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Comorbidity among patients with colon cancer in New Zealand

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Abstract

Aims To identify patient factors that are associated with a higher risk of comorbidity, and to assess the impact of comorbidity on risk of in-hospital death, length of stay and 5-year all-cause survival among a large cohort of patients with colon cancer in New Zealand.

Methods Comorbidity data were collected from patients who were diagnosed with colon cancer and admitted to public hospitals during 1996–2003. The comorbidity measures included all conditions listed in the Charlson Comorbidity Index, as well as a predetermined list of additional conditions. We examined predictors of higher comorbidity scores. We also measured the impact of comorbidity on in-hospital death, length of stay and 5-year all-cause survival using logistic, linear and Cox proportional hazard regression models to adjust for confounding by sex, age, ethnicity, extent of disease and area level deprivation.

Results There were 11,524 patients included in the study. 7.5% of females and 10.3% of men had Charlson scores of three or more. Higher comorbidity scores were associated with increasing age, and were more common among males, Māori and Pacific people, those with unknown extent of disease and those living in the most deprived quintile of New Zealand. Those with Charlson scores ≥3 had a higher risk of in-hospital death (OR=4.8; 95% CI 3.5–6.6), longer lengths of hospital stay (0.14 days 95% CI 0.08–0.2) and lower 5-year survival HR=2.0; 95%CI=1.8–2.3) compared with those with a score of 0.

Conclusion This study confirms that comorbidity is common among colon cancer patients in New Zealand, and has an adverse and independent effect on outcomes related to mortality and length of hospital stay.

Comorbidity is the coexistence of diseases or conditions with a disease of interest.[1] Studies in other countries have found that regardless of the primary disease in question, comorbidity is associated with poorer quality of life, longer and more expensive hospital stays, and poorer survival.[2–4] There has been little work published on the prevalence or impact of comorbidity among patients in New Zealand.

A paper by Davis et al[5] involved a hospital notes review of 1575 patients from the Auckland region in which screeners identified comorbid disease using the Charlson comorbidity index. Māori ethnicity, and living in more deprived areas were associated with comorbidity, which in turn was associated with a range of adverse outcomes including length of stay and inpatient mortality. However, the authors were not able to adjust the analyses for primary diagnosis other than through major diagnostic category of primary condition (e.g. circulatory system, digestive system). This is important because primary diagnosis is likely to have strongly confounded the

relationships between risk factors, comorbidity and adverse outcomes. Other studies have investigated the role of comorbidity in mediating cancer related outcomes.[6–8]

The study reported here uses routine data to focus on both the factors that predict comorbidity, and the impact of comorbidity measured using in-hospital death, length of stay and 5-year all-cause survival, among patients in the New Zealand context.

This study was carried out among a large group of patients admitted to hospital for surgical resection of colon cancer. We selected colon cancer for several reasons. First, for a subset of those with colon cancer, we had specific study data available to validate the comorbidity information held in routinely collected administrative datasets.[9]

Second, there is evidence that comorbidity affects outcomes from colon cancer both through the additional physiological burden of disease among those with comorbidity, and indirectly through the impact of comorbidity on treatment decisions.[6] Third, colon cancer affects mainly older people among whom comorbidity is relatively common.[10] Finally, colon cancer is not strongly associated with risk factors that are simultaneously risk factors for other major causes of comorbidity and death (such as cardiovascular disease).

This paper therefore aims to address three key questions. Firstly, how common is comorbidity in a large cohort of colon cancer patients in New Zealand? Secondly, what factors predict higher levels of comorbidity in this cohort? And finally, to what extent does comorbidity predict in-hospital death, length of stay and 5-year survival for patients admitted for surgical resection of colon cancer?

Methods

Patients were identified from the New Zealand Cancer Registry with a primary tumour in the colon (ICD-10-AM site codes C18-C19 excluding 18.1) and morphology consistent with adenocarcinoma, diagnosed between 1996 and 2003. Patients were ineligible if they were less than 25 years of age at diagnosis, were normally resident outside New Zealand, had a previous diagnosis of colon cancer, or were diagnosed after death.

Routine hospital discharge data coded to ICD-9-CM-A were obtained from New Zealand Health Information Service in 2005. We treated the first admission for surgical resection of colon cancer as the index admission. Where a patient did not receive surgical resection, we treated the first hospital admission with colon cancer as primary diagnosis as the index admission. Those without such an admission were excluded from the study. We used both principal and secondary diagnosis fields to identify comorbid conditions using an 8-year lookback period, this being the longest possible time for lookback for the earliest cancer registrations.

We identified all conditions included in the Charlson comorbidity index, as well as some additional conditions, listed in Table 1. The Charlson index was developed in 1987 using data from a cohort of 607 medical patients, and validated with a population of breast cancer patients.[11] Nineteen conditions are allocated a weight of 1 to 6 depending on the adjusted relative risk of 1-year mortality, and summed to give an overall score. A score of 0 indicates that none of these conditions were present, and higher scores indicate higher levels of comorbidity.

We used the Charlson index scores either uncategorised (when used as a dependent variable in regression) or categorised into 0, 1, 2 or 3+ (when used as a predictor of the outcome variables), and we also investigated the roles of specific comorbid conditions.

We used the Deyo et al[12] system which provides a method of translating the Charlson index which was originally constructed using medical notes review for use on administrative data using ICD coding. The algorithm was modified to take account of the fact that we collected data on additional conditions to those included in the Charlson Index (Table 1).

We followed the approach of Deyo et al,[12] except that we included non-colorectal malignancies in our definition of comorbidity if they were listed in index or prior hospital discharges.[13]

Table 1. Diagnostic codes used for mapping

Diagnostic category	ICD-9 codes
Myocardial infarction	410.x, 412*
Congestive heart failure	428.x
Peripheral vascular disease	441.x*, 443.9*, 785.4*, V43.4*, procedure 38.48
Cerebrovascular disease	430-437.x, 438*
Dementia	290.x*
Chronic respiratory disease	490-496*, 500-505*, 506.4*
Connective tissue disease	710.0-710.1*, 710.4*, 714.0-714.2*, 714.81*, 725*
GI ulcer disease	531.x-534.9*
Mild liver disease	571.2*, 571.4*, 571.5*, 571.6x*
Diabetes (mild to moderate)	250.0x-250.3x*, 250.7x*
Hemiplegia or paraplegia	342.x*, 344.1*
Moderate or severe renal disease	582.x*, 583.0-583.7*, 585*, 586*, 588.x*
Diabetes with end organ damage	250.4x-250.6x*
Any malignancy (except colon or rectal) including lymphoma or leukaemia	140.x-152.x*, 155.x-172.0*, 174.x-195.8*, 200.x-208.x*
Moderate or severe liver disease	572.2-572.8*, 456.0-456.21*
Metastatic solid tumour	196.x-199.1
AIDS	042.x-044.x
Angina‡	411.1*, 413.0*, 413.1*, 413.9*
Essential hypertension‡	401.x
Cardiac arrhythmias‡	426.x-427.x
Previous pulmonary embolism‡	415.1
Cardiac valve disease‡	394.x-397.0*, 424.0-424.3*
Inflammatory bowel disease‡	555.x*, 556.x*
Other neurological condition‡ [a]	332.x-336.x*, 340.x*, 341.x*, 343.x*, 345.x*, 358.x*, 359.x*
Major psychiatric conditions‡ [b]	295.x*, 296.x*, 298.0*

* included in definition of a comorbidity if they are listed either in the index or prior hospital discharge; other codes only included if they are recorded prior to index admission

‡ not included as part of Charlson Comorbidity Index

[a] includes multiple sclerosis, Parkinson's disease, other abnormal movement disorders, epilepsy, spinocerebellar disease, anterior horn disease, other diseases of spinal cord, other demyelinating diseases of CNS, cerebral palsy, myoneural disorders, muscular dystrophies.

[b] includes schizophrenia, bipolar disease and depressive psychosis

Extent of disease for each individual was categorised into local, regional, distant and unknown based on data from the Cancer Registry.[14] We also collected demographic details of patients; age (in five categories), sex, ethnicity (Māori, Pacific, Asian and NZ European/Other) and small area deprivation using the NZ Deprivation Index (NZDep) aggregated into quintiles.[15]

Mortality data were obtained by linking study patients to the New Zealand national mortality database, with follow-up to the end of 2005. Patients whose deaths were not recorded in the mortality database were assumed to be still alive at the end of follow-up.

Analysis—First, we assessed the prevalence of comorbidity in this cohort, and identified factors associated with its occurrence. We calculated counts and age/sex standardised proportions of Charlson comorbidity scores, and individual comorbid conditions. We examined multivariate (including age, sex, ethnicity, NZ Deprivation quintiles and extent of disease) predictors of higher Charlson comorbidity index scores using linear regression with a log transformation for the uncategorised Charlson scores.

Second, we investigated the impact of comorbidity on risk of in-hospital death, length of stay and 5-year all-cause survival. We first assessed the effects of comorbidity on these outcomes in age and sex adjusted models, and then adjusted additionally for ethnicity, NZ deprivation quintiles and extent of disease. We developed separate models for comorbidity measured using the Charlson co-morbidity score (categorised as 1, 2 and 3+) and the individual conditions listed in Table 1.

In-hospital death

Multivariable logistic regression was used to investigate in-hospital death, using either the index admission if it was the surgical resection of colorectal cancer or admission for primary resection occurring within 3 months of the index admission. All other admissions were excluded from analyses (N= 1311).

Length of stay

The effect of comorbidity on length of hospital stay was examined using linear regression, with log transformation of length of stay data. The same subset of data used in the analysis of in-hospital death was used for this analysis. The estimated parameters provide a (logged) measure of unit change in the outcome variable for every unit increase in the independent variable, e.g. if $\beta = 0.14$ in a regression of length of stay against Charlson score, then every standardised unit increase in Charlson score (e.g. increase of 1) is predicted to result in exp(0.14)=1.15—i.e. a 15% increase in days of length of stay.

5-year all-cause survival

Cox proportional hazards models were used to investigate 5-year all-cause survival. Hazard ratios (HR) are interpreted in the same way as relative risks with a HR>1 meaning that those with a given comorbidity score or condition have higher mortality and therefore poorer 5-year survival than those without the specified comorbidity.

Ethics—Approval for this study was granted by the New Zealand Multi-Region Ethics Committee.

Results

A total of 11,524 patients met the eligibility criteria for the study. Table 2 shows the characteristics of the cohort. The cohort comprised approximately equal numbers of males and females, was predominantly non-Maori non-Pacific non-Asian, and more than 80% were aged 60 years or older.

Prevalence and predictors of comorbidity—Table 3 shows the counts and age-sex standardised proportions for Charlson scores. As expected there was a highly skewed distribution of comorbidity scores with the majority of individuals having a Charlson score of 0. Males were somewhat more likely to have a Charlson score of 3 or more compared with females (10.3% compared with 7.5%).

Table 2. Characteristics of cohort

Patient factors		N	%
Total		11524	100.0
Sex	Male	5477	47.5
	Female	6047	52.5
Prioritised ethnicity	Maori	324	2.8
	Pacific	80	0.7
	Asian	119	1.0
	Euro/other	11001	95.5
Age group	25–50yrs	643	5.6
	51–60yrs	1392	12.1
	61–70yrs	3209	27.9
	71–80yrs	4028	35.0
	>80yrs	2252	19.5
NZDeprivation quintile	missing	607	5.3
	1	1405	12.2
	2	1980	17.2
	3	2486	21.6
	4	2945	25.6
	5	2101	18.2
Extent of disease	Local	2847	24.7
	Regional	5828	50.6
	Distant	2271	19.7
	Unknown	578	5.0

Charlson scores increased with age, and Māori and Pacific people had higher scores than Asian or NZ European/Other (e.g. the proportions with Charlson scores of 3 or more were 17.7%, 17.1%, 10.3 and 10.1% respectively). Increasing extent of disease was related to an increasing proportion of individuals with a Charlson score of 3+, although the group with unknown extent of disease had considerably higher Charlson scores than any other group (proportions with Charlson scores of 3+ were 8.8%, 9.5% and 12.0% for those with localised, regional and distant disease respectively. 18.8% of those with unknown extent of disease had Charlson scores of 3+).

Table 3. Charlson scores by sex, age, ethnicity NZDeprivation quintile and extent of disease; numbers age and sex-standardised * proportions

Variable		Charlson Scores**							
		0		1		2		3+	
		N	%	N	%	N	%	N	%
Sex	Female	4200	69.5	1033	17.1	344	5.7	456	7.5
	Male	3532	64.5	980	17.9	374	6.8	566	10.3
Age	25-50yrs	587	91.3	37	5.8	5	0.8	13	2.0
	51-60yrs	1147	82.4	155	11.1	34	2.4	55	4.0
	61-70yrs	2331	72.6	493	15.4	157	4.9	215	6.7
	71-80yrs	2473	61.4	826	20.5	293	7.3	416	10.3
	>80 yrs	1194	53.0	502	22.3	229	10.2	323	14.3
Extent of disease	Local	1901	62.0	530	20.1	179	9.2	226	8.8
	Regional	3900	61.5	1050	19.5	348	9.5	518	9.5
	Distant	1620	61.8	335	15.8	139	10.4	171	12.0
	Unknown	311	52.6	98	16.3	52	12.3	107	18.8

Variable		Charlson Scores**							
		0		1		2		3+	
		N	%	N	%	N	%	N	%
Ethnicity	Māori	187	49.5	62	21.0	20	11.9	49	17.7
	Pacific	51	40.0	13	29.0	6	13.9	8	17.1
	Asian	84	60.0	22	24.0	4	4.7	9	11.3
	Euro/Other	7410	61.5	1916	18.6	688	9.8	956	10.1
NZDeprivation	1	963	61.4	231	18.4	93	11.0	110	9.2
	2	1334	61.1	337	18.1	118	9.7	187	11.1
	3	1672	61.1	458	19.4	160	10.5	192	9.0
	4	1959	60.9	521	18.8	180	9.3	275	11.0
	5	1365	60.2	374	19.3	132	8.9	218	11.6
	Missing	439	63.6	92	18.3	35	9.8	40	8.3

* age and sex standardised to the age and sex structure of the cohort population

** higher scores indicate higher levels of comorbidity

Table 4 shows the comorbidity counts and age-sex standardised prevalence for conditions with a prevalence greater than 5%. Prevalence was greater for males than females for all conditions, with the exception of essential hypertension. For all conditions, prevalence tended to increase with age, although fewer individuals had diabetes in the >80 yrs age group than in the 71–80 yrs age group. Those with unknown extent of disease had notably higher prevalence of all conditions. Prevalence of essential hypertension and diabetes was greater among Maori and Pacific patients than Asian and NZ European/Other.

Maori also had a greater proportion with chronic respiratory disease, and Pacific had greater proportions with cerebrovascular disease and congestive heart failure. NZ European/Other had the greatest prevalence of cardiac arrhythmia and angina. The prevalence of recorded essential hypertension and chronic respiratory disease increased with increasing deprivation, while for other conditions no clear patterns were evident by deprivation group.

When we investigated the relationship between covariates and Charlson scores using multiple regression analysis, we found that increasing age, ethnicity (Māori and Pacific), sex (male), extent of disease and NZ deprivation (quintile 5) were all significantly associated with higher Charlson scores even after adjustment for other variables in the models (results available from authors).

Impact of comorbidity on outcomes—Tables 5a and 5b shows the odds ratios, parameter estimates and hazard ratios with 95% confidence intervals for regression models examining in-hospital death, length of stay and 5-year survival respectively. The Charlson scores were significantly associated with increased risks of in-hospital death with odds ratios monotonically increasing with increasing Charlson scores (Table 5a).

For individual conditions, there were significantly increased odds of in-hospital death for those with chronic respiratory disease, cardiac arrhythmia, previous myocardial infarction and cerebrovascular accidents, while those with recorded essential hypertension and angina had significantly decreased odds of in-hospital death (Table 5b).

Table 4. Prevalence of selected conditions* by sex, age, ethnicity NZ Deprivation quintile and extent of disease; numbers, age and sex-standardised * proportions

Variable		Essential Hypertension		Chronic Respiratory Disease		Diabetes		Cardiac Arrhythmia		Myocardial Infarction		Angina		Congestive Heart Failure		Cerebrovascular Accident	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Sex	Female	959	15.9	569	9.4	538	8.9	457	7.6	369	6.1	388	6.4	362	6.0	314	5.2
	Male	841	15.4	585	10.7	569	10.4	580	10.6	549	10.0	504	9.2	349	6.4	348	6.4
Prioritised Ethnicity	Maori	59	18.2	54	16.7	62	19.1	24	7.4	25	7.7	19	5.9	26	8.0	14	4.3
	Pacific	14	17.5	6	7.5	16	20.0	3	3.8	5	6.3	5	6.3	8	10.0	6	7.5
	Asian	13	10.9	5	4.2	15	12.6	4	3.4	9	7.6	4	3.4	6	5.0	4	3.4
	Euro/Other	1714	15.6	1089	9.9	1014	9.2	1006	9.1	879	8.0	864	7.9	671	6.1	638	5.8
Age group	25-50yrs	14	2.2	17	2.6	20	3.1	2	0.3	5	0.8	5	0.8	2	0.3	2	0.3
	51-60yrs	113	8.1	80	5.7	93	6.7	30	2.2	39	2.8	36	2.6	14	1.0	28	2.0
	61-70yrs	419	13.1	276	8.6	314	9.8	174	5.4	188	5.9	211	6.6	108	3.4	126	3.9
	71-80yrs	770	19.1	480	11.9	466	11.6	454	11.3	394	9.8	392	9.7	288	7.1	275	6.8
	81+yrs	484	21.5	301	13.4	214	9.5	377	16.7	292	13.0	248	11.0	299	13.3	231	10.3
NZ Deprivation Quintile	1	185	13.2	119	8.5	121	8.6	144	10.2	115	8.2	91	6.5	75	5.3	88	6.3
	2	279	14.1	186	9.4	183	9.2	169	8.5	150	7.6	142	7.2	138	7.0	105	5.3
	3	385	15.5	237	9.5	228	9.2	216	8.7	194	7.8	191	7.7	137	5.5	142	5.7
	4	511	17.4	327	11.1	289	9.8	268	9.1	255	8.7	257	8.7	186	6.3	180	6.1
	5	360	17.1	234	11.1	243	11.6	200	9.5	165	7.9	166	7.9	144	6.9	115	5.5
	Missing	80	13.2	51	8.4	43	7.1	40	6.6	39	6.4	45	7.4	31	5.1	32	5.3
Extent of Disease	Distant	323	14.2	203	8.9	203	8.9	168	7.4	155	6.8	144	6.3	127	5.6	94	4.1
	Local	467	16.4	282	9.9	273	9.6	283	9.9	229	8.0	255	9.0	171	6.0	146	5.1
	Regional	878	15.1	563	9.7	563	9.7	494	8.5	457	7.8	429	7.4	316	5.4	363	6.2
	Unknown	132	22.8	106	18.3	68	11.8	92	15.9	77	13.3	64	11.1	97	16.8	59	10.2

* conditions with a prevalence of 5% or greater in the cohort ** age and sex standardised to the age and sex structure of the cohort population

Table 5a. Odds ratios, parameter estimates and hazard ratios (95% CI) for regression models with Charlson scores and covariates predicting in-hospital death, length of stay or 5-year survival respectively

Charlson Score*	In Hospital Death Odds Ratios		Length of Stay Parameter Estimates (β)		Survival over 5 years Mortality hazard Ratios	
	Model 1[a]	Model 1 [b]	Model 2[a]	Model 2 [b]	Model 3[a]	Model 3[b]
1	**2.41 (1.79, 3.24)**	**2.51 (1.87, 3.39)**	0.03 (-0.02, 0.08)	0.03 (-0.02, 0.08)	**1.21 (1.12, 1.30)**	**1.26 (1.17, 1.37)**
2	**3.43 (2.36, 4.98)**	**3.52 (2.41, 5.13)**	0.02 (-0.05, 0.09)	0.02 (-0.05, 0.09)	**1.73 (1.54, 1.94)**	**1.75 (1.55, 1.97)**
3+	**4.52 (3.32, 6.14)**	**4.81 (3.52, 6.58)**	**0.14 (0.08, 0.20)**	**0.14 (0.08, 0.20)**	**1.95 (1.75, 2.17)**	**2.02 (1.81, 2.25)**

* Charlson score = 0 is reference group; [a] adjusted for age (6 categories) and sex only [b] adjusted for age (6 categories) , sex, ethnicity, NZ deprivation quintiles and extent of disease.

Table 5b. Odds ratios, parameter estimates and hazard ratios (95% CI) for regression models with comorbidity conditions and covariates predicting in-hospital death, length of stay or 5-year survival respectively

Comorbid Conditions[c]	In Hospital Death Odds Ratios		Length of Stay Parameter Estimates (β)		Survival over 5 years Hazard Ratios	
	Model 1[a]	Model 1 [b]	Model 2[a]	Model 2 [b]	Model 3[a]	Model 3[b]
Essential Hypertension	**0.73 (0.53, 1.00)**	**0.72 (0.52, 0.99)**	**-0.11 (-0.17, -0.04)**	**-0.10 (-0.17, -0.04)**	0.98 (0.90, 1.06)	0.98 (0.90, 1.07)
Chronic Respiratory Disease	**2.32 (1.74, 3.09)**	**2.40 (1.79, 3.22)**	**0.21 (0.13, 0.28)**	**0.21 (0.14, 0.29)**	**1.22 (1.11, 1.34)**	**1.20(1.17, 1.41)**
Diabetes	1.00 (0.69, 1.45)	1.01 (0.69, 1.46)	**0.17 (0.10, 0.25)**	**0.17 (0.09, 0.24)**	1.00 (0.98, 1.03)	1.00 (0.98, 1.03)
Cardiac Arrhythmia	1.30 (0.92, 1.84)	**1.42 (1.00, 2.02)**	-0.05 (-0.14, 0.04)	-0.04 (-0.12, 0.05)	1.08 (0.97, 1.20)	**1.15 (1.03, 1.29)**
Myocardial Infarction	**2.19 (1.59, 3.03)**	**2.20 (1.59, 3.06)**	**0.13 (0.05, 0.22)**	**0.13 (0.04, 0.21)**	**1.26 (1.13, 1.40)**	**1.22 (1.10, 1.37)**
Angina	**0.62 (0.41, 0.95)**	**0.59 (0.38, 0.90)**	-0.01 (-0.10, 0.07)	0.00 (-0.09, 0.08)	**0.86 (0.77, 0.97)**	**0.88 (0.78, 0.99)**
Congestive Heart Failure	1.20 (0.81, 1.78)	1.19 (0.80, 1.78)	-0.04 (-0.15, 0.07)	-0.04 (-0.15, 0.06)	**1.31 (1.16, 1.49)**	**1.25 (1.11, 1.42)**
Cerebrovascular Accident	**2.10 (1.37, 3.20)**	**2.12 (1.38, 3.25)**	0.00 (-0.12, 0.12)	0.05 (-0.07, 0.17)	1.15 (0.99, 1.33)	1.15 (0.99, 1.34)

[a] adjusted for age (6 categories) and sex only; [b] adjusted for age (6 categories), sex, ethnicity, NZ deprivation quintiles and extent of disease; [c] only comorbidities with prevalence>5% reported. Other conditions included in model include peripheral vascular disease, dementia, connective tissue disease, GI ulcer disease, mild liver disease, hemiplegia/paraplegia, renal disease, any malignancy, moderate to severe liver disease, metastatic solid tumour, previous pulmonary embolism, cardiac valve disease, IBD, other neurological conditions, major psychiatric conditions; Bolded estimates are statistically significant

The associations with length of hospital stay were less clear, with a significant association only seen among those with Charlson scores of 3+, compared with 0. That is, people with a Charlson score of 3 or more had a 15% (95% CI 8%-22%) increase in length of stay (exp(0.14)=1.15). Those with chronic respiratory disease, diabetes and previous myocardial infarction had significantly longer length of stays compared to those without the specified condition, while those with recorded essential hypertension had significantly shorter stays.

There was a monotonic increase in mortality rate (hazard) reflecting poorer all-cause 5-year survival with increasing Charlson scores. Some individual conditions were associated with higher 5-year mortality, particularly congestive heart failure (HR =1.25 95% CI 1.11-1.42), previous myocardial infarction (HR =1.22 95% CI 1.10-1.37) chronic pulmonary disease (HR =1.20 95% CI 1.17-1.41) and cardiac arrhythmia (HR =1.15 95% CI 1.03-1.29). However, a diagnosis of angina was associated with a significantly lower 5-year mortality rate (HR=0.88 95% CI= 0.78-0.99).

Discussion

In a large cohort of patients with colon cancer, we found that comorbidity was common, associated with increasing age, and among males, Māori and Pacific people, those with unknown extent of disease at diagnosis and those living in the most deprived quintile of New Zealand. Comorbidity was associated with a higher risk of in-hospital death, longer lengths of hospital stay and lower 5-year survival.

In some respects these results are self-evident; those who are sicker have poorer outcomes. However there has been very little work specifically investigating the impact of comorbidity among patients in the New Zealand context.[6-8]

Comorbidity affects nearly every aspect of health care both for the individual patient with comorbidity, and for health care providers managing such patients. Comorbidity has been shown to affect treatment choice, risk of complications, quality of life, mortality, and health care resource use.[2-6] It is therefore important to understand the patterns and impact of comorbidity in New Zealand.

Our results are largely consistent with other research. For example, many studies have found that comorbidity is common among patients with cancer generally, and colorectal cancer specifically.[6,16–28] The highly skewed distribution of comorbidity scores with only a small minority of patients scoring 3 or more is consistently seen.[17] Not surprisingly, Charlson scores were higher and all individual conditions were more common among older people; as has been reported previously, comorbidity was higher among males, Māori and those living in more deprived areas.[5]

Many studies have found that mortality risk increases, and survival decreases, with increasing global comorbidity score.[4,6,11,16,18,28–37] The magnitude of this association varies depending on the setting of the study, the methods used to measure comorbidity, and the timing of mortality or survival (e.g. in-hospital death, 1-year or 5-year mortality/survival).

Fewer studies have investigated the role of comorbidity with length of hospital stay, and the results are somewhat less consistent. Generally however, those with higher comorbidity have longer stays in hospital.[30 37 38] Of note is that the rules relating to the

coding of comorbid conditions in New Zealand state that comorbid conditions should be coded if they co-exist or arise during a given episode of care **and** if they affect patient management in a way that might extend length of hospital stay. This approach is likely to result in an emphasis on the most active and clinically important conditions, and of course introduces some circularity to the argument that routinely recorded comorbidity affects length of stay.

The patterns for individual conditions were somewhat variable, although most individual conditions adversely affected one or more of the outcomes we investigated. Recorded essential hypertension and angina were notable exceptions to this rule, in that patients with these conditions had significantly better outcomes than others. This finding is consistent with other studies[21 29 30] and is likely to be due to a type of information bias where those who have major, potentially life-threatening conditions are less likely to have conditions that are common and less serious recorded. As a result, those that do have these latter conditions, paradoxically, tend to be healthier than those with other comorbidities, and as a result have better outcomes.

Another interesting finding is that those with unknown extent of disease are considerably more likely to have a Charlson score of 3+, and more likely to have most of the individual conditions than those with recorded extent of disease. It seems likely that one of the reasons that these patients have not been staged is that they may be too unwell to be treated for their cancer, which is consistent with what is often anecdotally assumed.

Strengths and weaknesses of this study—The main strengths of this study are that it is based on a large cohort of patients, we restricted the study to those with a specific diagnosis to minimise confounding due to primary condition, and we used both individual conditions and a global measure of comorbidity (Charlson comorbidity index) to measure comorbidity.

The key weakness of the study was that we used routinely collected administrative data to identify comorbidity in the patients. Generally data obtained directly from medical notes is considered superior, however collecting such data is time-consuming and difficult. Also, while comorbidities tend to be more common if data are collected from medical notes, these data are not complete or error-free, nor are administrative data a subset of these data.[9 33 39 40]

In a previous publication we compared data collected from medical notes to those obtained from routine data sources and found that while there were differences between these data sources, both provided reasonable risk adjustment within multivariable models.[9]

We used the Charlson comorbidity index which is a well-established method of measuring comorbidity. However, there are issues with using this index. It was developed over 20 years ago on a relatively small group of patients in the US.[11] It includes some conditions which are unlikely to have a major impact on outcomes currently (e.g. peptic ulcer disease), it excludes some that are likely to have an impact (e.g. non-cerebrovascular neurological conditions), and it assumes that the impact of multiple conditions is additive on a relative scale.[6] However, to date no gold standard measure of comorbidity has been developed.

We have also only included patients with colon cancer for the reasons outlined in the introduction. These findings are probably generalisable to other patient groups, but it is not assured.

The findings of this study support the importance of comorbidity in terms of health service and patient impact. It is the first study in New Zealand to have used routinely collected comorbidity data for this purpose. These initial analyses suggest that general comorbidity, measured by Charlson scores, is strongly associated with in-hospital death, length of stay and 5-year survival. The relationships among individual comorbid conditions and these outcome variables are less consistent, although most major comorbid conditions were associated with a negative effect on one or more of the adverse outcomes we measured.

Further research is needed to confirm the impact of comorbidity on other groups, and to investigate whether the measurement of comorbidity can be improved in New Zealand.

Competing interests: None.

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