Supplementary Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

eFigure: RAI-C Questionnaire and Scoring System

Risk Analysis Index (RAI)

Last Name:_____ Last Four: _____

Date Form is Completed:_____ Date & Type of Anticipated Surgery:_____

A. Age, Sex & Cancer

Age	Score *without* Cancer	Score *with* Cancer
< 69	2	20
70-74	3	19
75-79	4	18
80-84	5	17
85-89	6	16
90-94	7	15
95-99	8	14
100+	9	13

1. Sex Female= 0 Male= 5 _____
2. Age _____
3. Does the patient have cancer?
   (Excluding skin cancer,except for melanoma)
   If no, score *without* cancer _____
   or
   If yes, score *with* cancer _____

B. Medical Co-Morbidities

4. Have you had unintentional weight loss in the past 3 months (>10 lbs)? No= 0 Yes= 5 _____
5. Renal failure? No= 0 Yes= 6 _____
6. Chronic/congestive heart failure? No= 0 Yes= 4 _____
7. Poor appetite? No= 0 Yes= 4 _____
8. Shortness of breath (at rest)? No= 0 Yes= 8 _____

C. Cognition, Residence & Activity of Daily Living

9. Do you reside in a setting other than independent living?
   If yes, check answer: Skilled nursing facility □ Assisted living □ Nursing home □
   No= 0 Yes= 8 _____
   If yes, were you admitted within the past 3 months? No □ Yes □

D. Activities of Daily Living & Cognitive Decline (*Circle score for each ADL*)

10. Mobility/Locomotion	11. Eating	12. Toilet Use	13. Personal Hygiene
0. Independent	0. Independent	0. Independent	0. Independent
1. Supervised	1. Supervised	1. Supervised	1. Supervised
2. Limited assistance	2. Limited assistance	2. Limited assistance	2. Limited assistance
3. Extensive assistance	3. Extensive assistance	3. Extensive assistance	3. Extensive assistance
4. Total Dependence	4. Total Dependence	4. Total Dependence	4. Total Dependence

14. Have your cognitive skills or status deteriorated over the past 3 months? No □ Yes □ (*see score chart*)

ADL Score *without* Cognitive Decline (*Sum of ADL Scores*)	ADL Score *with* Cognitive Decline
0	ADL Score -2
1,2	ADL Score -1
3,4	ADL Score 0
5-7	ADL Score +1
8,9	ADL Score +2
10,11	ADL Score +3
12,13	ADL Score +4
14-16	ADL Score +5

Score *without* cognitive decline _____ (0 to 16)
or
Score *with* cognitive decline _____(-2 to 21)

Total RAI Score: _____

Scoring Instructions: To calculate the RAI-C score, first look at the Age/Cancer table to determine the single value between 2 and 20 that corresponds to the patient's age and cancer status. Record this single value in the appropriate line for item 3. Next look at the ADL table and sum the scores (0-4) for the four ADLs queried in items 10-13. This sum is the ADL Score and should range between 0 and 16. Next look at the ADL/Cognitive-Decline table to determine the single value between -2 and 21 that corresponds to the patient's ADL Score and cognitive decline. Record the value in the appropriate line for item 14. Finally, sum the values for items 1,3-9, and 14 to yield a final RAI-C score between 0 and 81.

eAppendix: Rationale for selection of VASQIP variables

Age, sex, heart failure and shortness of breath: We identified VASQIP variables that are essentially identical to the RAI-C questionnaire and the MDS database, scoring them according to the RAI model parameters.

Renal Failure: To include all patients with a history significant renal failure, we combined the VASQIP variables for renal failure and dialysis such that if either variable were coded as present, we scored the RAI-A as having the risk of renal failure.

Cognitive Decline: The MMRI-R employed a dichotomous scoring of a single MDS variable reflecting deterioration of cognitive skills over the previous 90 days. VASQIP does not have a direct analogue to this variable, but we approximated it by considering cognitive deterioration present if the patient had impaired sensorium (IMPSENS), coma (COMA) or a stroke with neurological deficits (CVANEURO). As such the RAI-A focuses on severe cognitive impairment, and is thus likely less sensitive than the RAI-C or MMRI-R in detecting milder forms of cognitive dysfunction.

Cancer: The RAI-C cancer question probed for any diagnosis of cancer excluding non-melanoma skin cancers. The MDS variable from which this item was derived is defined as any cancer diagnosis with or without metastasis, and thus includes a wide range of disease processes. However, the presence or absence of cancer is the most heavily weighted factor in the scoring model, suggesting that in the nursing home population, the cancers assessed were most likely advanced with significant risks of mortality. There is no direct VASQIP analogue for this kind of cancer, but we chose 3 VASQIP variables that indicate more advanced and serious cancers rather than early and easily treated cancers: disseminated cancer (DISCANCER), chemotherapy for malignancy within 30 days prior to surgery (CHEMO), or radiotherapy for malignancy within 90 days prior to surgery (RADIO). If any of these 3 variables were present, we coded the RAI-A with additional cancer-related risk.

Activities of Daily Living (ADLs): The MDS codes ADLs across 10 dimensions, but the MMRI-R used only 4 dimensions scored on a 5-point scale. The RAI-C questionnaire probes each of these 4 dimensions from which an overall ADL score is calculated. The VASQIP has only a single variable assessing functional status as independent, partially dependent, totally dependent or unknown. We therefore used this single variable with a modified scoring convention to reflect these three ADL strata as specified in Table 1.

Independent Living: The RAI-C item probes for patients residing in any setting other than independence. There is no direct VASQIP analogue, but there is a variable that indicates the location from which patients come for their surgical procedure (e.g., home, nursing home, etc). This variable is called “transfer status” (TRANST), and we scored an increased risk of frailty for patients transferred to the hospital for their index operation from a nursing home, chronic care facility, spinal cord injury unit or intermediate care unit.

Appetite: The RAI-C probes weight loss and poor appetite in two separate questions. The VASQIP has a direct analogue for weight loss, but does not assess poor appetite. We therefore used the single VASQIP variable to code for both weight loss and poor appetite.

eTable 1: Comparison of MDS and VASQIP variables with RAI-A Scoring System

RAI Variable	MDS Variable	VASQIP Variable	RAI-A Scoring System*
1. Sex	Sex	SEX	+5 if "male"
2. Age	Age	AGE	Continuous (Scored as interaction with Cancer Diagnoses as per table in eFigure 1)
3. Cancer (excluding skin cancer, except for melanoma)	Cancer diagnosis with or without metastasis	DISCANCER or RADIO or CHEMO	1= any of the 3 variables "yes" 0 = all of the 3 variables "no"
4. Weight Loss ("Have you had unintentional weight loss in the past 3 months >10 pounds?"	Weight loss	WTLOSS	+5 if "yes"
5. Renal Failure	Renal failure	RENALFAIL or DIALYSIS	+6 if either variable "yes"
6. Chronic/Congestive Heart Failure	Chronic heart failure	HXCHF	+4 if "yes"
7. Poor Appetite	Poor appetite	WTLOSS	+4 if "yes"
8. Shortness of Breath at Rest	Shortness of breath	DYSPNEA	+8 if "yes"
9. Residence other than Independent Living	Recent admission to nursing home	TRANST	+8 if transferred to the hospital for the index operation from a nursing home, chronic care facility, spinal cord injury unit or intermediate care unit
10. Cognitive Deterioration ("Have your cognitive skills or status deteriorated over the last 3 months?")	Cognitive Deterioration	IMPSENS or COMA or CVANEURO	"yes" if any of 3 variables "yes" "no" if all of 3 variables "no" (Scored as interaction with Activities of Daily Living as per table below)
11. Activities of Daily Living (Mobility, Eating, Toileting, Personal Hygiene)	Short-Form ADL Scale in 4 dimensions	FNSTATUS	*Without Cognitive Decline* +16 = totally dependent +8 = partially dependent +0 = independent *With Cognitive Decline* +21 = totally dependent +10 = partially dependent -2 = independent

*The RAI-A score is calculated the same way as the RAI-C, and both scores range between 0 and 81. Scoring instructions for the RAI-C are found in eFigure 1.

eTable 2: Demographic characteristics of sample

	6856 with mortality			2785 with RAI-A			1021 with mFI		
	mean(sd)	%	N	mean(sd)	%	N	mean(sd)	%	N
Age (years)	60.7 (13.9)			59.7 (13.7)			60.2 (13.0)		
Sex									
male		96.4	6607		96.7	2692		95.8	978
female		3.6	249		3.3	93		4.2	43
Race									
Hispanic (white)		NA			1.2	32		0.7	7
American Indian		NA			1.0	27		1.3	13
Black		NA			4.7	127		4.7	46
Asian or Pacific Islander		NA			0.2	6		0.1	1
White		NA			81.2	2191		81.5	805
Unknown		NA			11.6	314		11.7	116
ASA Class									
1		NA			2.1	58		1.3	13
2		NA			20.2	563		21.2	217
3		NA			72.6	2021		72.6	741
4		NA			5.1	142		4.8	49
5		NA			0.0	1		0.1	1
Heart Failure-C		4.0	274		3.2	90		3.6	37
Heart Failure-A					0.1	3		0.2	2
Shortness of Breath-C		6.3	433		5.5	154		6.9	70
Shortness of Breath-A					5.3	147		1.3	13
Renal Disease-C		3.5	239		1.5	41		1.4	14
Renal Disease-A					2.2	60		0.6	6
Cancer-C		17.5	1197		16.9	470		17.8	182
Cancer-A					5.8	162		2.7	28
RAI-C Score	11.8 (8.0)			11.3 (7.7)			11.8 (8.1)		
RAI-A Score				9.6 (6.4)			8.3 (4.7)		
mFI Score							0.197(.095)		

Note: NA=not available; sd=standard deviation; C=clinical; A=administrative. The scores for heart failure, shortness of breath, renal disease and cancer are taken from the RAI-C questionnaire for variables marked “C”. For those marked “A”, the score represents the presence or absence of the VASQIP variables detailed in eTable 1.

eTable 3: Sensitivity, specificity and prevalence of frailty across the range of frailty scores

Cut point	6856with mortality			2785 with RAI-A			1021 with mFI		
RAI-C	sens.	spec.	prev.	sens.	spec.	prev.	sens.	spec.	prev.
6	.991	.035	.966	1.00	.031	.970	1.00	.039	.962
11	.719	.725	.292	.750	.745	.262	.688	.717	.299
16	.605	.796	.213	.625	.818	.199	.625	.799	.217
21	.518	.830	.184	.525	.834	.171	.500	.822	.183
26	.307	.952	.054	.300	.958	.046	.313	.947	.057
31	.193	.976	.027	.175	.980	.023	.125	.976	.025
36	.088	.991	.011	.075	.992	.009	.063	.988	.013
RAI-A									
6				1.00	.079	.922	1.00	.073	.929
11				.725	.814	.193	.625	.912	.097
16				.500	.896	.110	.563	.944	.064
21				.275	.921	.082	.250	.966	.037
26				.150	.975	.027	.188	.992	.011
31				.100	.984	.017	.125	.996	.006
36				.050	.994	.007	.063	.998	.002
mFI									
.137							1.000	.289	.715
.227							.750	.697	.310
.318							.500	.900	.107
.409							.375	.974	.031
.5							.125	.995	.007

Note: Table reports the sensitivity (sens.), specificity (spec.) of each test (RAI-C, RAI-A, mFI) in predicting 180-day mortality at different cut points across the range of frailty scores. It also reports the prevalence (prev.) of frailty at each cut point as the proportion of population with scores greater than the cut point.

eTable 4: Mortality rates and c-statistics for the RAI-C among all patients with known vital status

RAI-C Score	0-15	16-25	26-35	≥ 36	Overall	c-statistic
Number in Cohort	7465	1695	429	106	9695	
Proportion of Cohort	77.0%	17.5%	4.4%	1.1%	100.0%	
Mortality						
30-Day (n=9695)	0.3%	0.6%	1.9%	6.6%	0.5%	.716 (.635-.797)
180-Day (n=9165)	1.1%	3.4%	9.0%	17.3%	2.0%	.749 (.712-.786)
365-Day (n=8520)	1.8%	7.3%	16.7%	28.3%	3.6%	.761 (.732-.789)

Note: Mortality and c-statistics are calculated from the sample of 9778 patients successfully linked to vital statistics (Figure 1). When no specific date of surgery was known, length of survival was calculated from the date of RAI-C assessment. Follow up was sufficient to calculate 30, 180 and 365 day mortality in 9695, 9165 and 8520 cases, respectively.