution of the surgery itself towards post-operative death, in a cohort who are clearly unwell due to underlying lung disease, patients should be aware of the mortality of those undergoing surgery in these circumstances. The decrease in procedures for suspected IPF-CS after 2003 likely reflects the publication of American Thoracic Society (ATS) guidelines clarifying the diagnostic criteria for IPF and suggesting biopsy is not needed in those with typical radiological appearances (20).

The overall incidence of ILD in the US is not clear, but studies of conditions such as rheumatoid-arthritis associated ILD and sarcoidosis suggest it is increasing (21, 22). Most data surrounds IPF, which seems to be increasing worldwide (23), although perhaps less so recently in the US (24, 25), which may reflect fewer patients meeting strict ATS criteria, and an increasing number with 'unclassified' ILD. It is possible that the stable absolute number of surgical lung biopsies performed over time reflects decreasing utilization of the procedure in an increasing number of ILD patients, who are being diagnosed more commonly using radiology and multi-disciplinary meetings.

In conclusion, our data suggests that surgical lung biopsy for interstitial lung disease is associated with in-hospital mortality of 1.7% in elective patients, but a significantly increased mortality of greater than 15% in unplanned procedures. Increasing age and co-morbidity were the main risk factors for mortality, but male sex, open surgery and a provisional diagnosis of IPF-CS or CTD-ILD

were also associated. Clinicians should make patients aware of the high risk nature of non-elective surgical biopsy for ILD, and tailor their advice to individual clinical risk profiles.

Acknowledgements

Source of data: Nationwide Inpatient Sample (NIS) 2000-2011, Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.

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Figure Legends

Figure 1: Flow diagram of selection process for records with a surgical lung biopsy for interstitial lung disease.

Figure 2: Estimated number of surgical lung biopsies nationwide for interstitial lung disease.

Figure 3: Estimated number of surgical lung biopsies nationwide for a suspected diagnosis of idiopathic pulmonary fibrosis clinical-syndrome (ICD-9-CM code 516.3).

Figure 4: In-hospital mortality following surgical lung biopsy for the diagnosis of interstitial lung disease.

Tables

Table 1: Demographics of biopsy cohort (unweighted data)

	Total admissions ***(n=32,022)***	**Elective admissions** ***(n=21,227)***	**Non-elective admissions** ***(n=10,310)***
	Number (%)	Number (%)	Number (%)
Sex			
Male	15,351 (47.94)	9,942 (46.84)	5,163 (50.08)
Female	16,671 (52.06)	11,285 (53.16)	5,147 (49.92)
Age group (years)			
<45	5,192 (16.21)	3,153 (14.85)	1,958 (18.99)
45-54	6,264 (19.56)	4,229 (19.92)	1,944 (18.86)
55-64	8,093 (25.27)	5,643(26.58)	2,331 (22.61)
65-74	8,147 (25.44)	5,623 (26.58)	2,406 (23.34)
75-84	4,037 (12.61)	2,431 (11.45)	1,535 (14.89)
>84	289 (0.90)	148 (0.70)	136 (1.32)
Level of co-morbidity (Updated Charlson score)			
0	13,908 (43.43)	10,627 (50.06)	3,030 (29.39)
1	10,844 (33.86)	7,158 (33.72)	3,558 (34.51)
2	3,304 (10.32)	1,728 (8.14)	1,523 (14.77)
3 or greater	3,966 (12.39)	1,714 (8.07)	2,199 (21.33)

Higher Updated Charlson score = greater co-morbidity.

Table 2: In-hospital mortality following surgical lung biopsy for interstitial lung disease, by year

Year of biopsy	Total admissions	Elective admissions	Non-elective admissions
	Deaths (% mortality)	Deaths (% mortality)	Deaths (% mortality)
2000	822 (7.6)	120 (1.2)	591 (16.6)
2001	962 (7.5)	173 (2.2)	690 (17.6)
2002	923 (6.9)	196 (2.1)	727 (17.5)
2003	934 (7.3)	173 (2.1)	761 (17.6)
2004	875 (7.0)	131 (1.6)	745 (18.8)
2005	876 (6.6)	148 (1.7)	727 (16.6)
2006	876 (6.6)	139 (1.6)	736 (16.5)
2007	696 (5.4)	116 (1.3)	580 (14.1)
2008	715 (5.8)	135 (1.6)	580 (15.0)
2009	709 (5.5)	123 (1.5)	586 (13.2)
2010	696 (5.7)	139 (1.7)	557 (14.3)
2011	617 (4.9)	101 (1.2)	516 (13.5)
Total	*9700 (6.4)*	1695 (1.7)	7796 (16.0)

Deaths estimates rounded to nearest integer. Totals calculated using raw data rather than sum of rounded values.

Table 3: Multivariable analysis – associations with in-hospital death after surgical lung biopsy – elective procedures

Variables	Cases	Deaths (%)	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Sex						
Female	53,552	733 (1.4)	1.00		1.00	
Male	47,147	962 (2.0)	1.50 (1.22-1.85)	<0.001	1.41 (1.14-1.76)	0.002
Age (years)						
<45	14,985	95 (0.6)	1.00	<0.001	1.00	<0.001
45-54	20,073	148 (0.7)	1.16 (0.67-2.01)	(p for trend)	1.20 (0.68-2.12)	(p for trend)
55-64	26,680	393 (1.5)	2.33 (1.42-3.83)		2.00 (1.19-3.38)	
65-74	26,702	611 (2.3)	3.66 (2.28-5.88)		3.09 (1.87-5.09)	
75-84	11,547	418 (3.6)	5.86 (3.63-9.47)		4.46 (2.69-7.40)	
>84	711	29 (4.0)	6.56 (2.58-16.65)		5.25 (2.16-12.74)	
Updated Charlson score						
0	50,389	410 (0.8)	1.00	<0.001	1.00	<0.001
1	33,949	509 (1.5)	1.86 (1.41-2.45)	(p for trend)	1.83 (1.38-2.43)	(p for trend)
2	8,222	359 (4.4)	5.56 (4.09-7.56)		5.17 (3.75-7.14)	
3 or more	8,139	417 (5.1)	6.58 (4.83-8.96)		5.95 (4.32-8.20)	
Geographical region						
South	35,345	716 (2.0)	1.00		1.00	
Northeast	22,108	234 (1.1)	0.52 (0.37-0.73)	<0.001	0.53 (0.37-0.76)	0.001
Midwest	26,824	492 (1.8)	0.91 (0.69-1.19)	0.477	0.94 (0.71-1.25)	0.668
West	16,421	252 (1.5)	0.75 (0.55-1.03)	0.076	0.75 (0.54-1.04)	0.083
Year group						
2000-2002	23,311	490 (2.1)	1.00	0.009	1.00	0.028
2003-2005	25,719	452 (1.8)	0.83 (0.62-1.12)	(p for trend)	0.83 (0.61-1.14)	(p for trend)
2006-2008	26,163	391 (1.5)	0.71 (0.53-0.95)		0.76 (0.56-1.05)	
2009-2011	25,505	362 (1.4)	0.67 (0.49-0.93)		0.67 (0.47-0.95)	
Type of operation (post-October 2007 patients only)						
VATS	26,647	314 (1.2)	1.00		-	-
Open	9,511	218 (2.3)	1.96 (1.36-2.83)	<0.001	-	-
Provisional diagnosis (patients with single ILD diagnostic code only)						
PIF	79,853	1,143 (1.4)	1.00		1.00	
IPF-CS	7,303	374 (5.1)	3.71 (2.83-4.88)	<0.001	3.17 (2.36-4.26)	<0.001
CTD-ILD	1,111	67 (6.0)	4.39 (2.52-7.64)	<0.001	2.93 (1.65-5.22)	<0.001
Sarcoid	5,270	15 (0.3)	0.19 (0.06-0.59)	0.004	0.28 (0.09-0.89)	0.031
Other	3,148	14 (0.5)	0.32 (0.10-1.00)	0.050	0.19 (0.06-0.61)	0.005

Multivariable analysis excludes type of operation due to lower numbers; type of operation remained significant if included.
Higher Updated Charlson score reflects greater degree of co-morbidity.
Estimated numbers of cases and deaths rounded to nearest integer.
VATS: video-assisted thoracoscopic surgery. OR: Odds Ratio; 95% CI: 95% confidence interval.
PIF: post-inflammatory fibrosis; IPF-CS: idiopathic pulmonary fibrosis clinical-syndrome; CTD-ILD: connective tissue disease related interstitial lung disease; 'Other': hypersensitivity pneumonitis and pneumoconioses (including asbestosis) – grouped due to smaller numbers.

Table 4: Risk of in-hospital mortality (percent (95% confidence intervals)) following elective surgical lung biopsy for interstitial lung disease, by age and co-morbidity.

		Age <55 years	Age 55-74 years	Age > 74 years
MALES	**Updated Charlson score: 0-1**	0.4% (0.19-0.67)	1.5% (1.20-1.92)	2.7% (1.82-3.86)
	Updated Charlson score: 2 or greater	3.7% (2.29-6.06)	5.4% (4.02-7.12)	10.1% (7.33-13.87)
FEMALES	**Updated Charlson score: 0-1**	0.4% (0.25-0.70)	1.1% (0.87-1.48)	1.9% (1.21-2.94)
	Updated Charlson score: 2 or greater	1.9% (1.00-3.46)	4.0% (2.95-5.48)	5.7% (3.36-9.51)

Updated Charlson score from Quan H *et al.* Updating and Validating the Charlson Comorbidity Index and Score for Risk Adjustment in Hospital Discharge Abstracts Using Data from 6 Countries. *Am J Epidemiol* 2011; 173: 676-682

For information on how to calculate the updated Charlson score, see Figure E1 in the online supplement.

Figures

Figure 1

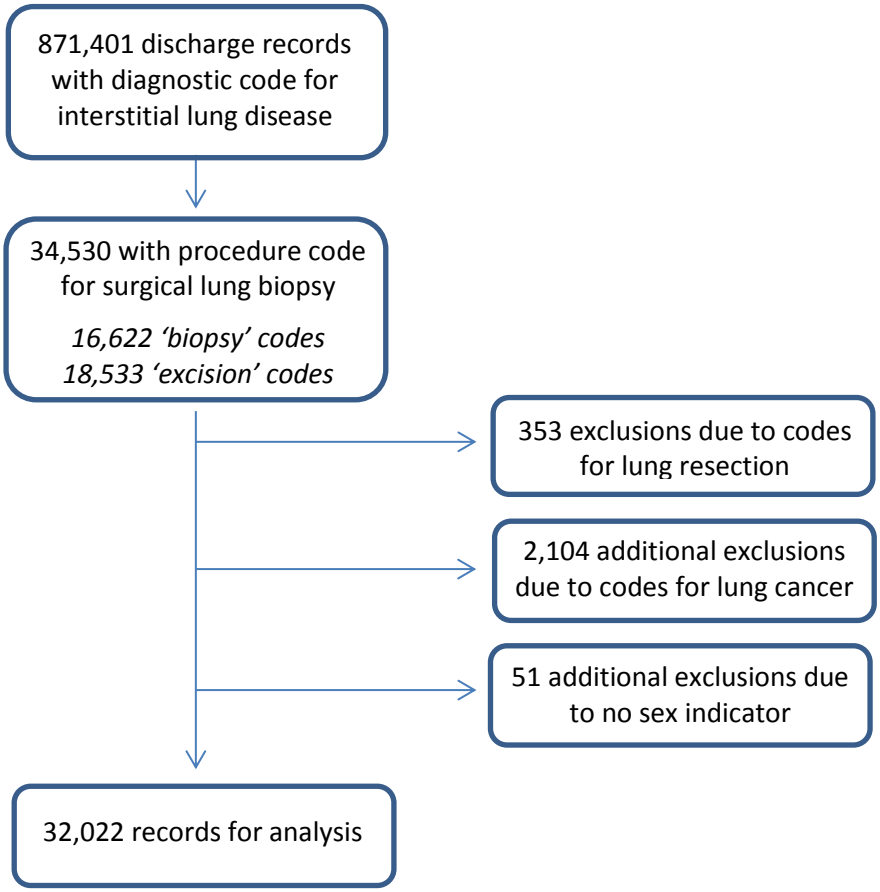


Figure 2

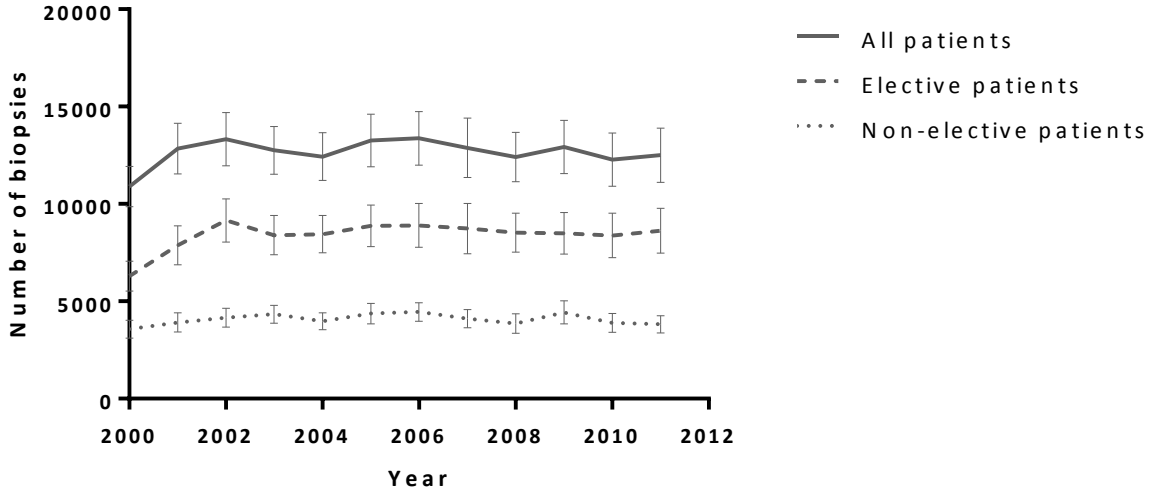


Figure 3

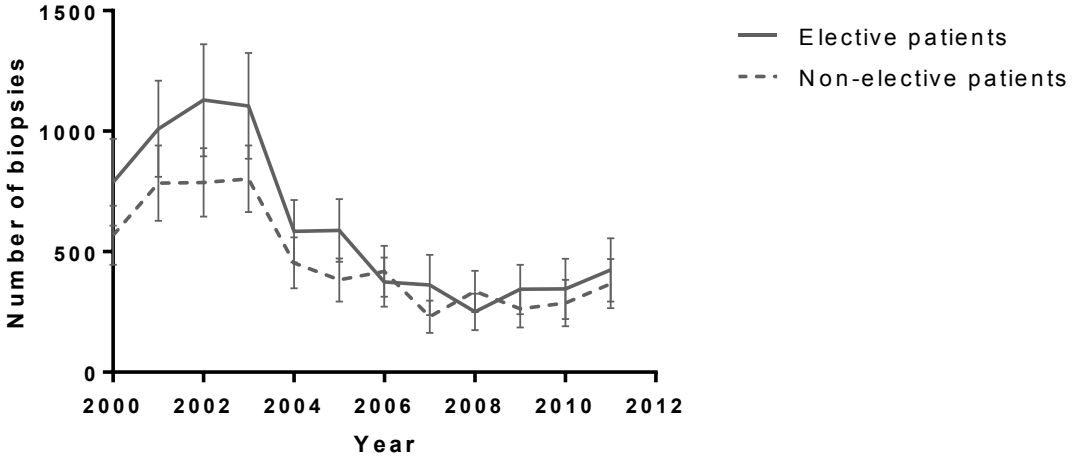
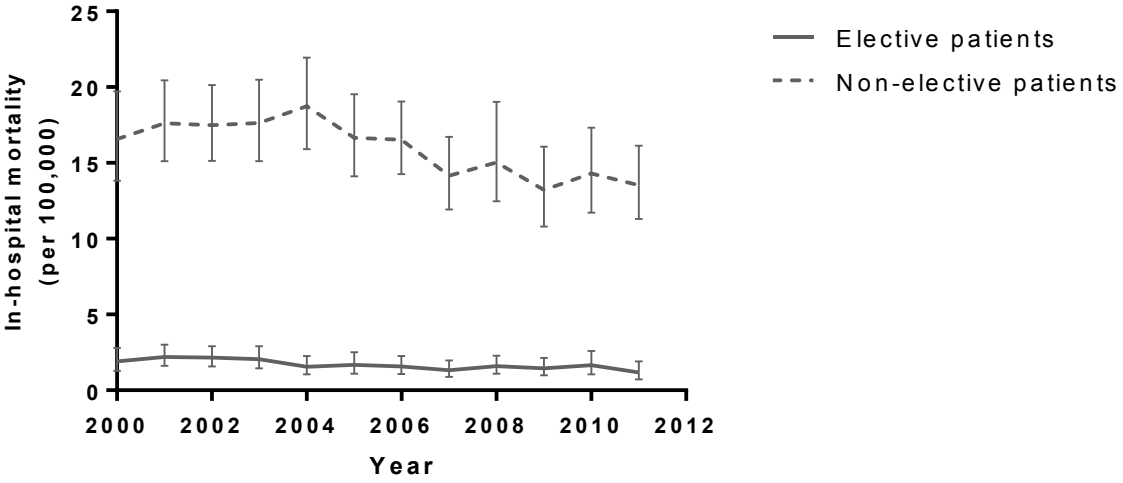


Figure 4


25
20
15
10
5
0
In-hospital mortality (per 100,000)
2000
2002
2004
2006
2008
2010
2012
Year
Elective patients
Non-elective patients