Factors Affecting Physicians' Intentions to Communicate Personalized Prognostic Information to Cancer Patients at the End of Life: An Experimental Vignette Study

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Purpose. *To explore the effects of personalized prognostic information on physicians' intentions to communicate prognosis to cancer patients at the end of life, and to identify factors that moderate these effects.* **Methods.** *A factorial experiment was conducted in which 93 family medicine physicians were presented with a hypothetical vignette depicting an end-stage gastric cancer patient seeking prognostic information. Physicians' intentions to communicate prognosis were assessed before and after provision of personalized prognostic information, while emotional distress of the patient and ambiguity (imprecision) of the prognostic estimate were varied between subjects. General linear models were used to test the effects of personalized prognostic information, patient distress, and ambiguity on prognostic communication intentions, and potential moderating effects of 1) perceived patient distress, 2) perceived credibility of prognostic models, 3) physician numeracy (objective and subjective), and 4) physician aversion to risk and ambiguity.* **Results.** *Provision of personalized prognostic information increased prognostic communication intentions (P < 0.001, $\eta^2 = 0.38$), although experimentally manipulated patient distress and prognostic ambiguity had no effects. Greater change in communication intentions was positively associated with higher perceived credibility of prognostic models (P = 0.007, $\eta^2 = 0.10$), higher objective numeracy (P = 0.01, $\eta^2 = 0.09$), female sex (P = 0.01, $\eta^2 = 0.08$), and lower perceived patient distress (P = 0.02, $\eta^2 = 0.07$). Intentions to communicate available personalized prognostic information were positively associated with higher perceived credibility of prognostic models (P = 0.02, $\eta^2 = 0.09$), higher subjective numeracy (P = 0.02, $\eta^2 = 0.08$), and lower ambiguity aversion (P = 0.06, $\eta^2 = 0.04$).* **Conclusions.** *Provision of personalized prognostic information increases physicians' prognostic communication intentions to a hypothetical end-stage cancer patient, and situational and physician characteristics moderate this effect. More research is needed to confirm these findings and elucidate the determinants of prognostic communication at the end of life.* **Key words:** *provider decision making; risk communication or risk perception; shared decision making; numeracy; physician-patient communication; affect and emotion.* **(Med Decis Making 2016;36:703–713)**

Prognostic information is critically important in health care.[1,2] For clinical decisions across the health care continuum—from disease prevention and screening to disease treatment and end-of-life (EOL) care—prognostic information allows physicians and patients to determine the appropriateness of medical interventions and to make decisions that are informed and consistent with patients' values and preferences. This need is particularly great at the end of life, when patients must come to terms with impending death and determine whether or when to pursue or forgo curative or palliative treatment goals and interventions. These difficult tasks depend on prognostic information, which must thus be effectively communicated to patients. Empirical evidence suggests, furthermore, that terminally ill patients desire such information.[1–3]

Yet physicians have been shown to be reluctant to communicate prognostic information to patients.[2,4–7] The reasons are multiple and incompletely understood but include physicians' lack of confidence in

the accuracy of their own prognostic judgments.[4,8–10] This lack of confidence is justifiable, given that physicians' prognostic judgments have been shown to be inaccurate and optimistically biased, and evidence-based prognostic information has historically been lacking.[9,10] The latter situation, however, has begun to change in recent years with the development of a growing number of clinical prediction models (CPMs)—multivariable statistical algorithms that use characteristics of patients, diseases, and treatments to produce personalized estimates of the probability of future health outcomes including mortality and survival.[11,12] CPMs for estimating prognosis at the end of life have been increasingly disseminated (e.g., on public Web sites such as eprognosis.org) and implemented in clinical practice and now provide physicians and patients with the prognostic information they need to make end-of-life (EOL) care decisions that are informed, individualized, and based on patient values. A growing number of CPMs estimate short-term (6–12 mo) survival and may thus be useful for acute, critical EOL care decisions—in both hospitalized and nonhospitalized patients—including decisions to pursue palliative versus curative treatment goals or to refer patients for hospice care.[13–17]

Whether the availability of CPMs will increase the extent to which physicians communicate prognostic information to patients, however, remains unclear. The landmark SUPPORT study showed that the mere provision of evidence-based prognostic information does not necessarily enhance the clinical use and communication of such information by physicians.[18] Numerous barriers may inhibit physicians' capacity or willingness to communicate evidence-based, personalized prognostic information

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to patients.[18] Structural factors, for example, are widely acknowledged and include lack of time and financial incentives for clinical discussions of prognosis.[2,8,19,20]

Situational barriers are another potentially important category and include clinical circumstances (e.g., disease acuity, severity, and trajectory) and patient characteristics as well as available clinical information.[8] The emotional state of patients, for example, may be a particularly important barrier to prognostic disclosure by physicians. Patient emotional distress is common at the EOL and may be psychologically aversive to physicians, promoting avoidance of difficult conversations.[21] Another potential barrier to prognostic disclosure is the irreducible uncertainty that arises from inherent limitations in the reliability, credibility, and adequacy of all prognostic estimates. This type of uncertainty, which decision theorists have termed *ambiguity*, is known to promote pessimistic appraisals of risk information and avoidance of decision making.[22,23] This response may discourage physicians from communicating prognostic information to patients.

Physician characteristics represent a final potential category of barriers to prognostic disclosure at the EOL. Beliefs and attitudes about the credibility or value of prognostic models and evidence, as well as differences in physicians' numeracy—both the objective and subjective ability to understand and use numbers—may make physicians more or less able to use evidence-based prognostic information and comfortable disclosing such information to patients. Individual differences in physicians' tolerance of ambiguity may also be influential. Ambiguity-tolerant physicians may be more accepting of the inherent, irreducible limitations in the accuracy and precision of prognostic estimates and hence more comfortable sharing these estimates with patients. Similar effects might result from individual differences in physicians' tolerance of uncertainty arising from other sources such as probability or risk (the fundamental indeterminacy of future outcomes).[24]

Although these and other factors may limit physician communication of prognosis at the EOL, empirical evidence on their effects is lacking, in particular with respect to situational and physician characteristics. The objective of the current study was to begin to address this problem. We conducted a factorial experiment, using a hypothetical vignette, aimed at exploring the potential effects of various situational and physician characteristics on physician interest in communicating evidence-based, personalized

prognostic information: 1) patient affective state, 2) ambiguity in prognostic estimates, 3) physician perceptions of the credibility of prognostic models, 4) physician numeracy, and 5) physician tolerance of uncertainty (both risk and ambiguity). The ultimate aim of this experimental vignette study was to generate proof-of-principle evidence to guide more definitive future studies in clinical settings and to inform the development of interventions to increase the extent and effectiveness of prognostic communication at the EOL.

METHODS

Study Population and Recruitment

The study population consisted of a convenience sample of attending and resident family medicine physicians ($N = 312$) belonging to a regional consortium of 5 family medicine residency programs in Maine and New Hampshire: Maine Medical Center, Maine-Dartmouth Family Medicine Residency, Eastern Maine Medical Center, Central Maine Medical Center, and Dartmouth-Concord Hospital. From November 2013 to January 2014, members of this consortium ($n = 158$) participated in a separate study led by the research team, in which each physician completed a battery of measures assessing their tolerance of different types of uncertainty (e.g., risk, ambiguity). For the current study, members of this cohort were recruited individually by targeted e-mails and verbal communications at department meetings. An incentive of $50 per participating physician was provided to his or her residency program.

Study Design

The study consisted of a 2×2 online factorial experiment employing a hypothetical case vignette with prognostic ambiguity and patient affect varied between subjects (Figure 1). The vignette was adapted from a case developed by Barnato and others[25] and used in a mixed-methods study of physician decision making in EOL care. The case depicted a patient with end-stage gastric carcinoma who is admitted to the hospital with respiratory distress, likely secondary to cancer progression. The vignette was modified to incorporate our factors of interest, as summarized in Figure 2. The vignette had 2 parts: part 1 presented the case history, and part 2 presented prognostic information.

Prognostic information (absent, present) was operationalized in a pre/post manner, by presenting the

physician participants with case information in part 1 (without prognostic information) at which time they responded to measures assessing the outcomes of interest. Participants were then provided with an individualized mortality risk estimate calculated by a hypothetical CPM in part 2, at which time they responded again to measures assessing the outcomes of interest.

The between-subjects prognostic ambiguity condition (absent, present) was operationalized by communicating a hypothetical individualized mortality risk estimate as either a point estimate ("12-month mortality risk estimate of 78%") or a range ("12-month mortality risk estimate of 70–86%"). The between-subjects patient affect condition (emotional distress high, emotional distress low) was operationalized by the presence versus absence of language describing a patient and family member as either distressed, tearful, or apprehensive. Participants were randomly assigned to experimental groups and sent an e-mail containing a URL to access the online study survey hosted through REDCap, a secure, Health Insurance Portability and Accountability Act–compliant, Web-based survey application.

Measures

Outcome Measure

Prognostic communication intentions were measured using 2 items administered both before and after provision of prognostic estimates: 1) "How comfortable do you feel discussing prognosis with this patient and his family member?" and 2) "How likely are you to provide this patient and his family member with an estimate of prognosis?" Both questions used 6-point Likert-type scales ranging from 0 = *not at all* to 5 = *extremely*. These questions were asked both before and after provision of prognostic estimates to each participant. Responses were averaged to form a single scale score ($\alpha_{before} = 0.76$ and $\alpha_{after} = 0.85$).

Covariates and Moderators

Physician characteristics included age, sex, years in practice since residency training, and current proportion of time spent in clinical practice.

Perceived credibility of prognostic models was measured using a 4-item scale ($\alpha = 0.76$) developed for this study and ascertaining general perceptions of the accuracy, trustworthiness, and usefulness of prognostic models: 1–2) "In your opinion, how accurate [uncertain] are the risk estimates produced by clinical prediction models in general?" 3) "Do you think that physicians should trust the risk estimates
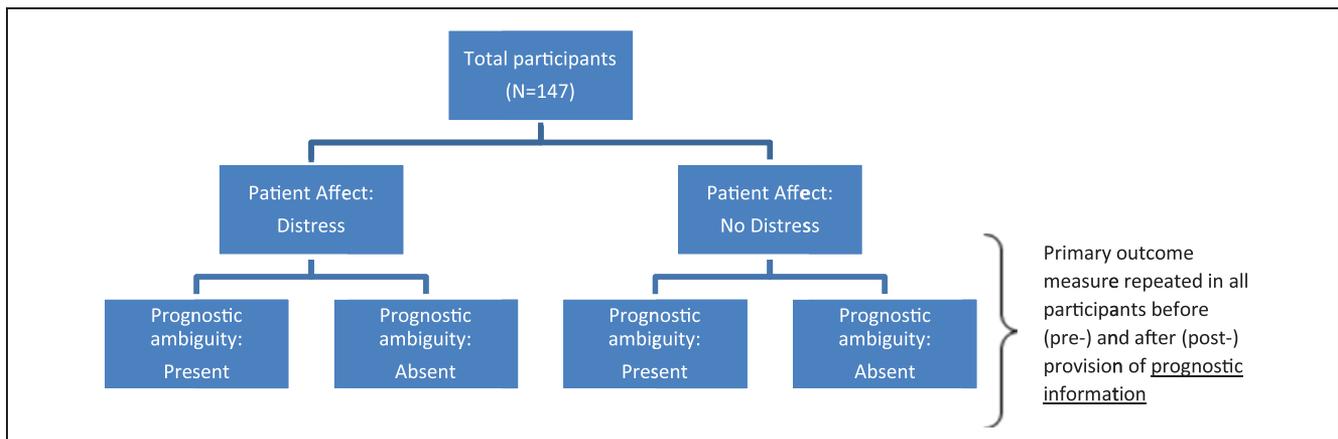
Figure 1 *Experimental design and conditions.*

PART 1

A 78-year old man with metastatic gastric carcinoma was transferred to the hospital from a skilled nursing facility with hypoxia, presumed most likely caused by cancer progression. You are summoned to the bedside approximately 8 hours after the patient's arrival on the hospital ward, because his nurse was concerned about gradually increasing tachypnea, tachycardia, hypotension, and hypoxia.

The patient chart includes documentation of widely metastatic gastric cancer, including lymphangitic spread to the lungs, and a spiral computed tomography negative for pulmonary embolism. The patient was recently discharged from the hospital 3 weeks ago following a 3-month hospital stay complicated by prolonged mechanical ventilation.

The Emergency Department physician's impression was that the patient's current dyspnea and hypoxia were most likely as a result of cancer progression, although a possible pneumonia could not be ruled out.

[**The patient and his wife both appear emotionally distressed. The patient is tearful and apprehensive. His wife is also crying and pleading with you and nurse, "Do something."**] The patient turns to you and asks your impression of his medical condition. In the course of the conversation, he then asks, "Am I going to be OK?"

PART 2

You inform the patient that more information is required to determine his prognosis, and defer further discussion for the time being. In the meantime, you prescribe oxygen, intravenous fluids, empiric antibiotic therapy, and transfer the patient to the Intensive Care Unit for close observation. You then utilize a recently developed clinical prediction model, developed at the National Cancer Institute and validated in a large national sample of cancer patients with similar characteristics, to determine the patient's prognosis based on his clinical characteristics. The model produces a 12-month mortality risk estimate of [**point estimate: 78%/range: 70-86%**] for this patient.

On the second hospital day, the patient's clinical condition has neither improved nor deteriorated. You return to the bedside. [**You again find the patient and his wife appearing extremely apprehensive, tearful, and emotionally distraught**] The patient again asks, "Am I going to be OK?"

Figure 2 *Clinical vignette (alternative experimental text bracketed in bold).*

generated by clinical prediction models?'' and 4) ''Do you think that physicians should use clinical prediction models when determining prognosis?'' All questions used 6-point Likert-type scales ranging from *not at all* to *extremely*. Responses were averaged to form a single scale score.

Risk aversion was measured using the 6-item Pearson Risk Attitude scale ($\alpha = 0.85$) adapted from the 20-item risk-taking subscale of the Jackson Personality Index by Pearson and others[26] to study physicians' aversion to risk in medical decision making. Among emergency department physicians, higher scores on the Risk Aversion scale have been associated with higher rates of admission for patients with acute chest pain.

Ambiguity aversion was measured using the 6-item Ambiguity Aversion in Medicine scale ($\alpha = 0.65$) developed by Han and others[27] to measure aversion to ambiguity—conceptualized specifically in behavioral decision theory terms, as uncertainty regarding the reliability, credibility, or adequacy of risk information. Greater ambiguity aversion has been shown to predict lower interest in a hypothetical ambiguous cancer screening test,[27] pessimistic cognitive appraisals of screening tests,[28] and lower breast cancer–screening intentions.[29]

Objective numeracy was measured using a 3-item scale modified from the Berlin Numeracy Test,[30] which was made more relevant to physicians by altering one of the items to make it discuss the proportion of people in a small town who ''have a genetic mutation'' rather than who are ''members of a choir.'' A response-option typographical error made 1 item uninterpretable, leaving a 2-item scale with potentially reduced measure reliability.

Subjective numeracy was measured using the STAT-confidence scale, designed to assess confidence in using medical statistics ($\alpha = 0.85$).[31]

Manipulation Check

A single item was used to assess the adequacy of the distress manipulation: ''How distressed do you think the patient in this scenario was?'' In addition, the perceived verisimilitude of the vignette was assessed by a single item, ''How realistic is the scenario, based on your practice experience?'' The items used a 6-item Likert-type response scale ranging from *not at all* to *extremely*.

Hypotheses

The following hypotheses were tested:

H1: A series of experimentally manipulated factors will influence prognostic communication intentions:
H1a: *Provision of prognostic information* will increase communication intentions.
H1b: *Prognostic ambiguity* will decrease communication intentions.

H1c: *Patient emotional distress* will decrease communication intentions.
H2: A series of factors will moderate the positive effect of providing prognostic information on prognostic communication intentions:
H2a: *Risk aversion*: greater risk aversion will decrease the positive effect of prognostic information.
H2b: *Ambiguity aversion*: greater ambiguity aversion will decrease the positive effect of prognostic information.
H2c: *Perceived credibility of prognostic models*: greater perceived credibility will increase the positive effect of prognostic information.
H2d: *Objective numeracy*: greater objective numeracy will increase the positive effect of prognostic information.
H2e: *Subjective numeracy*: greater subjective numeracy will be associated with greater intentions to communicate numeric prognostic information.

Data Analyses

A general linear modeling framework was used to assess the effect of the experimental manipulations and individual-difference and demographic measures on the primary outcome of communication intentions. Power was not determined a priori, given the study's opportunistic nature (the sample consisted of an existing study cohort) and the absence of previous similar studies of the outcome of interest. The study was thus exploratory in nature and aimed at generating initial effect size estimates. The analysis was completed in 2 stages because the experimental design was not fully crossed (the ambiguity manipulation applied only to part 2 because no prognostic information was presented in part 1). First, a linear model—with the change score for prognostic communication intentions as the dependent variable—was used to assess the effects of the provision of personalized prognostic information (i.e., from part 1 to part 2 of the vignette) on communication intentions and to identify predictors of these effects. A second linear model was used to assess factors predicting intentions to communicate prognostic information once it was available (i.e., within part 2 of the vignette). We used an automated model selection algorithm from the glmulti package in R to test all possible models and rank them by Bayesian Information Criterion (BIC).[32] The model with the lowest BIC was retained as the best-fitting model. Problems with traditional approaches to model selection include the reliance on arbitrary thresholds for *P* values and that backward and forward stepwise methods will not always

result in the same final model.[33] However, as a sensitivity analysis, we also used a standard backward elimination procedure, which resulted in the same variable selection and pattern of associations. We then examined the final best-fitting model, with and without the demographic control variables of gender, age, time since residency, and percentage of time spent in clinical practice. All analyses were conducted with the R statistical software package (version 3.2.1).

RESULTS

Of 158 participants in the original uncertainty tolerance study, 24 had either no valid contact information or were lost to follow-up. Of the remaining 134 individuals, 93 completed the experiment (response rate = 69%). Participant characteristics are in Table 1.

Manipulation Checks

Participants perceived greater patient distress in the distress than in the nondistress condition ($\bar{x}$ = 4.21 v. 3.48, t = 4.28, $P < 0.001$). Overall, 88% of participants rated the vignette as "fairly," "very," or "extremely" realistic, while 4% of participants rated it as "a little" or "not at all" realistic and were excluded from subsequent analyses (total N = 89).

Provision of Personalized Prognostic Information: Effects and Predictors

Consistent with predictions, there was a significant main effect of providing personalized prognostic information on prognostic communication intentions such that intentions were higher once prognostic information was present ($\bar{x}$ = 3.52) as compared with when it was absent ($\bar{x}$ = 2.87), $F_{1,88}$ = 53.95, $P < 0.001$, $\eta^2 = 0.38$. Table 2 shows the parameter estimates and 95% confidence intervals (CIs) for the best-fitting model predicting change in communication intentions both with and without controls. Contrary to predictions, however, there were no significant effects of the experimental factors (patient distress or prognostic ambiguity) on prognostic communication intentions.

However, several other variables moderated the influence of prognostic information on prognostic communication intentions in ways consistent with predictions. After accounting for demographic controls (model 2), greater perceived credibility of prognostic models was associated with a larger increase

Table 1 Study Population Characteristics

	n	%
Age, y		
$\leq$30	23	25
31–40	28	30
41–50	23	25
51–60	14	15
61–70	5	5
Sex		
Male	41	45
Female	51	55
Program		
Eastern Maine Med Center	20	22
Maine-Dartmouth	18	19
Maine Medical Center	31	33
Concord Hospital	11	12
Central Maine Med Center	13	14
Years since residency		
0	28	34
1–3	11	13
4–9	9	11
10–19	17	21
20–40	16	20
Percentage clinical time		
0–19	1	1
20–39	28	30
40–59	10	11
60–79	26	28
80–99	24	26
100	3	3

in communication intention ($P = 0.007$, $\eta^2 = 0.10$; Figure 3a), as was greater objective numeracy ($P = 0.01$, $\eta^2 = 0.09$; Figure 3b). Furthermore, although patient emotional distress as an experimentally manipulated factor had no demonstrable moderating effect, greater perceived emotional distress was associated with a smaller increase in communication intention following provision of prognostic information when compared with less perceived emotional distress ($P = 0.02$, $\eta^2 = 0.07$; Figure 3c). Being female was also associated with larger increases in communication intention ($P = 0.01$, $\eta^2 = 0.08$).

Intentions to Communicate Available Prognostic Information: Predictors

The next set of models focused on intentions to communicate prognostic information once it was available (i.e., in part 2 of the vignette), in a completely crossed between-subject comparison. Table 3 shows the parameter estimates and 95% CIs for the best-fitting model predicting communication

Table 2 Best-Fitting Linear Model (with and without Controls) for Change in Communication Intention before and after Prognostic Information ($N = 89$)

Predictor	Model 1	Model 2
Ambiguity aversion	−0.04*	−0.04
	(−0.09, 0.003)	(−0.09, 0.02)
Risk aversion	0.02	0.02
	(−0.02, 0.05)	(−0.01, 0.06)
Credibility of prognostic models	0.35**	0.42***
	(0.04, 0.66)	(0.12, 0.72)
Subjective numeracy	0.007	−0.005
	(−0.10, 0.09)	(−0.11, 0.10)
Objective numeracy	0.28**	0.34**
	(0.03, 0.54)	(0.08, 0.60)
Distress rating of patient	−0.27***	−0.25**
	(−0.47, −0.06)	(−0.47, −0.04)
Gender (1 = male, 2 = female)	—	0.46***
		(0.10, 0.83)
Age	—	−0.02
		(−0.33, 0.30)
Years since residency	—	−0.01
		(−0.05, 0.03)
Proportion of time spent in clinical	—	−0.001
		(−0.01, 0.005)

Note: Unstandardized regression coefficients (95% confidence interval).
*$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.

intentions in part 2 both with and without controls. Contrary to predictions, there were no significant main effects of either experimentally manipulated factor (patient distress or prognostic ambiguity) or of risk aversion. Consistent with predictions, however, several other variables predicted prognostic communication intentions. After accounting for controls (model 2), greater ambiguity aversion was associated with lower prognostic communication intentions ($P = 0.06$, $\eta^2 = 0.04$), whereas both greater perceived credibility of prognostic models ($P = 0.02$, $\eta^2 = 0.09$) and greater subjective numeracy ($P = 0.02$, $\eta^2 = 0.08$) were associated with higher intentions.

DISCUSSION

This study explored factors influencing family physicians' intentions to communicate evidence-based, personalized prognostic information to a seriously ill cancer patient at the EOL. The study used a hypothetical vignette, focused on the responses of physicians and not patients, and examined communication intentions rather than actual behaviors; its findings are thus clearly preliminary. To our knowledge, however, the current study is the first to use experimental methods to quantify the potential effects of personalized prognostic information on physicians' prognostic communication to dying patients and to identify potential moderators of these effects. The study thus provides valuable proof-of-principle evidence to guide future research to understand situational and physician characteristics that influence physicians' prognostic communication in EOL care.

The study's primary finding was that the provision of personalized prognostic information increased physicians' prognostic communication intentions. This finding is consistent with predictions and endorses the value of efforts to develop and implement CPMs in EOL care. If made available at the point of care, such models might finally provide physicians with the evidence and confidence they need to broach the issue of prognosis with dying patients.[21]

The equally important finding of our study, however, was that the effect of personalized prognostic information depended on several moderating factors. In our study, the positive effect of providing versus not providing such information on prognostic communication intentions was associated with greater perceived credibility of prognostic models, greater objective numeracy, less perceived emotional distress of the patient, and physician gender. These
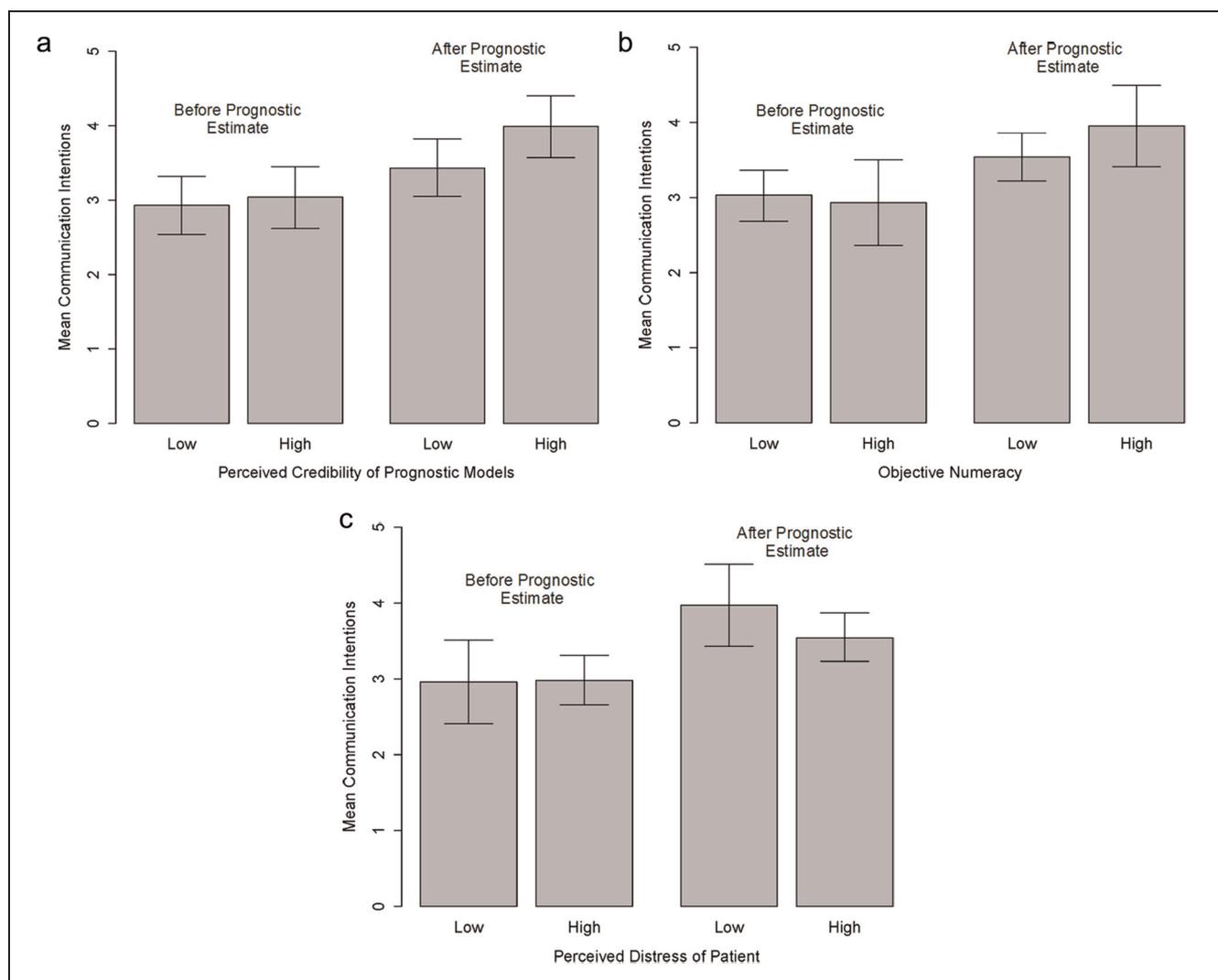
Figure 3 (a) Moderators of the influence of prognostic information on prognostic communication intentions: perceived credibility of prognostic models. (b) Moderators of the influence of prognostic information on prognostic communication intentions: objective numeracy. (c) Moderators of the influence of prognostic information on prognostic communication intentions: perceived patient distress.

findings are consistent with predictions and add to growing evidence on the variety of ways in which objective numeracy—the ability to use numbers—influences people's responses to and use of quantitative risk information.[34] The negative effect of perceived patient distress on physicians' prognostic communication intentions may manifest the influence of several factors. For example, people have been shown to neglect probabilistic information in emotionally rich situations[35] and may further avoid discussing prognosis with emotionally distressed patients because of fears of exacerbating emotional distress

or undermining hope.[36] More research is needed to test these and other alternative explanations.

Once numeric prognostic information was made available to physicians (at time 2), the likelihood to communicate it was influenced again by greater perceived credibility of prognostic models and also by greater subjective numeracy and lower aversion to (greater tolerance of) ambiguity. Past research has indicated that physicians lower versus higher in subjective numeracy are less likely to communicate numbers to explain screening test results to patients.[37] The present results are consistent with

Table 3   Best-Fitting Linear Model for Communication Intentions after Receiving Prognostic Information ($N = 89$)

Predictor	Model 1	Model 2
Ambiguity aversion	−0.08*	−0.06*
	(−0.15, −0.02)	(−0.14, −0.01)
Credibility of prognostic models	0.49***	0.54**
	(0.07, 0.91)	(0.97, 1.00)
Subjective numeracy	0.19***	0.18**
	(0.06, 0.32)	(0.03, 0.34)
Objective numeracy	0.03	0.05
	(−0.31, 0.37)	(−0.34, 0.45)
Gender (1 = male, 2 = female)	—	0.29
		(−0.27, 0.86)
Age	—	−0.24
		(−0.71, 0.23)
Years since residency	—	0.02
		(−0.04, 0.07)
Proportion of time spent in clinical	—	−0.001
		(−0.01, 0.01)

Note: Unstandardized regression coefficients (95% confidence interval).
*$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.

these findings and add support to the notion that subjective numeracy drives motivational and emotional processes that exert influence—independent of objective numeracy—on the communication of prognostic information.[34]

These findings need to be confirmed but are consistent with predictions and have several implications for future research and clinical practice. They suggest the need for further research to identify determinants of the perceived credibility of prognostic models and to educate physicians about the accuracy, utility, and appropriate clinical use of these models. They also raise the need for more work to understand how ambiguity tolerance develops in physicians and whether it can be "taught and nurtured."[38] Finally, our findings have practical import for efforts to use evidence-based prognostic models in EOL care. They suggest the importance of establishing and promoting the credibility of such models to physicians. They also suggest the need to enhance physicians' capacity not only to understand and use quantitative information but also to effectively manage the emotional distress that both patients and physicians may experience during the dying process. More research is needed to determine how best to accomplish these challenging tasks.

The null findings of our study point to additional future research needs. Contrary to predictions, our manipulations of prognostic ambiguity and patient emotional distress did not influence physicians' intentions to communicate prognostic information. One reason may have been that the study was underpowered, and our findings provide initial effect size information to power more definitive future studies. It is also possible that our experimental manipulations were insufficiently strong to elicit their intended effects. For example, the size of the statistical range used to operationalize ambiguity may have been too narrow to convey a degree of ambiguity that was psychologically or clinically significant. Similarly, although our manipulation check suggested otherwise, the manner in which emotional distress was conveyed in the vignettes may still have been insufficiently strong or vivid to elicit an emotional response; this may be a fundamental limitation of all paper-based vignettes. More research is needed to develop and test alternative experimental manipulations of these factors (e.g., using video stimuli or patient simulation). Finally, our study also found no influence of individual differences in aversion to risk—the other primary source of uncertainty in prognostic estimates[39]—on prognostic communication intentions. This finding supports the need to distinguish between specific types and sources of uncertainty (e.g., risk, ambiguity, complexity) when measuring uncertainty tolerance and assessing its effects.[39]

Our study had other limitations that further qualify its conclusions, aside from its hypothetical nature and focus on intentions rather than actual

communication behaviors. The sample population was relatively small and limited to family medicine physicians in a single, predominantly rural geographic region. Family medicine physicians, furthermore, may have limited familiarity and experience not only estimating prognosis but also providing acute hospital-based care for dying cancer patients. Although we believe that such physicians—particularly in rural practice settings—do routinely care for such patients, more work is needed to assess the generalizability of our findings to physicians in other specialties (e.g., oncology) and locations. Another fruitful direction for future work would be to assess the magnitude, accuracy, and associated uncertainty of physicians' own prognostic estimates. We used only 1 clinical vignette focused on 1 cancer type, set of clinical circumstances and prognostic estimates, and hypothetical prognostic model. Confirming our findings will require the development and validation of additional vignettes depicting a wider range of clinical scenarios.

Perhaps the most important limitation of our study was its singular focus on only the physician side of physician-patient prognostic communication. Clearly, patient perceptions and responses have equally critical effects on the extent, nature, and outcomes of the communication of personalized prognostic information between physicians and patients. Previous studies have shown, for example, that patients have negative perceptions of the competence of physicians who use computerized clinical decision support tools.[40,41] Such perceptions may make both physicians and patients reluctant to use these tools. Our own work has also suggested that patients' utilization of personalized prognostic information is limited by their lack of experience with using such information, a tendency to favor heuristic- over risk-based decision-making strategies, and perceptions that model-derived risk information is less valuable than other types of evidence (e.g., emotions, recommendations of trusted physicians, personal narratives).[42] More research is needed to examine how these and other patient-level factors influence both patients' and physicians' willingness to engage in communication about personalized prognostic information at the EOL.

Despite these limitations, our study provides important seminal evidence that the provision of evidence-based personalized prognostic information may increase physician-patient prognostic communication at the EOL and that several potentially modifiable factors may enhance this effect. It remains for future research to confirm these findings and

establish their generalizability and to develop effective interventions to improve the use and communication of prognostic information in EOL care.

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