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Examining the Potential Relationship Between Multidisciplinary Cancer Care and Patient Survival: An International Literature Review

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Background and Objectives: The aim of this review is to examine the relationship between multidisciplinary cancer care and patient survival.
Methods: A literature review was undertaken between January 1950 and September 2009. Included studies described multidisciplinary cancer care and its relation to patient survival. Multidisciplinary care was defined as involvement of a team of clinical and allied specialists whose intent is individualized patient management. Studies were critically appraised for internal and external validity. All study designs were included.
Results: Twenty-one studies met eligibility criteria for this review, including two systematic reviews, one abstract, and 18 original studies. Pooling of results was not possible due to heterogeneity of patient populations, disease sites, measured outcomes, and follow-up periods. Twelve studies (one prospective and six retrospective cohort studies, five before–after series) reported statistically significant association between multidisciplinary care and patient survival.
Conclusions: Due to methodological limitations, this review is unable to assert a causal relationship between multidisciplinary care and patient survival. In order to better evaluate this relationship, the oncology community must first accept a common definition of multidisciplinary care. Future efforts can then elucidate which aspects of multidisciplinary care impact survival, with consideration of confounding patient and tumour factors.
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KEY WORDS: **cancer; multidisciplinary; teamwork; survival**

INTRODUCTION

Contemporary cancer management is progressively becoming more sophisticated and specialized. From the detection of a lesion and recognition of its clinical and radiologic characteristics, to its confirmatory diagnosis and treatment, the management trajectory for a cancer patient is a multidisciplinary and frequently multimodal path requiring the input of many uniquely qualified individuals. The challenge lies in efficiently and effectively coordinating these key individuals to optimize the delivery of cancer care for health care providers and for patients.

Multidisciplinary care can flourish in many formats. Diverse input on patient management can be achieved through multidisciplinary clinics [1–4], organization of a hospital-wide multidisciplinary cancer program [5–7], creation of multidisciplinary diagnosis and treatment protocols [8], formation of a cancer service collaborative [9], or the use of multidisciplinary cancer conferences [10]. Given this multiplicity of formats, multidisciplinary care has been variably defined [11–13], but fundamentally encompasses collaborative patient care by a team of individuals where all diagnostic and treatment options are discussed and tailored for each patient. Although the team composition may vary by disease site and institution, independent contributors may include representatives from medical oncology, radiation oncology, surgery/surgical oncology, pathology, diagnostic imaging, palliative care, nursing, nutrition, and social work [12].

Multidisciplinary care is purported in the literature to offer many benefits to both patients and to providers. These include improved perceived satisfaction and psychological benefits for patients [1], comprehensive treatment decision-making by all involved specialists [10], improved integration of care for institutions and for health providers [5], ongoing education for health care providers [5,14], and increased access to clinical trials [11]. These benefits have prompted heath care organizations in the United Kingdom [15], Europe [16–18], the United States [19], Asia [7], and Australia [20] to formally promote and establish multidisciplinary care as a tenet of standard cancer management. In addition, the presence of multidisciplinary teams is a benchmark used for the attainment of accreditation and government funding [19].

Despite international support for multidisciplinary cancer care, one of the most elusive and poorly understood associations is the effect of an organized multidisciplinary approach on patient survival. This relationship is difficult to characterize with confidence as there is no single model or definition of multidisciplinary care. Furthermore, it is complex to determine which, if any, of the multiple purported benefits

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of multidisciplinary care impact patient survival. Despite this ambiguity, establishing an association between multidisciplinary care and objective patient outcomes is a vital component to justifying continuing expenditures in time, effort, and finances to coordinate and promote this healthcare approach. Therefore, the primary objectives of this review are to examine the quality of evidence linking multidisciplinary cancer teams to changes in patient survival, and to nurture future research questions linking survival with various aspects of multidisciplinary care.

METHODS

Search Strategy

A literature search was conducted using MEDLINE, EMBASE, CINAHL, and the Cochrane Library (1950 to September 2009). The following search terms were used:

- Neoplasms AND
- Patient care team OR
- (Multidisciplinary team OR multidisciplinary meeting OR multidisciplinary clinic) OR
- Tumor? board AND
- Survival OR survival analysis OR survival rate OR disease-free survival

All searchers were exploded to broaden the scope of the search. Searches were limited to the English language. Reference lists from original studies were reviewed.

Eligibility

All citations and abstracts were examined and screened for eligibility by a single individual (NLH). Articles were included in this review if the study examined multidisciplinary care (collaborative patient care by a team of clinical and allied specialists whose collective diagnostic and therapeutic intent was individualized patient management), and documented patient survival as an endpoint. All study designs were included. Studies were also included if they examined *related* concepts (e.g., specialist or hospital volume) with a *suggested* association to multidisciplinary teams or multidisciplinary care. The latter definition was included as there is no single established international definition of multidisciplinary care. Studies were excluded if they described models of multidisciplinary care without correlation to patient survival, or if they were not in the English language.

Data Extraction and Critical Appraisal

All studies that met eligibility criteria were reviewed in their entirety by a single individual (NLH). The quality of evidence was assessed using criteria to evaluate internal and external validity [21]. Internal validity was assessed by examining presence or absence of a comparison group, and adjustment for confounders or effect modifiers. External validity was assessed by examining study design, study population, and definition of multidisciplinary care.

Data Synthesis

Although it was the intention to statistically pool the results from these studies to determine the relationship between multidisciplinary care and patient survival, heterogeneity in study design, study populations, follow-up periods, and measurement of outcomes in the eligible studies precluded utility of meta-analysis.

RESULTS

Characteristics of Retrieved Studies

The initial literature search retrieved 186 articles. All abstracts were reviewed for eligibility. Figure 1 shows retrieval and selection of included studies. No completed randomized trials were retrieved. Initially, 141 articles were excluded because they addressed multidisciplinary care *or* survival outcomes but not both. A further 23 studies were excluded as they did not measure an association between multidisciplinary care and survival. Finally, a study by Reimer et al. [22] was excluded as it examined *postulated* survival using an online tool instead of accrued patient data. After final appraisal, 20 articles and one conference abstract met eligibility criteria for this review.

Parameters describing the critical appraisal of these studies, and a summary of survival results, are shown in Tables I and II. Although there were multiple endpoints examined in the included studies, this review concentrates on survival associated with multidisciplinary care or related measures.

Seventeen original articles and one conference abstract can be categorized in two groups based on study design. The first group of 11 cohort studies includes eight population based retrospective studies [23–30], two small retrospective studies [31,32] and one prospective single institution study [33]. Five of the cohort studies have explicit comparison groups [27–30,33] and eight include their definition of multidisciplinary care [23,24,28–33]. Two studies refer to the *ideal* multidisciplinary cancer team as outlined in existing national policy documents [25,26]. Of the five cohort studies with explicit comparison groups, four use indirect variables and suggest association of these measures with multidisciplinary care [27–30]. Three of these studies use clinician workload to imply the presence of multidisciplinary care [27,29,30] while the fourth study uses the presence of a specialist surgeon to imply multidisciplinary care [28]. All cohort studies except one [32] consider patient and tumour-related factors as confounders and effect modifiers in their multivariable analyses.

The second group of studies comprises seven before–after series [34–39], including one conference abstract [40]. In the abstract, the multidisciplinary team is not clearly defined. Of the six complete before–after series, five are single-institution studies [35–39] and all include explicit definitions of the multidisciplinary care setting. These five studies examine patient survival before and after establishment of their respective multidisciplinary endeavors. The sixth before–after series is population-based and temporally compares patient survival after implementation of a national effort in the United Kingdom to promote multidisciplinary care [34].

Survival

There were two systematic reviews included in this assessment examining multidisciplinary care and outcomes in breast cancer [41] and lung cancer [42] patients respectively. In breast cancer, the authors concluded that there is a paucity of evidence to support the association of multidisciplinary care and changes in survival. Similarly, authors examining lung cancer studies concluded that there is limited evidence to support linking multidisciplinary teams with patient survival. Neither of these reviews were able to statistically pool results due to clinical heterogeneity. Individual studies contained within these systematic syntheses are included in this review.

Nineteen original studies measured survival as an outcome in relation to direct or implied aspects of multidisciplinary care. The single conference abstract in this review [40] reported marginal statistical significance in its before–after series. One-year survival improved after introduction of a multidisciplinary team (MDT) and site specialization in radiation oncology [from 18.3% (95% CI

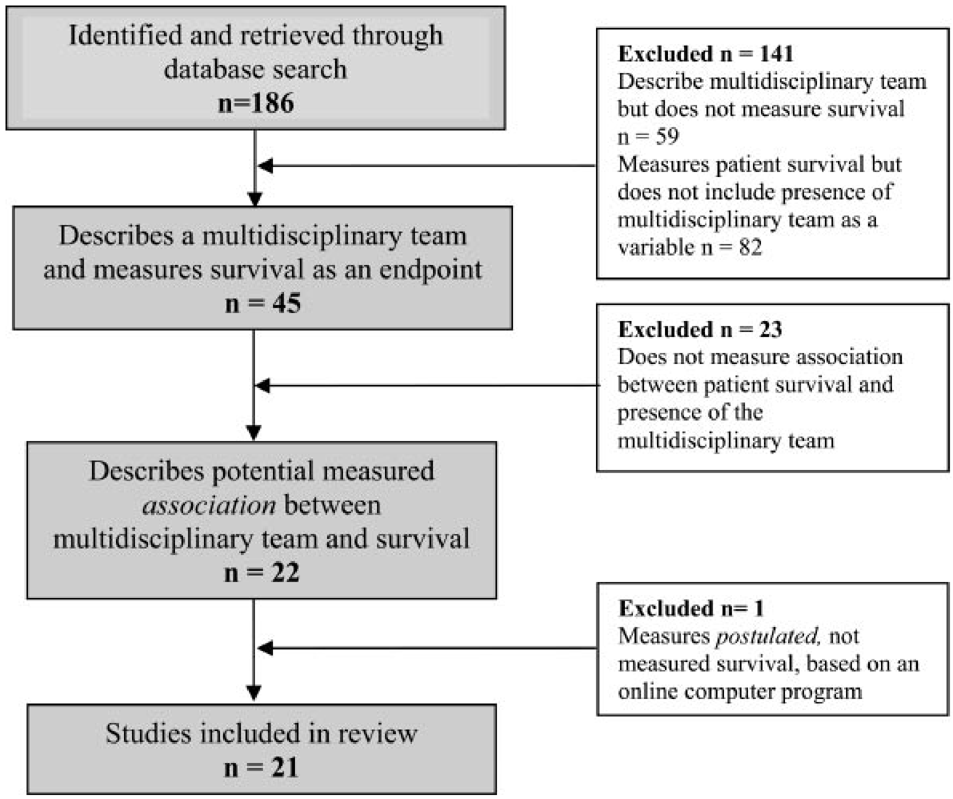

Fig. 1. Systematic retrieval and exclusion of articles for review.

13.6–23.0%), to 23.5% (95% CI 18.3–28.7%)] with $P = 0.049$. However, the MDT is not specifically defined in the abstract and all patients are over 70 years of age.

Four studies in this review reported nonstatistically significant associations between aspects of multidisciplinary care and patient survival [26,27,37,42]. Three of these studies specifically define their MDTs [26,37,43] while one cohort study used presence of increased clinician caseload to imply presence of a MDT [27]. A pilot randomized control led trial reported by Murray et al. [43] compared a rapid diagnostic pathway, including the presence of a multidisciplinary team, to usual care, for lung cancer patients. The MDT group appeared to have worse 2-year survival (33% compared to 40% in the non-MDT group), but the authors do not give an estimate of the number of patients necessary to detect a meaningful difference between the two groups. However, this pilot study demonstrated feasibility of the trial design to measure its targeted endpoints in a larger effort.

Twelve studies reported statistically significant improvement in patient survival with use of multidisciplinary care [23,25,28–31,34–36,38,39,44]. Of these 12 studies, three used surrogate measures of multidisciplinary care including surgical workload [29,30] and presence of specialist care [28]. Of the remaining nine studies, five are single-institution studies [35,36,38,39,44] while the remainder are population-based. In the before–after series by Dillman and Chico [35], the relative 5-year survival was statistically increased after institution of a MDT for 22 of the 24 reported anatomic cancer sites. However, two of the four sites for which subset comparisons of cancer stage at diagnosis were completed (lung and prostate) had statistically significant variations in the proportions of patients with local and regional disease before and after institution of the MDT, with the post-MDT period having an increased proportion of patients with earlier-stage disease.

The remaining two studies [24,32] suggested an improvement in survival with MDTs but did not document changes using objective comparative measures such as hazard ratios or adjusted relative risk.

Quality Assessment

This review is limited by a lack of completed randomized controlled trials and substantial clinical and methodological heterogeneity. Although 13 of the 21 studies had comparison groups, criteria were not consistent among studies (e.g., surgeon volumes, before and after implementation of multidisciplinary clinic, temporal comparisons). Many confounders and effect modifiers were consistent between studies (e.g., age, stage, use of adjuvant treatments), despite anatomic site variability, but were inconsistently used in multivariable analyses. Eight different anatomic sites were specifically addressed in this review, and one study [35] amalgamated 24 different anatomic sites. Only two [24,32] of the 21 studies take place outside of the United Kingdom. Therefore, since health care systems vary from country to country, generalized applicability of conclusions cannot be assured.

DISCUSSION

The goal of this review was to seek associations between multidisciplinary care and patient survival. Although evidence seems to favor a survival advantage with the use of multidisciplinary care, or related aspects of multidisciplinary care, the relationships reported in this review warrant cautious interpretation, and consideration of several important conceptual and methodological issues.

TABLE I. Parameters for Studies Examining the Association Between Multidisciplinary Teams (MDTs) and Survival

	Study design	Setting	Sample size	Anatomic site	Definition of multidisciplinary team/care	Use of comparison group (s)?	Considered confounders and/or effect modifiers	Measured outcome(s)
Junor et al. [23]	Population-based retrospective cohort	Scotland	N = 533	Ovary	Joint clinic where gynecologists and oncologists agreed on the most appropriate management throughout the postoperative treatment	No	Age, stage, pathology, degree of differentiation, histologic subtype, presence of ascites, consultation specialist, surgeon specialty, residual disease, MDT management, receipt of chemotherapy	Receipt of platinum-based chemotherapy, 5-year survival
Sainsbury et al. [30]	Population-based retrospective cohort	United Kingdom	N = 12,861	Breast	Surgeon workload, receipt of chemotherapy	Yes—workload classified into categories of median number of consultations per year	Age, socioeconomic status, extent of disease, tumor grade, year of treatment, treatment received	Surgical volumes per center, proportion of patients receiving chemotherapy/radiation, 5-year mortality
Gillis and Hole [28]	Population-based retrospective cohort	Scotland	N = 3,786	Breast	Specialist surgeon (work in dedicated clinic, links with other disciplines and trials, separate records for cancer care)	Yes—nonspecialist surgeons	Age, socioeconomic status, tumor size, nodal status	5- and 10-year survival
Price et al. [40]	Before–after series	Scotland	$N_1 = 262$, $N_2 = 280$, All > 70 years	Nonsmall cell lung	Unclear definition of MDT, site specialization in radiation oncology	Yes—pre- and postinstitution of MDT/site specialization	Gender, stage, histology	Delivery of radiotherapy, 1-year survival
Murray et al. [43]	Pilot randomized controlled trial	United Kingdom	N = 88	Lung	Establishment of rapid 2-step rapid diagnosis pathway including defined MDT meetings	Yes—randomized to rapid or conventional pathways	Age, gender, performance status, type of lung cancer, stage	Type of treatment received, time to treatment, quality of life, patient and GP satisfaction, 2-year survival
Stefoski Mikeljevic et al. [29]	Population-based retrospective cohort	United Kingdom	N = 11,329	Breast	Surgical workload, implied association with MDT	Yes—workload classified into categories of mean number new consultations per year, comparison with data from Sainsbury et al. [30]	Age, grade, disease extent, treatment modality, type of surgery, socioeconomic status, time period, surgeon workload, hospital workload	5-year survival
Birchall et al. [34]	Population based before–after series	England	$N_1 = 566$, $N_2 = 727$	Head and neck	Multidisciplinary clinic defined as clinic where patient assessed by at least one consultant oncologist and radiotherapist and one head and neck surgeon	Yes—2 temporal groups (1: 1996–1997, 2: 1999–2000)	Age, stage, tumor site, assessment by MDT, cancer network, receipt of pretreatment chest X-ray	Incidence, number of cases treated, wait times for treatment, processes of care, type of treatment received, 2-year survival
Wong et al. [32]	Retrospective cohort, single institution	Australia	N = 343	Metastatic nonsmall cell lung	Multidisciplinary lung cancer clinic attended by medical oncologists, radiation oncologists, respiratory physicians and thoracic surgeons	No	Age, performance status, symptoms at presentation, (no multivariable analysis completed)	Receipt of chemotherapy, referral to medical oncology or palliative care unit, enrollment in clinical trial, 5-year survival
Martin-Ucar et al. [37]	Before–after series	United Kingdom	$N_1 = 65$, $N_2 = 175$	Nonsmall cell lung	Establishment of MDT meetings and appointment of specialist thoracic surgeon	Yes—pre- and postspecialist surgeon and MDT meetings	Age, stage	Resection rate, type of procedure preformed, postoperative mortality, 1- and 5-year stage-specific survival
Forrest et al. [36]	Before–after series, single institution	Scotland	$N_1 = 117$, $N_2 = 126$	Inoperable nonsmall cell lung	Team consisting of 2 respiratory physicians, 2 surgeons, a medical oncologist, a clinical oncologist, a palliative care physician, a radiologist and a specialist respiratory nurse	Yes—pre (group 1) and post (group 2) MDT	Age, gender, deprivation index, tumor type, stage, (compared between groups but NO multivariable analysis completed)	Treatment received, median survival before and after institution of MDT
Dillman and Chico [35]	Before–after series, single institution	United States	$N_1 = 5,487$, $N_2 = 10\ 548$	24 tumor sites	Community-based cancer center, with medical and administrative leadership and weekly MDT meetings	Yes—intramural and extramural (SEER) comparison	Age, gender, race, stage (as per SEER)	Treatment received, 5-year survival (observed and relative)
Kelly et al. [24]	Population based retrospective cohort	Canada	N = 87	Uterine sarcoma	Treatment at cancer center, pathology review and discussion of management by multidisciplinary team	No	Age, stage, histologic subtype, receipt of radiotherapy, chemotherapy	Patterns of care, 5- and 10-year recurrence rate and overall survival

Shylasree et al. [31]	Retrospective cohort	Wales	N = 287, 20 hospitals (including 2 cancer centers)	Ovary	Decision for postoperative decision regarding chemotherapy made by cancer center MDT	No	Age, stage, histologic subtype, attempt at debulking surgery, residual disease, postoperative management by MDT, place of primary surgery, primary surgeon specialty, receipt of platinum-based chemotherapy	Preoperative investigations, referral patterns, progression-free survival, 1- and 3-year mortality
Stephens et al. [38]	Retrospective before–after series, single institution	Cardiff and Wales	$N_1 = 77$, $N_2 = 67$	Esophagus with curative intent surgery	Team of 2 specialist surgeons, 2 radiologists, 1 oncologist, 2 gastroenterologist, 1 anesthetists, 1 pathologist, 1 specialist nurse	Yes—before and after establishment of multidisciplinary team	Age, histologic subtype, MDT management, lymph node status, ASA grade, receipt of neoadjuvant chemo/radiotherapy, type of operation, operating surgeon	Proportion of open/close laparotomy, proportion of thoracotomies, operative mortality, 5-year survival, median survival
Morris et al. [25]	Population-based retrospective cohort	United Kingdom	N = 12,358 patients in, 13 cancer teams	Colorectal	Not specified but implied "ideal team" in manual of cancer services and improving outcomes guidance	No	Age, stage, townsend deprivation score, year of diagnosis, extent of Calman-Hine plan implementation with (a) degree of site specialist care (b) formation of MDT	Use of anterior resection, use of preoperative radiation for rectal cancer, use of chemotherapy for Dukes C/D colon cancer, 5-year survival
Downing et al. [27]	Population based retrospective cohort	United Kingdom	N = 1,500	Cervical	Oncologist and gynecologist workload, implied association with MDT	Yes—workload classified into categories of median number patient managed per year	Age, stage, year of treatment, histological type, socioeconomic status, receipt of radiotherapy	5-year survival
Houssami and Sainsbury [41]	Systematic review	N/A	14 articles + 1 abstract	Breast	Varies with study	Varies with study	Varies with study	Varies with study
Morris et al. [26]	Population-based retrospective cohort	United Kingdom	N = 12,961 patients in 13 teams	Breast	Not specified but implied "ideal team" in manual of cancer services and improving outcomes guidance	No	Age, stage, townsend deprivation score, year of diagnosis, extent of Calman-Hine plan implementation with (a) adherence to manual of cancer services standards (team score of growth) (b) extent of site specialization	Use of breast conserving surgery (BCS), use of BCS + adjuvant radiotherapy, 5-year survival
Coory et al. [42]	Systematic review	N/A	16 articles	Lung	Varies with study	Varies with study	Varies with study	Varies with study
MacDermid et al. [39]	Before–after series, single institution, single surgeon	United Kingdom	$N_1 = 176$, $N_2 = 134$	Colorectal	MDT includes colorectal surgeon, radiologist, pathologist, clinical oncologist, nurse specialist, and audit clerk	Yes—pre (1997–2002) and post (2002–2005) MDT	Age, gender, dukes stage, site of cancer, year of surgery	Proportion receiving chemotherapy, factors predicting prescription of chemotherapy and survival, 3-year survival
Lordan et al. [44]	Prospective cohort, single institution	United Kingdom	$N_1 = 108$, $N_2 = 223$	Metastatic colorectal	MDT always including liver surgeon and 2 dedicated oncologists from single institution vs. direct referral from other hospital	Yes—referral by MDT with liver surgeon and oncologists (N_1) and referral from other institutions (N_2)	Age, gender, ASA class, operative blood loss, intra/postoperative transfusions, hospital stay, resection margin, tumor size, septicemia, diaphragm invasion, preoperative chemotherapy, number of metastases, evidence of postresection recurrence	1, 3, and 5 year overall and disease-free survival

SEER, surveillance, epidemiology, and end results database; GP, general practitioner; ASA, American Society of Anesthesiologists.

TABLE II. Results for Studies Examining the Relationship Between Multidisciplinary Teams (MDTs) and Survival

	Study design	Anatomic site	Survival results
Junor et al. [23]	Population-based retrospective cohort	Ovary	Overall 5-year survival: 23.6%
Sainsbury et al. [30]	Population-based retrospective cohort	Breast	Adjusted hazard ratio: 0.60 (95% CI 0.46–0.78, $P<0.001$ when attend multidisciplinary clinic) 5-year mortality and adjusted risk ratio death <10 cases/year: 1.00 (reference) 10–29 cases/year: 0.97 (95% CI 0.90–1.06) 30–49 cases/year: 085 (95% CI 0.77–0.93) >50 cases/year: 0.86 (95% CI 0.79–0.94) Receipt of chemotherapy: 0.95 (95% CI 0.93–0.97)
Gillis and Hole [28]	Population–based retro spective cohort	Breast	5-year survival: 67% (specialist) 58% (nonspecialist) 10-year survival: 49% (specialist), 41% (nonspecialist) Adjusted hazard ratio: 0.84 (95% CI 0.75–0.94) if treated by specialist surgeon—16% reduction in risk of death when treated by specialist surgeon Consistent difference across age and socioeconomic strata
Price et al. [40]	Before–after series	Lung	1-year survival (>70 years) 18.3% (95% CI 13.6–23.0%) pre-MDT and site specialization 23.5% (95% CI 18.3–28.7%) post-MDT and site specialization $P=0.049$
Murray et al. [43]	Pilot randomized con trolled trial	Lung	2-year survival: $P=0.7$ 33% MDT group 40% non-MDT group
Stefoski Mikeljevic et al. [29]	Population-based retrospective cohort	Breast	5-year overall survival: 66% Adjusted relative risk (RR) death <10 cases/year: 60%, RR death 1.15 (95% CI 1.03–1.28) 10–29 cases/year: 64%. RR death 1.10 (95% CI 1.02–1.18) 30–49 cases/year: 66%, RR death 1.01 (95% CI 0.93–1.08) ≥50 cases/year: 68% (reference) Hospital workload nonsignificant
Birchall et al. [34]	Population-based before–after series	Head and neck	2-year survival Group 1: 64.1% (95% CI 60.2–68.0) Group 2: 65.1% (95% CI 61.6–68.6) Adjusted hazard ratio: 0.70, ($P=0.02$) when assessed by MDT in group 2
Wong et al. [32]	Retrospective cohort, single institution	Metastatic nonsmall cell lung	Median overall survival: 5 months Overall 1-year survival: 19.8%
Martin-Ucar et al. [37]	Before–after series	Nonsmall cell lung	1-year survival: 62% (pre-MDT), 63% (post-MDT) 5-year survival: 32% (pre-MDT), 31% (post-MDT) Nonsignificant once stage adjusted Median survival—stage 1 (34 patients), $P=0.9$ 46 months (95% CI 31–61 months) pre-MDT (34 patients) 46 months (95% CI 22–70 months) post-MDT (80 patients)
Forrest et al. [36]	Before–after series, single institution	Inoperable nonsmall cell lung	Median survival 3.2 months in group 1 Median survival 6.6 months in group 2 ($P<0.001$)
Dillman and Chico [35]	Before–after series	24 tumor sites	5-year survival: 52% (pre-MDT), 58% (post-MDT) $P<0.001$ Median survival: 70 months (pre-MDT), 96 months (post-MDT) Relative 5-year survival: 63% (pre-MDT), 71% (post-MDT) SEER (external comparison): 58% (pre-MDT time period), 64% (post-MDT time period)
Kelly et al. [24]	Population-based retrospective cohort	Uterine sarcoma	Overall median survival: 55 months 5-year overall survival: 48% 10-year overall survival: 21%
Shylasree et al. [31]	Retrospective cohort + survey	Ovary	Overall median survival: 802 days Median progression free survival: 746 days 1-year survival: 65% 3-year survival: 60% Adjusted hazard ratio 1.79 (95% CI 1.09–2.93, $P=0.012$) if postoperative care at peripheral hospital compared to gynecology oncology MDT at cancer center (reference)

TABLE II. (*Continued*)

	Study design	Anatomic site	Survival results
Stephens et al. [38]	Before–after series, single institution	Esophagus	Operative mortality: 26% (historical cohort) vs. 5.7% (MDT cohort) 5-year survival: 10% (historical cohort) vs. 52% (MDT cohort), $P < 0.001$ Median survival: 18 months (95% CI 10–26 in historical cohort) vs. 66 months (95% CI 15–116 in MDT cohort), $P < 0.001$ Adjusted hazard ratio: 0.34 (95% CI 0.20–0.56, $P < 0.001$) when managed by MDT
Morris et al. [25]	Population-based retrospective cohort	Colorectal	Overall 5-year survival: 38.3% Median 5-year survival: 38.1% Adjusted hazard ratio: 0.97 (95% CI 0.94–0.99, $P = 0.01$) with 25% increase in MDT score—25% increase in team score associated with 3% reduction in risk of death for all colorectal patients
Downing et al. [27]	Population-based retrospective cohort	Cervical	5-year survival Overall: 62.9% (95% CI 60.4–65.3) Adjusted hazard ratio <4 cases/year: 1.00 (reference) 4–11 cases/year: 0.85 (95% CI 0.68–1.05) ≥12 cases/year: 0.81 (95% CI 0.64–1.01)
Houssami and Sainsbury [41]	Systematic review	Breast	14 studies and one abstract providing information on multidisciplinary care or related aspects, and clinical outcomes 2 case series: treatment patterns 4 cohort studies: increased survival with specialist caseload 5 cohort studies: hospital caseload and survival, 3 positive associations 3 cohort studies: increased survival with increased specialist care
Morris et al. [26]	Population-based retrospective cohort	Breast	Overall 5-year survival: 69.7% (95% CI 68.9–70.5) Median 5-year survival: 68.7% Adjusted hazard ratio: 0.96 (905% CI 0.89–1.02, $P = 0.18$) with 25% increase in MDT score—25% increase in team score associated with a 4% reduction in risk of death Adjusted hazard ratio: 0.93 (95% CI 0.86–1.01, $P = 0.10$) with 25% increase in surgical specialization—25% increase in specialization associated with a 7% reduction of death
Coory et al. [42]	Systematic review	Lung	16 studies describing multidisciplinary team working in relation to survival, practice patterns and wait times for treatment 1 pilot randomized controlled trial—describes survival as an endpoint 7 Before–after series—4 describing survival as an endpoint 8 case series—none describing survival as a endpoint
MacDermid et al. [39]	Before–after series, single institution	Colorectal	3-year survival 76% (pre-MDT) vs. 70% (post-MDT) for DUKES B ($P = 0.486$) 58% (pre-MDT) vs. 66% (post-MDT) for DUKES C ($P = 0.023$) Receipt of adjuvant chemotherapy: 13% (pre-MDT) vs. 31.3% (post-MDT) ($P = 0.0002$) MDT status significant predictor of receipt of chemotherapy (OR 3.56, CI 1.90–6.68, $P < 0.0001$) MDT status significant predictor of mortality (HR 0.73, CI 0.72–0.98, $P = 0.044$)
Lordan et al. [44]	Prospective cohort, single institution	Metastatic colorectal	Overall survival 1 year—90.3% (referral from MDT with surgeon/oncologist) vs. 90.3% (direct referrals) 3 year—76.2% (referral from MDT with surgeon/oncologist) vs. 54.1% (direct referrals) 5 year—49.8% (referral from MDT with surgeon/oncologist) vs. 43.3% (direct referrals) Overall mortality significantly decreased with referral by MDT with liver surgeon/oncologists ($P = 0.0001$) Disease free survival 1 year—65.4% (referral from MDT with surgeon/oncologist) vs. 70.3% (direct referrals) 3 year—31.0% (referral from MDT with surgeon/oncologist) vs. 37.6% (direct referrals) 5 year—27.1% (referral from MDT with surgeon/oncologist) vs. 27.9% (direct referrals) Overall disease free survival not significantly decreased with referral by MDT with surgeon/oncologists ($P = 0.205$)

Defining Multidisciplinary Care

One of the major issues surrounding the relationship of multidisciplinary care and survival is the lack of a consistent definition of multidisciplinary care. This deficiency hampers investigation of benefit from multidisciplinary care. Three of the studies presented in this review with statistically significant increases in survival measured variables, including case volume [29,30] and specialist designation [28], and implied a possible association with multidisciplinary care. The cohort study by Gillis and Hole [28] indicated that association with pathologists and oncologists was implied in the designation of a *specialist*. Although specialists often work in treatment centers with large case volumes, and with available multidisciplinary personnel, it is imprudent to fully equate these surrogate measures with coordinated multidisciplinary care, as specialist clinicians with high caseloads may work independently to manage patients, irrespective of an available team-oriented practice environment. Furthermore, these studies do not attempt to measure which aspects of high caseload or clinician specialization correlate with improved survival. For example, improved survival may be associated with more precise surgical technique with increasing volumes of cases, better available systemic or radiotherapeutic adjuvant options, more frequent availability of clinical trials, or more appropriate selection of patients to receive individual treatments. These details must be clarified before surrogate measures can confidently be used to equate to multidisciplinary care.

Temporal Changes

The before–after series methodology reported in seven of the reported studies warrants interpretation with prudence. Six of these studies describe results from the United Kingdom, where reorganization and restructuring of the National Health Service has prompted widespread use of multidisciplinary teams [15,45]. Systematic reorganization in the United Kingdom is highlighted by two studies examining patients before and after the implementation of changes in health care delivery. In a study of head and neck cancer patients, two cohorts, one before (566 patients) and one after (727 patients) cancer care reorganization, were identified by clinicians in each designated area, and confirmed with the Cancer Register and through arbitrary case note sampling [34]. This study demonstrated improved adherence to clinical standards of care, including referral to a multidisciplinary clinic, in the postrestructuring cohort. Overall, there was improved 2-year survival for patients seen at a multidisciplinary clinic. In a similar study of inoperable lung cancer patients in Scotland, two cohorts of patients were identified—one before (117 patients) and one after (126 patients) the implementation of multidisciplinary teams [36]. Information extracted from case notes in this study demonstrated an improved median survival in patients treated by a multidisciplinary team (3.2 months with no multidisciplinary team, 6.6 months with multidisciplinary team).

Although it a convenient and less expensive method to evaluate changes in outcome as opposed to a randomized controlled trial, the temporal comparison of two groups in a before–after series is often difficult due to the inherent characteristics of patients in each group. Management of cancer is dynamic and diagnosis and treatment protocols are constantly evolving to adopt advances in screening and management. Therefore, temporal comparison of groups before and after implementation of organized multidisciplinary care may also represent changes in treatment protocols with accompanying improvements in survival. This is aptly illustrated by the before–after series by Dillman and Chico [35], where statistically significant improvement in overall relative survival was observed, but the later group (from 1992 to 1999) reported statistically significant differences in the use of systemic therapy, biologic therapy and combined modality therapies. In addition, this later group also demonstrated earlier stage at diagnosis with statistically greater proportion of patients with local or regional disease (as compared to distant metastatic disease) in lung and prostate cancers. This may represent lead-time bias in the detection of earlier stage disease with changes in screening. Therefore, an observed increase in survival in this study is indeed a composite measure of earlier disease detection, increased application of multimodality treatment, in addition to benefit conferred by the implementation of multidisciplinary care. Although statistical adjustment was completed in the analysis of many of these studies to account for variations in treatment received, the relative contributions of each of these temporal changes is difficult to ascertain with certainty. Causal associations between multidisciplinary care and survival are therefore impossible to confidently assert in before–after series.

Use of Administrative Databases

The use of administrative data also limits some of the conclusions that may be drawn from this review. Six of these studies [23,25,26,28,30,34] use population—based cancer registry data to identify cohorts of patients with ovarian, breast (three studies), colorectal and head and neck cancers. Multidisciplinary involvement in these cases was identified by subsequently consulting the case records of these patients in only two [23,34] of these studies. While using registry data for patient identification prevents the bias associated with clinician selection of patients, registry data offers limitations with respect to the variables available for analysis. The constraints of registry data are reflected in inherent errors related to completeness and accuracy of the inputted administrative data, and in the inaccessibility of information on surgeon skill, patient comorbidities, performance status, and quality of life. In addition, temporal changes in clinical practice, such as doses and indications for radiation, chemotherapy, or hormone therapy, or changes in recommended surgical procedures, cannot be differentiated in survival models created from registry data. Finally, only two of these studies utilized multilevel statistical modeling to account for the clustering effect of patient care in hospitals/regions [25,26]. These limitations may have significant and immeasurable effects on the observed patterns of patient survival.

Development and Evaluation of Multidisciplinary Care

Methodological variability and lack of a consistent definition of multidisciplinary care in this literature review invokes several important issues. While clinicians acknowledge the value of multimodality therapy for cancer, evidence-based components of coordinated multidisciplinary care are lacking. If cancer care providers are unable to define the components multidisciplinary care, it is impossible to rigorously measure its implementation or to evaluate its influence on patient, provider, and system outcomes. Clearly, as described above, the measurement of surrogate endpoints is not a wise option.

Based on the included studies, multidisciplinary care implies, at minimum, the concurrent input of surgical, radiation and/or medical oncologists for patient management, depending on the needs of the specific anatomic cancer site. Radiologists are the most common adjunct to treatment decision-making. The most common venues for multidisciplinary decision-making are clinics or regularly organized meetings, often occurring in designated cancer centers. Participants physically meet together or are virtually linked via tele or phone conference.

Once potential components are defined, multidisciplinary care can be rigorously implemented and evaluated. However, it is currently unclear which aspects of multidisciplinary care, namely specialist care, case volume, propensity to receive adjuvant therapies, or improved cross-disciplinary collaboration, contribute most to the suggested survival advantage conferred by the multidisciplinary setting. Accurate measurement of these components, with clear specification of the structures and processes within the multidisciplinary model (e.g., presence of varying specialists at multidisciplinary clinics, number of cancer patients reviewed within each hospital), and accurate assessment of confounding patient and tumor factors, may help to elucidate the elements of multidisciplinary care that ought to be strongly supported with organized policy initiatives. The best method to measure these effects would be a randomized controlled trial comparing patients who either received organized multidisciplinary care or existing care (e.g., sequential visits to oncology specialists). However, in the current climate of increasingly prominent multidisciplinary teams in cancer care, and the time-consuming and costly nature of investigating such complex processes, a rigorously designed prospective cohort study, examining long-term survival outcomes, may be a more feasible option. In this case, it is important to recognize and statistically account for clustering of patients within hospitals, as this may contribute to practice pattern variability and differences in survival outcomes.

When evaluating multidisciplinary care, measured outcomes may fall into three major categories—(A) Patient survival, (B) subjective patient and provider satisfaction, and (C) efficiency and cost at government and hospital levels. Survival outcomes must be adjusted for patient stage, cancer site, and patient demographic factors. Studying efficiency and cost is important as multidisciplinary cancer care involves resources not only to *implement* multidisciplinary collaborations (e.g., providing physical space for specialists to convene, or teleconferencing equipment), but also to *maintain* multidisciplinary care (e.g. manpower to gather and organize patient data for case presentation, incentives for providers to attend multidisciplinary clinics or meetings, regular audit of patient outcomes). Closely related to cost, it is useful to examine the relationship of multidisciplinary care with health system efficiency by determining whether coordinated multidisciplinary processes facilitate a more timely passage of cancer patients through their treatment trajectories. Assessments of cost and system efficiency need to be undertaken on national or regional levels, as funding models for health care, whether though government and/or private organization, contribute to variability in the cost of coordinated multidisciplinary care.

LIMITATIONS

The major limitation of this study is the substantial heterogeneity in definition of multidisciplinary teams, in study designs, and subsequent inability to pool results. This review is limited also by a lack of randomized controlled trials. Trials are time-consuming, expensive, and difficult to generalize, especially in the context of complex interventions such as multidisciplinary care, where patient care is influenced by multiple factors [33]. However, observational studies and before–after series are susceptible to bias as it is difficult to isolate the influence of multidisciplinary care from concurrent changes in cancer care. Lastly, all reviewed articles were in the English language and quality assessment was completed by a single individual. However, this review was completed in the context of a larger project on multidisciplinary teamwork where retrieved studies were verified by two included authors (FCW and LP).

CONCLUSIONS

Multidisciplinary cancer care is growing in international prominence and exploration of its effects on outcomes is plentiful within the literature; however, at the present time there is no clear evidence that multidisciplinary care improves survival. While further investigations are required to justify the continued expenditure of time, money, and resources, a crucial first step is to create a clear, consistent and internationally accepted definition of multidisciplinary care so that its components can be systematically implemented, compared, and evaluated for benefit.

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