Review Article

The accuracy of clinicians' predictions of survival in advanced cancer: a review

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Abstract: The process of formulating an accurate survival prediction is often difficult but important, as it influences the decisions of clinicians, patients, and their families. The current article aims to review the accuracy of clinicians' predictions of survival (CPS) in advanced cancer patients. A literature search of Cochrane CENTRAL, EMBASE, and MEDLINE was conducted to identify studies that reported clinicians' prediction of survival in advanced cancer patients. Studies were included if the subjects consisted of advanced cancer patients and the data reported on the ability of clinicians to predict survival, with both estimated and observed survival data present. Studies reporting on the ability of biological and molecular markers to predict survival were excluded. Fifteen studies that met the inclusion and exclusion criteria were identified. Clinicians in five studies underestimated patients' survival (estimated to observed survival ratio between 0.5 and 0.92). In contrast, 12 studies reported clinicians' overestimation of survival (ratio between 1.06 and 6). CPS in advanced cancer patients is often inaccurate and overestimated. Given these findings, clinicians should be aware of their tendency to be overoptimistic. Further investigation of predictive patient and clinician characteristics is warranted to improve clinicians' ability to predict survival.

Keywords: Advanced cancer; clinical prediction; prognosis; survival

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Background

Clinicians' predictions of survival (CPS) involve a complex process that attempts to formulate an easily understood survival prediction for patients (1,2). Health care professionals (HCPs) benefit from survival prediction, as they are able to make treatment recommendations based on this prediction (1). CPS is also important to patients and their families because of its relevance to prognosis, setting appropriate goals for management, and preparing for the patient's future (1). In fact, 61% of patients preferred to have their prognosis communicated by their doctor, and 98% of patients wanted this information communicated accurately and honestly (2).

Advanced cancer is typically characterized by an accelerated decline in health over the final weeks of a patient's life (3). Due to the predictability of this decline, prognostication of advanced cancer patients is often easier compared to patients with early stage disease (3). However, literature has shown that physicians tend to be overly optimistic and overestimate their patients' survival (2,4-14). Inaccurate predictions may hinder optimal management; for instance, overestimating survival may lead to over-treatment or late referral to palliative care, while underestimating survival may lead to under-treatment or premature referral to palliative care (1). Thus, the objective of this paper is to review the accuracy of clinicians' ability to predict survival

in advanced cancer patients.

Methods

Search strategy

A search in Cochrane CENTRAL, Ovid EMBASE, and Ovid MEDLINE was conducted for articles published in English between 2000 and May 2015. Keywords and subject headings used in the literature search included: neoplasms, terminally ill, carcinoma, disease, neoplasm metastasis, forecasting, prognosis, survival analysis, life expectancy, survival, mortality, physicians, hospices, and terminal care. The search strategy used is provided in *Appendix 1*.

Selection criteria

Studies were considered eligible during title and abstract screening if: (I) they involved a prospective cohort or retrospective cohort study design; (II) the primary subjects in the study were advanced cancer patients; (III) the study reported on the ability of clinicians to predict survival with a documented comparison of CPS versus observed survival (either the ratio of the estimated to observed survival was reported, or both the estimated and observed survival were reported independently to allow calculation of the estimated-to-observed survival ratio). All non-original articles, including literature reviews, editorials, and commentaries, were excluded. All studies concerning individual prognostic markers and tools, including biological and molecular markers and their ability to predict survival, were also excluded. Finally, studies including patients without a cancer diagnosis were excluded.

Data collection

Two authors (Cheon and Agarwal) screened titles and abstracts independently and established consensus through discussion where necessary to determine articles eligible for full-text screening. Articles considered eligible at the title and abstract review stage were evaluated at the full-text screening phase independently using the same reviewers and inclusion/exclusion criteria. Consensus was established by discussion between the two reviewers where necessary.

Data extraction

The following data was extracted from all included articles: year and country of publication, the number of centres included, patient characteristics, clinician characteristics, survival prediction data, level of evidence, identified patient-related and clinician-related prognostic factors, and main conclusions. Patient characteristics included the number of patients, primary tumour site, location of metastases, description of patient/cancer/metastasis, mean and standard deviation (SD) of patients' age, male to female patient ratio, time since diagnosis, number of patient deaths, and Karnofsky Performance Status score. Clinician characteristics consisted of the type of clinicians, their specialities, mean and SD of clinicians' age, male to female clinician ratio, and clinicians' duration of clinical and specialty-related experience. Lastly, the survival prediction data included the criteria for accuracy, median estimated and observed survival, the inter-quartile range of the survival estimate, the ratio of the estimated to observed survival, and the optimistic error.

Median estimated and observed survival was standardized to days. To compare the accuracy of clinical prediction among studies, a ratio of the estimated to observed survival was noted if presented by the papers, or calculated by the authors if directly absent in the papers. Estimated-to-observed survival ratios were calculated for each included study (*Table 1*) (2,4-17). To calculate the aforementioned ratio, we used the following formula: median estimated survival (days) divided by the median observed survival (days). In studies in which both probabilistic CPS and temporal CPS were presented, temporal CPS was analyzed.

Results

A total of 1,481 abstracts were initially identified in the literature search, of which 32 came from Cochrane CENTRAL, 1,041 came from Ovid EMBASE, and 408 came from Ovid MEDLINE. Data extraction and analysis of clinicians' ability to predict survival were carried out for 15 articles (*Figure 1*), as shown in *Tables 1* and *2*.

Patient characteristics

Primary tumour site was reported in 14 of the 15 included studies. The three most common primary tumour sites and location of metastases for included patients are reported in *Table 2*. The most common primary tumour site, as listed by 13 of 14 studies, was respiratory/lung (2,4-9,11,13-17), followed by breast in 8 of 14 studies (4,6,7,11-15), and gastrointestinal (4,8,11,14-17) and genitourinary/

Table 1 Clinicians' predictions of survival (CPS)

Reference	No. patients	Median estimated survival (days)	Median observed survival (days)	Estimated survival/ observed survival	Overestimation/underestimation of CPS
Perez-Cruz *et al.*, 2014 (4)	311	At 14 days to death:	At 14 days to death: 14	1.43	Overestimation
		Physicians (n=45): 20			
		Nurses (n=43): 20			
Kiely *et al.*, 2013 (5)	244	334.58	304.17	1.1	Overestimation
Fairchild *et al.*, 2014 (2)	155	All (n=395): 219.7	All: 126.6	All: 1.74	All: overestimation
		Medical group (n=150): 201.5	Medical group: 120.1	Medical group: 1.68	Medical group: overestimation
		Radiation therapist (n=119): 210.8	Radiation therapist: 116.3	Radiation therapist: 1.81	Radiation therapist: overestimation
		Nursing (n=73): 233.8	Nursing: 141.6	Nursing: 1.65	Nursing: overestimation
		Allied health professionals (n=53): 271.9	Allied health professionals: 147.7	Allied health professionals: 1.84	Allied health professionals: overestimation
Kondziolka *et al.*, 2014 (6)	150	All cancer specialists (n=18): 311.77	295.04	All cancer specialists: 1.06	All cancer specialists: overestimation
		Neurosurgeons (n=6): 358.92		Neurosurgeons: 1.22	Neurosurgeons: overestimation
		Radiation oncologists (n=7): 334.58		Radiation oncologists: 1.13	Radiation oncologists: overestimation
		Medical/neuro-oncologists (n=5): 219		Medical/neuro-oncologists: 0.74	Medical/neuro-oncologists: underestimation
Kiely *et al.*, 2013 (15)	189	273.75	334.58	0.82	Underestimation
Tseng *et al.*, 2013 (7)	N/A	Case 1: 365	Case 1: 456.25	Case 1: 0.8	Case 1: underestimation
		Case 2: 182.5	Case 2: 68.44	Case 2: 2.67	Case 2: overestimation
		Case 3: 730	Case 3: 456.25	Case 3: 1.6	Case 3: overestimation
Hui *et al.*, 2011 (8)	151	Nurses: 20	12	Nurses: 1.67	Nurses: overestimation
		Physicians: 14		Physicians: 1.17	Physicians: overestimation
Clément-Duchêne *et al.*, 2010 (9)	85	Consultants: 179.9	81.9	Consultants: 2.20	Consultants: overestimation
		Registrars: 149.8		Registrars: 1.83	Registrars: overestimation
		Residents: 150.5		Residents: 1.84	Residents: overestimation
Chow *et al.*, 2010 (10)	5	When actual survival was <1 month:		Actual survival estimated to 1 month:	Actual survival estimated to 1 month:
		Physicians: 121.67		Physicians: 4.0	Physicians: overestimation
		Nurses: 182.5		Nurses: 6.0	Nurses: overestimation
		Radiation therapists: 182.5		Radiation therapists: 6.0	Radiation therapists: overestimation
		When actual survival was 6 months:		Actual survival 6 months:	Actual survival 6 months:
		Physicians: 365		Physicians: 2.0	Physicians: overestimation
		Nurses: 365		Nurses: 2.0	Nurses: overestimation
		Radiation therapists: 304.17		Radiation therapists: 1.67	Radiation therapists: overestimation
		When actual survival was 9 months:		Actual survival 9 months:	Actual survival 9 months:
		Physicians: 182.5		Physicians: 0.67	Physicians: underestimation
		Nurses: 243.33		Nurses: 0.89	Nurses: underestimation
		Radiation therapists: 152.08		Radiation therapists: 0.56	Radiation therapists: underestimation

Table 1 (*continued*)

Table 1 (*continued*)

Reference	No. patients	Median estimated survival (days)	Median observed survival (days)	Estimated survival/ observed survival	Overestimation/underestimation of CPS
Chow *et al.*, 2010 (10) (continued)	5	When actual survival was 12 months:		Actual survival 12 months:	Actual survival 12 months:
		Physicians: 182.5		Physicians: 0.5	Physicians: underestimation
		Nurses: 273.75		Nurses: 0.75	Nurses: underestimation
		Radiation therapists: 182.5		Radiation therapists: 0.5	Radiation therapists: underestimation
		When actual survival was 16 months:		Actual survival 16 months:	Actual survival 16 months:
		Physicians: 365		Physicians: 0.75	Physicians: underestimation
		Nurses: 365		Nurses: 0.75	Nurses: underestimation
		Radiation therapists: 486.67		Radiation therapists: 1.0	Radiation therapists: neither
Barnes *et al.*, 2010 (11)	137	182.5	76.04	2.4	Overestimation
Lam *et al.*, 2008 (16)	167	70	76	0.92	Underestimation
Hartsell *et al.*, 2008 (12)	898	365	282.88	1.29	Overestimation
Chow *et al.*, 2005 (13)	739	197.4	111.3	1.77	Overestimation
Faris *et al.*, 2003 (14)	162	21	10	2.1	Overestimation
Higginson *et al.*, 2002 (17)	275	42	42	1.0	Neither

N/A, not available.

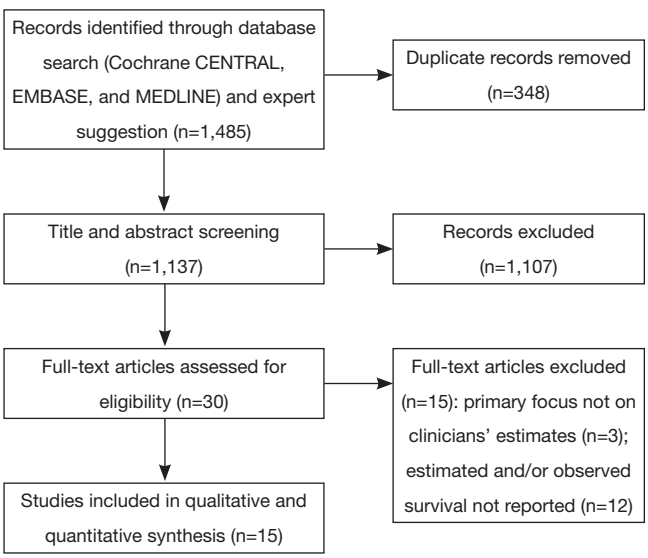

Figure 1 Flow diagram for articles included in the review.

gynaecologic/prostate (2,4,7,8,12,13,17), each in seven of 14 studies. Other primary tumour sites were melanoma (6) and unknown primary (2), each in one of 14 studies. The location of metastases for patients was also similar among studies: six of seven studies involved patients with brain metastases (2,6,7,11,14,15), five with bone metastases (2,7,12,14,15), three with liver metastases (7,14,15), two with lung or pleural metastases (14,15), and one with soft tissue metastases (14).

Clinicians' predictions of survival (CPS)

Data on prediction of survival was reported in the literature for various HCPs, ranging from physicians to nurses. The methods by which data was collected varied among the articles. The majority of the papers recorded the expected survival time once (2,5-17); however, the time at which survival predictions were made differed. For example, survival predictions were made after clinical assessment (2), before patient consultation (11), after enrolment into the palliative care service (16), at study entry (12), or after consultation (13). When survival time was estimated more than once, survival prediction was made daily until death or discharge (4).

In addition to different methods of data collection, the

Table 2 Patient and clinician characteristics

Reference	Patient characteristics		Clinician characteristics	
	Three most common primary tumour sites [%]	Location of metastases [%]	Type of clinician	Specialty
Perez-Cruz *et al.*, 2014 (4)	Gastrointestinal (GI) [30]; respiratory [13]; breast [11]; gynaecologic [11]	N/A	Physicians trained in palliative care (n=40); Nurses (n=29)	Palliative care
Kiely *et al.*, 2013 (5)	Lung [100]	N/A	Oncologists	Oncology
Fairchild *et al.*, 2014 (2)	Lung [48.4]; genitourinary [30.6]; primary unknown [8.7]	Bone and/or brain	Medical group—radiation oncologist, residents, medical students, and fellows (n=150); radiation therapists (n=119); nursing—nurse practitioner, registered nurse, and nursing students (n=73); allied health professionals—clinical nutritionist, occupational therapist, pharmacist, and respiratory therapist (n=53)	Palliative radiation oncology
Kondziolka *et al.*, 2014 (6)	Non-small cell lung [43.3]; breast [20]; melanoma [14]	Brain	Neurosurgeons (n=6); radiation oncologists (n=7); medical/neuro-oncologists (n=5)	Cancer specialists
Kiely *et al.*, 2013 (15)	Breast [18]; colorectal [16]; lung [15]	Lung or pleura [32]; liver [31]; bone [28]; brain [4]	Medical oncologists (n=21)	Oncology
Tseng *et al.*, 2013 (7)	Case 1: prostate; case 2: non-small cell lung; case 3: breast	Case 1: bone; case 2: bone, liver, and brain; case 3: bone	Radiation oncologists (attending physicians and residents)	Palliative oncology
Hui *et al.*, 2011 (8)	GI [20]; respiratory [18]; gynaecologic [15]	N/A	Nurses (n=20); physicians (n=8)	Palliative care
Clément-Duchêne *et al.*, 2010 (9)	Lung [100]	N/A	Residents (n=5); registrars (n=3); consultants (n=4)	Chest disease
Chow *et al.*, 2010 (10)	N/A	N/A	Physicians (n=24); oncology nurses (n=33); radiation therapists (n=58)	Rapid response radiotherapy
Barnes *et al.*, 2010 (11)	Lung [59.1]; breast [16.1]; GI [7.3]	Brain	Physicians (n=31)	Medical oncology (n=21); family physician (n=5); surgeon (n=2); internal medicine (n=2); palliative care(n=1)
Lam *et al.*, 2008 (16)	Lung [34.1]; liver [14.4]; lower GI tract [13.8]	N/A	Physician-in-charge (n=1)	Palliative care
Hartsell *et al.*, 2008 (12)	Breast [51]; prostate [49]	Bone	Physicians	N/A
Chow *et al.*, 2005 (13)	Lung [51]; breast [17]; prostate [16]	N/A	Palliative radiation oncologists (n=6)	Rapid response radiotherapy
Faris *et al.*, 2003 (14)	GI tract [24]; breast [17]; lung [12]	Soft tissue [70]; liver [48]; lung [33]; bone [27]; brain [17]	Oncologists (n=3)	Oncology
Higginson *et al.*, 2002 (17)	GI tract [31]; lung [28]; genito-urinary [12]	N/A	Multi-professional palliative care teams (nurses, physicians, and social workers)	Palliative care

N/A, not available.

criteria for accuracy of employed predictions also differed by study. Perez-Cruz *et al.* [2014], Hui *et al.* [2011], Lam *et al.* [2008], and Faris *et al.* [2003], who reported on 311, 151, 167, and 162 patients respectively, considered CPS to be accurate if it was within approximately 33% of the observed survival (4,8,11,14). In contrast, Kiely *et al.* reported on 244 patients in 2013 and considered CPS to be precise if it was within 0.75–1.33 times the observed survival (5), while Fairchild *et al.* reported on 155 patients in 2014 and determined CPS within 30 days of observed survival as correct (2). Lastly, Higginson *et al.* [2002] considered CPS to be accurate if observed survival fell between the minimum and maximum CPS, in their study involving 275 patients (17).

Accuracy of clinical prediction of survival

An estimated-to-observed survival ratio less than 1 (i.e., underestimation of survival) was calculated for all HCPs noted in two studies (15,16), and for a portion of HCPs or for 1 or more time-points assessed in three studies (6,7,10). The ratio ranged from 0.5–0.92 across these studies (6,7,10,15,16).

In contrast, nine studies reported a ratio greater than 1 (i.e., overestimation of survival) for all HCPs (2,4,5,8,9, 11-14), and three studies reported a ratio greater than 1 for a portion of HCPs or for 1 or more assessed time-points (6,7,10). The range of the ratio was 1.06–6 (2,4-14). Patients' survival duration was estimated more than once by Perez-Cruz *et al.* (4). Interestingly, the authors found that the median estimated survival was consistently higher than observed survival, regardless of how near patients were to death (4).

Differences among clinicians

While several studies did not report significant differences in the accuracy of survival prediction between physicians and nurses (4,11), some discrepancies were evident, suggesting that profession type may have some influence on CPS. Some studies noted a higher accuracy of CPS by physicians compared to nurses, and by residents and registrars compared to consultants (8,9). In addition, Fairchild *et al.* [2014] found no significant differences in accuracy between the medical group (consisting of a radiation oncologist, residents, medical students, and fellows), radiation therapists, nurses (consisting of a nurse practitioner, registered nurse, and nursing students), and allied health professionals (consisting of a clinical nutritionist, occupational therapist, pharmacist, and respiratory therapist), with the exception of a difference found between radiation therapists and allied health professionals (P=0.04) (2).

Although the specialities of clinicians varied, most clinicians practiced either in palliative care and/or oncology. Three studies indicated that the accuracy of CPS was not dependent on clinicians' experience or years of practice (8,11,13). Hui *et al.* [2011] also reported that differences in clinicians' age and sex were not significant factors for the prediction of survival (8).

Discussion

Summary of evidence

This review aimed to analyze the accuracy of clinicians' prediction of survival in advanced cancer patients. Building on the initial landmark study by Parkes *et al.* [1972] (18), which suggested little concordance between predicted and observed survival with 83% of prediction errors being overoptimistic, this review of recent literature suggests that clinicians tend to more often overestimate than underestimate patients' survival, as 12 studies reported optimistic predictions (2,4-14), while five studies (6,7,10,15,16) included pessimistic predictions.

Limitations

Several inconsistencies are present in the conclusions presented by the individual papers. Comparisons across different studies are difficult, considering differences in methodology, such as the diverse criteria used by each study to determine significance, and method employed to measure the accuracy of survival predictions. For instance, Kiely *et al.* [2013] suggested that oncologists' estimates of their patients' survival were imprecise (5). In contrast, Faris *et al.* [2003] stated that the correlation (0.678) between clinician-predicted and observed survival was significant (P=0.01) (14). Furthermore, Perez Cruz *et al.* [2014] noted that how near patients were to death did not affect the direction of survival estimation (i.e., survival was always overestimated). On the contrary, Chow *et al.* [2010] reported an interesting finding: survival predictions for patients with a survival duration of ≤6 months had a tendency to be optimistic, with

an estimated-to-observed survival ratio range of 1.67–6.0, while patients with a survival duration of ≥9 months had a tendency to be pessimistic, with a range of 0.5–1.0 (10). Ultimately, several studies draw attention to the fact that CPS are inaccurate (4,6,7,9,10,12,13,17). It is also important to recognize that other considerations beyond CPS and observed patient survival, including patient and clinician characteristics, models to guide clinician predictions and decision-making, and other variables influencing clinician predictions and subsequent decision-making, warrant further investigation. Analysis of these other variables may be useful for better survival predictions. Lastly, while the quality of the included studies was not critically appraised, our review includes studies with small samples, which may limit the generalizability of our findings.

A strength of our review is that we conducted a search of three databases to identify relevant literature in the area, and included studies assessing any subset(s) of HCPs at varying lengths of follow-up.

Conclusions

The ability of clinicians to predict survival accurately is difficult; however an estimate of patients' survival is necessary for HCPs, patients, and their families to make the most appropriate decisions. Clinicians must be aware and cognisant of this inaccuracy in CPS, and in particular, the tendency of HCPs to overestimate survival. This study highlights the need to further investigate the formulation of better survival prediction tools or perhaps the use of CPS in combination with other tools to predict survival. To improve the accuracy of survival prediction in advanced cancer patients, the ability of prognostic models as tools to estimate survival more accurately should be investigated (19-21). Accurate prediction of survival, followed by honest communication of prognosis with patients and their families, are essential for the appropriate delivery of palliative care.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Supplementary

Appendix 1 Search strategy for Ovid MEDLINE.
Database: Ovid MEDLINE(R) and Ovid OLDMEDLINE(R) [1946-May Week 1, 2015] Search Strategy:

1. exp Neoplasms/ and exp terminally ill/ [1371]
2. exp Neoplasms/ and ((terminal* or advanced or "stage IV") adj2 (cancer or neoplasm* or carcinoma or disease)).mp. [58790]
3. exp Neoplasm Metastasis/ [162600]
4. or/1-3 [214514]
5. exp Forecasting/ [72074]
6. exp Prognosis/ [1160020]
7. exp Survival Analysis/ [198744]
8. exp Life Expectancy/ [14362]
9. (prognostic factor* or prognostic tool*).mp. [61574]
10. ((predict* or forecast or estimat* or timing) adj2 (survival or life expectancy or life span)).mp. [21292]
11. exp Mortality/ [293231]
12. or/5-11 [1505536]
13. ((physician* or clinician* or clinical or oncologist*) adj4 (predict* or forecast or estimat* or timing) adj4 (survival or surviv* or life span or life expectancy or hospice or palliative or outcome)).mp. [6176]
14. 4 and 12 and 13 [490]
15. limit 14 to (english language and humans and yr="2000 -Current") [408]