mHOMR: a prospective observational study of an automated mortality prediction model to identify patients with unmet palliative needs

Pete Wegier ,[1,2,3] Allison Kurahashi ,[4] Stephanie Saunders,[5] Bhadra Lokuge,[4] Leah Steinberg,[3,4] Jeff Myers,[3,4,6] Ellen Koo,[7] Carl van Walraven,[8,9,10] James Downar[9,11,12]

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For numbered affiliations see end of article.

Correspondence to
Dr Pete Wegier, Humber River Hospital, Toronto, Canada; pwegier@hrh.ca

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ABSTRACT

Objective Identification of patients with shortened life expectancy is a major obstacle to delivering palliative/end-of-life care. We previously developed the modified Hospitalised-patient One-year Mortality Risk (mHOMR) model for the automated identification of patients with an elevated 1-year mortality risk. Our goal was to investigate whether patients identified by mHOMR at high risk for mortality in the next year also have unmet palliative needs.

Method We conducted a prospective observational study at two quaternary healthcare facilities in Toronto, Canada, with patients admitted to general internal medicine service and identified by mHOMR to have an expected 1-year mortality risk of 10% or more. We measured patients' unmet palliative needs—a severe uncontrolled symptom on the Edmonton Symptom Assessment Scale or readiness to engage in advance care planning (ACP) based on Sudore's ACP Engagement Survey.

Results Of 518 patients identified by mHOMR, 403 (78%) patients consented to participate; 87% of those had either a severe uncontrolled symptom or readiness to engage in ACP, and 44% had both. Patients represented frailty (38%), cancer (28%) and organ failure (28%) trajectories were admitted for a median of 6 days, and 94% survived to discharge.

Conclusions A large majority of hospitalised patients identified by mHOMR have unmet palliative needs, regardless of disease, and are identified early enough in their disease course that they may benefit from a palliative approach to their care. Adoption of such a model could improve the timely introduction of a palliative approach for patients, especially those with non-cancer illness.

Key messages

What was already known?

- mHOMR is a highly accurate model for the identification of patients with an elevated risk of mortality in the next year.
- mHOMR has been shown to be both feasible and acceptable for the identification of patients who may benefit from a palliative approach to their care.

What are the new findings?

- mHOMR accurately identified patients who have unmet palliative needs, defined as a severe uncontrolled symptom or a readiness to engage in advance care planning.

What is their significance?

- Adoption of an automated identification model such as mHOMR could help improve the timely introduction of a palliative approach for patients.

INTRODUCTION

One important obstacle to improving end-of-life care is the failure of clinicians to reliably identify those who are approaching the end of life and assess them for unmet palliative needs, such as uncontrolled symptoms or a readiness to discuss care planning. Although many organisations have highlighted the importance of addressing unmet palliative needs early in the course of an illness,[1] most patients only receive palliative interventions in the final weeks or days of life, if at all.[2] Part of the problem is that clinicians cannot assess every single patient for unmet palliative needs; in practice, they focus their assessments on a high-risk group identified using clinical gestalt or a provider-dependent tool such as

the Surprise Question. However, these methods can be inaccurate and unreliable,[3] which limits the effectiveness of any intervention that they are supposed to trigger.[4] Additionally, all these tools rely on a healthcare provider who is willing to use them at the bedside; however, there has been very low uptake of interventions triggered by the Surprise Question[5] and clinicians have reported to be unwilling use such tools in certain patient populations, such as the frail elderly.[5–8] Rather, we require accurate and automated systems for the timely identification of patients who may benefit from a palliative approach to care.[4]

Recently, we[9 10] and others[11] have described the use of computer-based models that use data in patients' electronic health records to automatically identify those at an elevated risk of death in the near future with a greater accuracy than has been shown with clinician-dependent models[12] or the commonly used Surprise Question.[3] These pilot studies have shown that the use of such predictive models is clinically feasible, acceptable to both patients and healthcare providers, and the implementation of these models increases the proportion of patients who are referred to a palliative care consultant or who have documented care planning discussions.[9–11] While these predictive models accurately identify those with an increased mortality risk,[12] we currently do not know whether the identified patients have uncontrolled symptoms or are ready to discuss care planning—ie, unmet palliative needs. Accordingly, this study measured the prevalence of unmet palliative needs among patients with an increased annual mortality risk as identified by our modified Hospitalised-patient One-year Mortality Risk (mHOMR)[9 10] model.

METHODS

We conducted a prospective observational one-group study to assess the unmet palliative needs of patients with an elevated mHOMR Score at two quaternary healthcare facilities in Toronto, Canada. The mHOMR model was applied to all admissions to the General Internal Medicine service at each site between May and August 2018 (Site 1) and February and November 2019 (Site 2).

Model

The model relies on just nine data points routinely available at the time of admission—(1) patient age, (2) patient sex, (3) admitting service, (4) whether the current admission was an urgent 30-day readmission, (5) number of emergency department (ED) visits in the past 12 months, (6) admissions by ambulance in the past 12 months, (7) patient's living status (independent at home, rehab facility, at home with home care, nursing home or chronic care hospital), (8) admission urgency of the current admission (elective, ED with ambulance, ED without ambulance) and (9) whether the current admission was directly to the intensive care unit—and has been shown to be one of the most accurate mortality prognostication models currently available.[9 12 13] An earlier version of the model included an additional three data fields—admitting diagnosis, Charlson Comorbidity Index and the use of supplemental oxygen at home—but were removed from the mHOMR model as these data fields were not coded until a patient was discharged and did not substantially affect the accuracy of the model.[9]

Patients

In our previous work in examining the feasibility[9] and acceptability[10] of mHOMR, we recruited 200 consecutive patients per site. We had set the threshold for flagging a patient at elevated risk of mortality (mHOMR+) at 0.21—ie, an expected 1-year mortality risk exceeding 21%. This threshold was chosen as a result of discussion within the research team, which included physicians from the General Internal Medicine service at each site, with the goal of avoiding alert fatigue and false-positive notifications. Based on data from the derivation of the mHOMR model,[9] mHOMR scores of 0.21 or greater would result in a manageable number of mHOMR+ patients—given the resources of the two sites—and had a sensitivity of 59%, specificity of 90%, positive predictive value of 36%, negative predictive value of 96%, positive likelihood ratio of 5.9 and negative likelihood ratio of 0.46 for mortality within 12 months of admission.

As the threshold for a patient being flagged as mHOMR+ is primarily a function of healthcare system resources, our goals in this study were to (1) measure the prevalence of unmet palliative needs among mHOMR+ patients; and (2) compare those patients to patients with lower mHOMR scores. Accordingly, we identified all patients whose expected 1-year mortality risk exceeded 10%—ie, an mHOMR Score >0.10. We divided participants into those with mHOMR scores 0.21 or greater (as in our previous work[9 10] and those with mHOMR scores>0.10 but <0.21. We expected patients with the higher mHOMR scores to have significant unmet palliative needs.

Recruitment

As this was the first study to examine the unmet palliative needs of patients identified by mHOMR, we set a recruitment target of 200 patients at each site, in line with our previous work.[9 10] Trained and experienced research assistants (AK, SS, BL, EK) approached all newly identified mHOMR+ patients each morning, after first meeting with the admitting team to obtain permission to approach these patients and to confirm they were competent to participate in the study. If a patient was incapable of participating in the study, their substitute decision maker (SDM) could enrol them and complete the assessments on the patient's behalf. If a patient or SDM was unavailable, multiple subsequent attempts were made throughout the day

and following days, until the research assistants had spoken to the patient or SDM. For enrolled patients, the median (IQR) time from admission to enrolment was 2 (1) days; however, as the exact time of enrolment was not tracked (only the date), the median time to enrolment was most likely shorter.

Definition of 'unmet palliative needs'

A recent review of the literature found 'lack of consensus concerning the attributes of illnesses needing palliation and the ambiguous use of the adjective "palliative"'.[14] Thus, for our study, we chose to focus on the presence of severe symptoms or a desire to participate in care planning discussions as indications of unmet palliative needs, as these are two of the most common domains of patient needs addressed by palliative care. Consenting participants completed the Edmonton Symptom Assessment Scale Revised (ESAS-r),[15] which is routinely used in clinical care to assess nine common symptoms using a 0–10 Likert scale—pain, tiredness, drowsiness, nausea, lack of appetite, shortness of breath, depression, anxiety, in addition to overall well-being—and any additional problem the patient wishes to identify. Patients also completed the 4-item version of Sudore's Advance Care Planning (ACP) Engagement Survey[16] to assess for readiness to engage in care planning; this tool has recently been validated in Ontario.

We defined a patient as having 'unmet palliative needs' if they: (1) reported any symptom score >6 on the ESAS-r—which is typically defined as 'severe'[17]; and/or (2) if, on the ACP Engagement Survey, the patient responded to the question 'How ready are you to talk to your doctor about the kind of medical care you would want if you were very sick or near the end of life?' with a response of 4 ("definitely in the next 30 days") or 5 ("I have already done it"). We included the response "I have already done it" from the ACP Engagement Survey in our definition of unmet palliative needs as previous studies have shown admitting teams rarely ask about preadmission ACP that was developed with a physician,[18] and documented goals of care in the inpatient setting rarely reflect the values of the patient, when known.[19] Hence, a score of 5 is most likely to represent a patient with known wishes that are not accurately documented, which can serve as a prompt for the healthcare team to discuss and document these.

Analysis

As there exists a significant disparity in the palliative care received by patients with different diagnoses in Ontario,[2] unblinded research assistants (AK and EK) reviewed patient charts for primary diagnosis information in order to classify patients by disease group similar to our previous study[9] (groups are based on trajectories described by Lunney *et al*).[20] Diagnoses were grouped as cancer, organ failure (eg, congestive heart failure/chronic obstructive pulmonary disease exacerbation), or frailty related (eg, admission from a long-term care facility, admission from home with a fall, confusion or another condition that would not require admission in a non-frail individual). Classifications were verified by an experienced physician (JD) prior to analysis. All analyses were conducted using R[21] V.4.0.3. Comparisons of unmet needs across the two mHOMR threshold groups were performed using Pearson's χ^2 tests with Yates' continuity correction.

RESULTS

Across both sites, a total of 518 mHOMR+ patients were approached, with 403 (78%) of those consenting to be included in the study. Table 1 presents characteristics of all patients identified at both mHOMR thresholds who consented to be included in the study—57% were male and the mean (SD) age was 75 (10); the median (IQR) length of stay in hospital was 6 (7) days; nearly all (94%) survived to discharge; 25% had a Do Not Resuscitate (DNR) order in place at or during the admission; and 11% had a palliative care consultation or a documented family meeting during the admission.

Overall, we found that 73% of patients reported a symptom score >6 on the ESAS-r; 59% reported readiness to engage in ACP with their physician; 87% reported either a symptom score >6 or readiness to engage in care planning with their physician; and 44% reported both (figures 1 and 2). Of the 236 patients who indicated they were ready to engage in care planning with their physician, 29% (69) had a DNR order in place at or during the admission.

We found several differences when we compared patients with mHOMR scores≥0.21 and those with scores of 0.10–0.21. Patients with mHOMR scores of 0.10–0.21 were younger (mean age of 68 vs 82), had lower mHOMR scores (median 0.151 vs 0.300), had shorter lengths of stay in acute care (median 5 days vs 7), less frequently had a DNR order at or during admission (17% vs 35%) and less frequently experienced family meetings during admission (7% vs 14%), compared with patients with mHOMR ≥0.21. Importantly, there were no differences in the prevalence of unmet palliative needs between patients in the two groups.

Patients classified into different disease groups reported different unmet palliative needs, although the most prevalent symptoms across all trajectories were tiredness, drowsiness and poor well-being (online supplemental table 1 and figure 2). Across all disease groups, patients had similar rates of uncontrolled symptoms and willingness to engage in ACP with their physicians.

DISCUSSION

In this prospective observational study of consecutive patients identified by the mHOMR model, we found that the prevalence of unmet palliative care needs was

Table 1 Characteristics of all patients identified by mHOMR

	Overall	mHOMR ≥0.21	0.10≤ mHOMR < 0.21	P value*
% (N)	100% (403)	45% (181)	55% (222)	
Age—mean (SD)	75 (10)	82 (8)	68 (7)	
Sex—% (N)				
Female	43% (174)	44% (79)	43% (95)	
Male	57% (229)	56% (102)	57% (127)	
mHOMR Score—median	0.197	0.300	0.151	
Length of stay (days)—median (IQR)	6 (7)	7 (8)	5 (7)	
Survival to discharge—% (N) (95% CI)	94% (380) (92% to 97%)	94% (170) (90% to 97%)	95% (210) (92% to 98%)	
DNR order at or during admission—% (N) (95% CI)	25% (101) (21% to 29%)	35% (64) (28% to 42%)	17% (37) (12% to 22%)	
Documented family meeting during admission—% (N) (95% CI)	10% (41) (7% to 13%)	14% (26) (9% to 20%)	7% (15) (3% to 10%)	
Documented palliative care consult during admission—% (N) (95% CI)	11% (43) (8% to 14%)	12% (22) (7% to 17%)	10% (21) (6% to 13%)	
ESAS>6—% (N) (95% CI)	73% (295) (69% to 78%)	77% (140) (71% to 84%)	70% (155) (64% to 76%)	0.113
Ready to speak to physician about ACP—% (N) (95% CI)	59% (236) (54% to 63%)	55% (99) (46% to 62%)	62% (137) (55% to 68%)	0.187
Both ESAS>6 and ready for ACP—% (N) (95% CI)	44% (179) (40% to 49%)	46% (84) (39% to 54%)	43% (95) (36% to 49%)	0.531
Either ESAS>6 or ready for ACP—% (N) (95% CI)	87% (352) (84% to 91%)	86% (155) (80% to 91%)	89% (197) (85% to 93%)	0.434

*Tests compared across the two mHOMR thresholds—Pearson's χ^2 tests with Yates' continuity correction.

ACP, Advance Care Planning; DNR, Do Not Resuscitate; ESAS, Edmonton Symptom Assessment Scale; mHOMR, modified Hospitalised-patient One-year Mortality Risk.

very high. Almost three quarters had one or more severe symptoms, more than half were ready to discuss care planning with a physician, and almost nine out of ten had one of the two. Participants in this study stayed in hospital an average of 1 week and the vast majority were discharged alive. But despite their elevated risk of mortality, severe symptoms, readiness to discuss care planning, and an average inpatient stay of 1 week, very few patients had a documented discussion about goals of care or a palliative care consultation. The main findings of this study were seen across different disease groups and in patients at both high and moderate risk of mortality. This suggests that our mHOMR model is a useful means of identifying people who are nearing the end of life and have unmet palliative needs that are currently not being identified or addressed, at a timely point in their disease course when they are in a well-resourced, acute care setting and have ample time to benefit from a palliative approach.

The mHOMR model appears well suited for the timely identification of patients who may benefit from a palliative approach to care. While originally designed as a mortality prediction model, our findings indicate that a large majority of patients identified by mHOMR also have palliative needs which are currently not being addressed. At the mortality threshold, we used in this study, mHOMR also preferentially identified patients with non-cancer disease trajectories—a population that often has little, if any, interaction with palliative care prior to their final days of life.[2] The fact that the high prevalence of unmet palliative needs was found in not only the high (>0.21) mortality risk group, but also in the moderate (0.10–0.21) mortality risk group, suggests that patients in the latter group might also benefit from palliative interventions, if sufficient palliative resources were available for deployment.

Without a reliable and timely means of identifying people with unmet palliative needs, we will struggle to improve end-of-life care. Clinicians cannot perform a comprehensive assessment of every patient they see, so tools have been developed to help with case identification, including the Supportive and Palliative Care Indicator Tool,[22] the Gold Standards Framework Proactive Identification Guide[23] and the Necesidades Paliativas Tool.[24] These tools all adopt a similar paradigm—clinicians first must identify a subgroup of people at elevated risk of mortality using the Surprise Question, a checklist of clinical or functional criteria, or both. Those at elevated risk of mortality undergo a comprehensive assessment of their needs and then the clinical team develops a management plan to address those needs. The initial step—identification—is beset by many challenges. First of all, the accuracy of current identification tools is poor to moderate at best[3]; low sensitivity means that many dying patients are not identified, while a low positive predictive value means that clinicians are often directed towards patients who may not be the highest priority. Moreover, busy

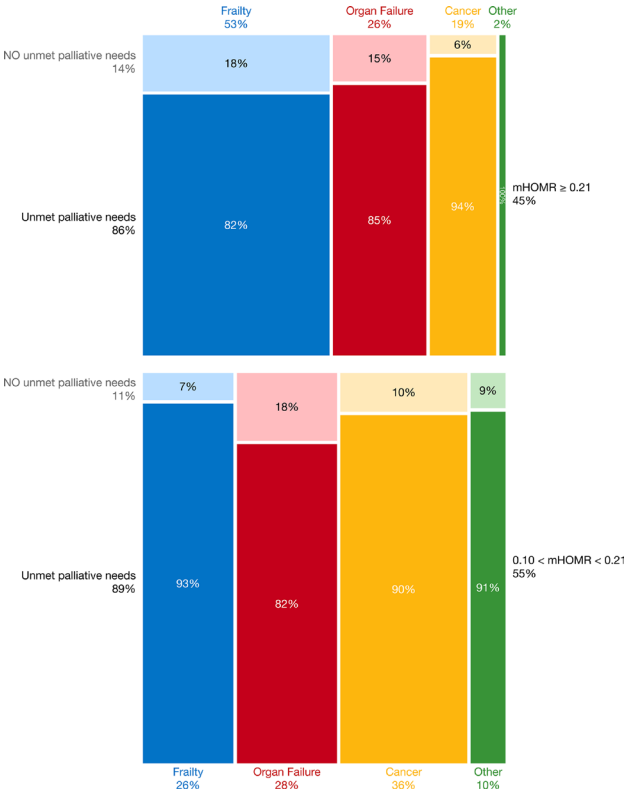

Figure 1 Mosaic plot of the distribution of patients across Hospitalised-patient One-year Mortality Risk (mHOMR) scores, disease groups and whether they had unmet palliative needs. Values indicate proportion of patients in that group, with the count in parentheses.

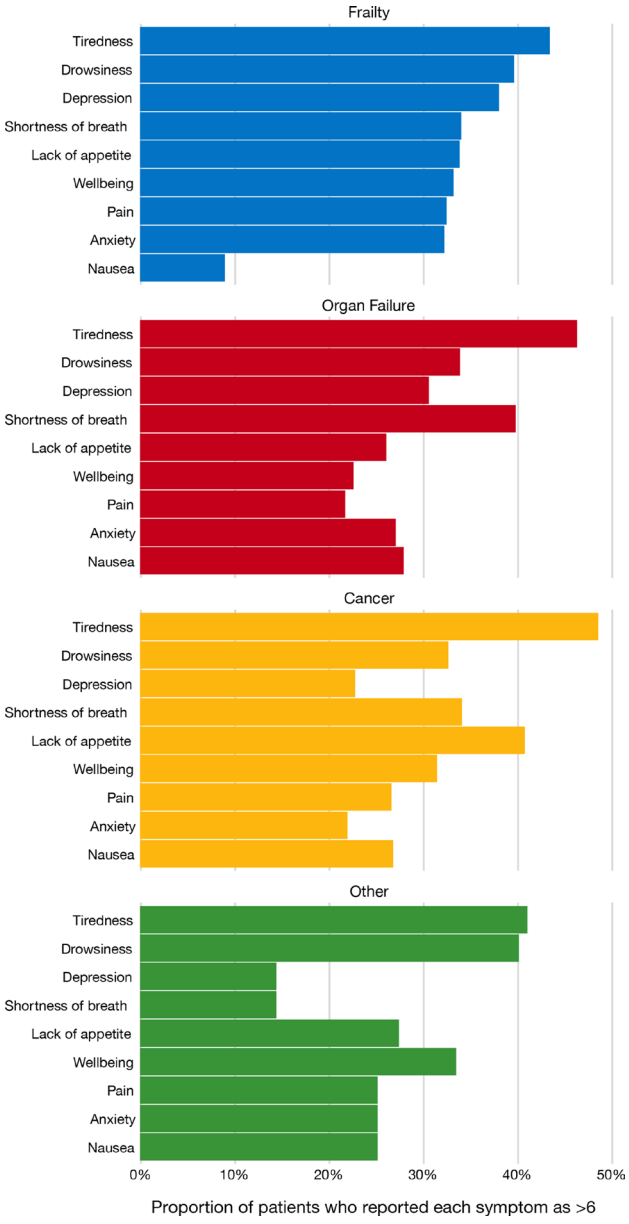

Figure 2 Bar plot of the incidence of self-reported prevalence of symptom scores>6 across disease groups.

frontline clinicians often do not have the time or inclination to spontaneously use these tools, and uptake has been low in practice.[5–7] This may be particularly true for patients with non-cancer illnesses and frailty, who are far less likely to receive palliative care than those with cancer. mHOMR is one of the most accurate mortality prognostication models currently available,[9 12 25] it preferentially identifies people with non-cancer illnesses, and it is not provider dependent.

In our previous study, an mHOMR notification did not trigger an automatic palliative care consultation, but we also found a significant increase in palliative care consultation and documented patient/family meetings regardless.[9] Courtright *et al* recently reported their experience implementing an automated tool that also used information in the electronic health record to identify patients with an elevated risk of mortality in the coming year.[11] In their study, the notification prompted a palliative care consultation, although the admitting team could opt out of the consult. They found that their intervention led to a significant increase in palliative care consultation, ACP documentation and home palliative care referrals; however, they did not evaluate the unmet palliative needs of identified patients. Both of these mortality prediction tools are designed to work in inpatient settings; however, there are also tools designed to work in long-term care and community care settings that could serve a similar function.[26] If implemented properly and potentially used in combination, these tools could help ensure that early identification becomes routine across settings.[4]

Simply identifying unmet palliative needs does not mean that those needs will be addressed, or that care will be improved as a result. Mittmann *et al* recently reported the results of a large-scale effort to integrate a palliative approach to care in patients identified using the Surprise Question.[27] Although identified patients did use palliative care services and received home visits more than historical controls, they also had a significantly higher rate of hospitalisation and ED visits for non-palliative purposes, suggesting that they were a selected group who accessed more healthcare overall, rather than just more palliative care.

Limitations

First, due to the lack of consensus around terminology in palliative care,[14] we used a definition of 'unmet palliative needs' based on established thresholds for symptom scores. Second, our estimate of the prevalence of palliative care consultation and family meetings was based on the health record, which may not include undocumented events. Third, we were unable to perform an a priori power calculation for the comparison between moderate and high mHOMR patients, so the lack of significant difference may represent a false negative. Fourth, we did not screen patients with low mHOMR scores (<0.10) for unmet palliative needs, so we do not know whether these needs were present regardless of mortality risk. Fifth, we did not follow these patients after discharge to determine their actual mortality rate or the care that they received. However, our study was not intended to revalidate the mHOMR model or to compare the prevalence of symptoms and readiness for ACP engagement among all patients. We sought only to determine whether those who were felt to be at greatest risk of death also had unmet palliative needs and might therefore benefit from a palliative approach. Finally, we recognise that people with a low mortality risk may also have severe symptoms and wish to discuss care planning, and we would ideally want to address everyone's needs. However, given how inconsistently palliative care is provided even to people within months of their death, we feel that it is important to focus our initial efforts on patients at the greatest risk of death.

CONCLUSIONS

We found that the mHOMR model can be used to accurately and reliably identify patients with a variety of illnesses who (1) are at high risk of mortality; (2) have unmet palliative needs; and (3) are still early enough in their disease course that they could benefit from the integration of a palliative approach. The widespread adoption of this sort of automated tool could help ensure a timelier adoption of a palliative approach for those who are nearing the end of life, particularly for those with non-cancer illness and frailty. Our next steps will be to implement this tool broadly across a number of acute care facilities to drive routine assessment of unmet palliative needs and ultimately to drive interventions that will help to meet those needs.

Author affiliations

[1]Humber River Hospital, Toronto, Ontario, Canada
[2]Institute for Health Policy, Management, & Evaluation, University of Toronto, Toronto, Ontario, Canada
[3]Department of Family & Community Medicine, University of Toronto, Toronto, Ontario, Canada
[4]Temmy Latner Centre for Palliative Care, Sinai Health System, Toronto, Ontario, Canada
[5]Rehabilitation Sciences, McMaster University, Hamilton, Ontario, Canada
[6]Albert and Temmy Latner Family Palliative Care Unit, Bridgepoint Active Healthcare, Toronto, Ontario, Canada
[7]Toronto General Research Institute, University Health Network, Toronto, Ontario, Canada
[8]Ottawa Hospital Research Institute, Ottawa, Ontario, Canada
[9]Department of Medicine, University of Ottawa, Ottawa, Ontario, Canada
[10]Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, Ontario, Canada
[11]Division of Palliative Care, Ottawa Hospital, Ottawa, Ontario, Canada
[12]Bruyere Research Institute, Ottawa, Ontario, Canada

Twitter Pete Wegier @petewegier

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Competing interests None declared.

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ORCID iDs
Pete Wegier http://orcid.org/0000-0003-0191-136X
Allison Kurahashi http://orcid.org/0000-0001-5109-4121

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Supplementary Table 1—Characteristics of mHOMR+ patients across disease group and thresholds

		mHOMR ≥ 0.21					0.10 ≤ mHOMR < 0.21				
	Overall	All Disease Groups	Frailty	Organ Failure	Cancer	Other	All Disease Groups	Frailty	Organ Failure	Cancer	Other
% (N)	100% (403)	45% (181)	24% (96)	12% (48)	8% (34)	1% (3)	55% (222)	14% (57)	16% (63)	20% (80)	5% (22)
Age — *Mean (SD)*	75 (10)	82 (8)	84 (7)	82 (9)	80 (8)	80 (9)	68 (7)	69 (6)	69 (8)	69 (6)	62 (7)
Sex — *% (N)*											
Female	43% (174)	44% (79)	44% (42)	48% (23)	35% (12)	67% (2)	43% (95)	47% (27)	40% (25)	36% (29)	64% (14)
Male	57% (229)	56% (102)	56% (54)	52% (25)	65% (22)	33% (1)	57% (127)	53% (30)	60% (38)	64% (51)	36% (8)
mHOMR score — *Median*	0.197	0.300	0.298	0.335	0.280	0.266	0.151	0.154	0.157	0.149	0.139
Length of stay (days) — *Median (IQR)*	6 (7)	7 (8)	6 (8)	6 (4)	11 (10)	4 (4)	5 (7)	4 (8)	6 (6)	6 (7)	4 (3)
Survival to discharge — *% (N)*	94% (380)	94% (170)	95% (91)	96% (46)	88% (30)	100% (3)	95% (210)	98% (56)	97% (61)	89% (71)	100% (22)
"Do Not Resuscitate" order at or during admission — *% (N)*	25% (101)	35% (64)	30% (29)	44% (21)	38% (13)	33% (1)	17% (37)	7% (4)	21% (13)	21% (17)	14% (3)
Documented family meeting during admission — *% (N)*	10% (41)	14% (26)	8% (8)	12% (6)	35% (12)	0% (0)	7% (15)	2% (1)	2% (1)	15% (12)	4% (1)
Documented palliative care consult during admission — *% (N)*	11% (43)	12% (22)	7% (7)	8% (4)	32% (11)	0% (0)	10% (21)	0% (0)	2% (1)	25% (20)	0% (0)
ESAS > 6 — *% (N)*	73% (295)	77% (140)	71% (68)	81% (39)	88% (30)	100% (3)	70% (155)	75% (43)	64% (40)	71% (57)	68% (15)
Ready to speak to physician about ACP — *% (N)*	59% (236)	55% (99)	49% (47)	69% (33)	56% (19)	0% (0)	62% (137)	56% (32)	57% (36)	70% (56)	39% (13)
Both ESAS > 6 and ready for ACP — *% (N)*	44% (179)	46% (84)	38% (46)	65% (31)	50% (17)	0% (0)	43% (95)	39% (22)	38% (24)	51% (41)	36% (8)
Either ESAS > 6 or ready for ACP — *% (N)*	87% (352)	86% (155)	82% (79)	85% (41)	94% (32)	100% (3)	89% (197)	93% (53)	82% (52)	90% (72)	91% (20)

Abbreviations. mHOMR—modified Hospitalised-patient One-year Mortality Risk; DNR—Do Not Resuscitate; ESAS—Edmonton Symptom Assessment Scale; ACP—Advance Care Planning.