Published in final edited form as:

Med Care. 2015 July ; 53(7): 646–652. doi:10.1097/MLR.0000000000000368.

Provider differences in use of implanted ports in older adults with cancer

Allison Lipitz-Snyderman, PhD¹, Elena B. Elkin, PhD¹, Coral L. Atoria, MPH¹, Camelia S. Sima, MD, MS¹, Andrew S. Epstein, MD², Victoria Blinder, MD¹, Kent A. Sepkowitz, MD³, and Peter B. Bach, MD, MAPP¹

¹Department of Epidemiology and Biostatistics, Memorial Sloan-Kettering Cancer Center, New York

²Gastrointestinal Oncology Service, Memorial Sloan-Kettering Cancer Center, New York

³Department of Quality and Safety, Memorial Sloan-Kettering Cancer Center, New York

Abstract

Background—Identifying unwarranted variation in healthcare can highlight opportunities to reduce harm. One often discretionary process in oncology is use of implanted ports to administer intravenous chemotherapy. **While there are benefits, ports carry risks.** This study's objective was to assess **provider-driven variation in** port use among cancer patients receiving chemotherapy.

Research Design—Retrospective assessment using population-based SEER-Medicare data to assess differences in port use across healthcare providers of older adults with cancer. Participants included over 18,000 patients ages 66 and older diagnosed with breast, colorectal, lung, or pancreatic cancer in 2005–2007, treated by approximately 2,900 providers. We identified port use for patients receiving treatment from hospital outpatient facilities versus physicians' offices. Our main analysis assessed the likelihood of a patient receiving a port given port use by the provider's

Corresponding author: Allison Lipitz-Snyderman, PhD, Center for Health Policy and Outcomes, Department of Epidemiology and Biostatistics, Memorial Sloan Kettering Cancer Center, 300 East 66th Street, 14th Floor, New York, NY 10065, snyderma@mskcc.org, 646-888-4471 (phone) / 646-227-7102 (fax).

Elena B. Elkin, PhD, Center for Health Policy and Outcomes, Department of Epidemiology and Biostatistics, Memorial Sloan Kettering Cancer Center, 300 East 66th Street, 14th Floor, New York, NY 10065, elkin@mskcc.org, 646-888-4472 (phone) / 646-227-7102 (fax)

Coral L. Atoria, MPH, Center for Health Policy and Outcomes, Department of Epidemiology and Biostatistics, Memorial Sloan Kettering Cancer Center, 300 East 66th Street, 14th Floor, New York, NY 10065, SwartzC@mskcc.org, 646-888-4480 (phone) / 646-227-7102 (fax)

Camelia S. Sima, MD, MS, Department of Epidemiology and Biostatistics, Memorial Sloan Kettering Cancer Center, 307 East 63rd Street, 2nd Floor, New York, NY 10065, simac@mskcc.org, 646-735-8107 (phone) / (646) 735-0032 (fax)

Andrew S. Epstein, MD, Gastrointestinal Oncology Service, Department of Medicine, Memorial Sloan Kettering Cancer Center, 300 East 66th Street, 10th Floor, New York, NY 10065, EpsteinA@mskcc.org, 646-888-4313 (phone) / 646-888-4256 (fax)

Victoria Blinder, MD, Center for Health Policy and Outcomes, Department of Epidemiology and Biostatistics, Memorial Sloan Kettering Cancer Center, 300 East 66th Street, 14th Floor, New York, NY 10065, blinderv@mskcc.org, 646-888-4470 (phone) / 646-227-7102 (fax)

Kent A. Sepkowitz, MD, Infectious Disease Service, Department of Medicine, Memorial Sloan Kettering Cancer Center, 405 Lexington Ave., 3rd Floor, New York, NY 10174, sepkowik@mskcc.org, 646-888-5908 (phone) / 646-888-5649 (fax)

Peter B. Bach, MD, MAPP, Center for Health Policy and Outcomes, Department of Epidemiology and Biostatistics, Memorial Sloan Kettering Cancer Center, 300 East 66th Street, 14th Floor, New York, NY 10065, bachp@mskcc.org, 646-888-4474 (phone) / 646-227-7102 (fax)

The authors report no disclosures.

last patient. For a sub-set of high-use providers, we examined individual provider-level variation by estimating the risk-adjusted likelihood of insertion.

Results—Patients receiving chemotherapy in hospital outpatient facilities were significantly less likely to receive a port than those treated in physicians' offices, with adjusted odds ratios (AOR) varying from 0.50 to 0.75 across cancer sites. Implanting a port was associated with increased likelihood of port insertion in the provider's next patient (AOR varied from 1.71 to 2.25). Significant between-provider variation was found among providers with at least 10 patients.

Conclusions—Our findings support the idea that there is provider-driven variation in the use of ports for chemotherapy administration. This variation highlights an opportunity to standardize practice and reduce unnecessary use.

INTRODUCTION

Identifying unwarranted variation in healthcare can highlight opportunities for improvement. Variation in practice has long been documented at the physician, group practice, institution, and regional levels.¹⁻⁶ Yet, for **specific** healthcare processes that **carry risks but are** discretionary, tendencies for providers to use or to not use them have not been extensively studied. By recognizing **and documenting these tendencies**, we can help to identify likely users and target interventions to these providers to help reduce the use of risky processes under discretionary circumstances.

One process in oncology that is potentially risky and often discretionary is the use of implanted ports. Implanted ports are devices placed under the skin to enable venous access to administer intravenous (IV) treatments such as chemotherapy.⁷ For some patients, an acceptable alternative is a temporary IV catheter.

Ports can have benefits to patients and clinicians. The port is easy to maintain **and** provides ready venous access for patients with difficult to access veins or those receiving therapy over long periods of time.⁸ It can **also** facilitate outpatient administration of **chemotherapy and other treatments**. For common diseases like colon cancer, it can support continuous chemotherapy infusion, which can result in fewer toxicities compared to bolus administration.⁹ Ports have the advantage of ready, convenient venous access, and may reduce discomfort and anxiety associated with repeated venous punctures. They have been shown to be largely accepted by patients who have them, particularly for those who did not experience complications.^{8,10,11} Temporary IV catheters can take nurses time to insert and have a risk of extravasation.¹²

Despite the benefits of using ports, they also have disadvantages that providers should consider in decision making. The main disadvantage is that port use is associated with complications such as infections and thromboses, which may result in chemotherapy delays, costs, or morbidity.^{7,8,13,14} Port implantation also involves a minor surgical procedure that carries risks. Although the port is often removed after completion of chemotherapy, many patients develop a scar on the upper chest, which may cause emotional distress.⁸ In one randomized study of ports versus temporary IV catheter use, port use was shown to reduce discomfort, but did not have benefits to overall quality of life.¹¹

Despite known complications, guidelines for the selection of a venous access device are non-specific and the decision is often left to the provider. Current U.S. guidelines primarily focus on catheter maintenance, selection of the appropriate insertion site, and prevention of complications.^{7,15-17} Given the lack of specification for matching patients to an appropriate venous access device when several choices are available, providers may have tendencies to use or not to use ports. Their personal experiences, the characteristics of their practices, incentives, convenience, or patient preferences may influence provider tendencies. The American Society of Clinical Oncology (ASCO) Clinical Practice Guidelines Committee recommends further research to assess the use of such chemotherapy administration methods in practice.⁷ If port use varies among providers **as suspected**, irrespective of patient factors, it may signal an opportunity to standardize care to maximize patient benefit.

The objective of this study was to assess provider-driven variation in port use for cancer patients receiving chemotherapy. If there is evidence of potentially unwarranted variation, it suggests opportunities to standardize care to maximize patient benefit and reduce harm. We hypothesized that providers' past behavior would predict their future behavior, supporting the idea that providers have tendencies to use or not to use such services. We also hypothesized that patients receiving chemotherapy in the hospital outpatient facility setting would be less likely to have a port implanted than patients receiving chemotherapy in the physicians' office setting. Physicians in office-based settings may be more responsive to incentives or the need for convenience.¹⁸

METHODS

Data source

We analyzed population-based SEER-Medicare data to assess differences in port use across healthcare providers of older adult patients with cancer, diagnosed 2005-2007. The SEER-Medicare database contains information from two linked population-based sources of data primarily on people aged 65 years or older with cancer: the Surveillance Epidemiology and End Results (SEER) cancer registries and Medicare enrollment and claims files. The National Cancer Institute (NCI) sponsored SEER program includes several states and registries, covering approximately 28% of the U.S. population.¹⁹ The SEER registries collect information on site and extent of disease, first course of cancer-directed therapy, and socio-demographic characteristics, with active follow-up for date and cause of death. For patients age 65 and over, SEER records have been linked to Medicare claims. Compared with the U.S. older adult population, the SEER-Medicare population has a similar age and sex distribution, a slightly higher proportion of individuals living in urban and high-income areas, and a smaller proportion of non-white individuals.¹⁹

Study sample

The study sample included patients ages 66 years or older who received cancer-directed surgery for breast, colorectal, lung, or pancreas cancers within 1 year of diagnosis and began chemotherapy treatment within 1 year following surgery.^{20,21} We included those at least age 66 to allow for a full year of pre-diagnosis claims data. Patients were diagnosed between 2005, the first year of more detailed Current Procedural Terminology (CPT) codes for port

use, and 2007.^{22,23} We examined each patient's Medicare claims prior to the start of chemotherapy. We excluded patients who did not receive cancer-directed surgery. These patients were more likely to have known advanced disease that would require extended chemotherapy use.

We excluded patients who were enrolled in an HMO or who had incomplete Medicare coverage from the year prior to diagnosis through two years after diagnosis, or whose cancer diagnosis was made only at the time of death. We also excluded patients who only had chemotherapy claims from the inpatient setting, and patients who had a claim for hemodialysis within two years **after** their cancer diagnosis to focus on port use for chemotherapy administration.

Variables and outcomes

The following patient, disease, and treatment characteristics from SEER and Medicare records were included in our analyses: age, sex, race, a modified Charlson comorbidity index (based on all inpatient, outpatient, and physician claims from 1 year prior to diagnosis),^{24,25} marital status, median income of Census tract of residence, geographic region, metropolitan location, stage, prior cancer, year of diagnosis, and radiation therapy.²⁶

To assign patients to a setting of care delivery, we used the source of their chemotherapy claims: hospital outpatient file or **the National Claims History** (NCH) file (physicians' office).²⁷ We assigned patients with both NCH and hospital outpatient claims (14%) to the source of their first chemotherapy claim. This approach was highly consistent with an alternative approach that classified setting by the majority of chemotherapy claims rather than the first claim. We assigned patients to a specific provider based on the first chemotherapy claim. For this analysis, claims after May 2007 were not examined because the National Provider Identifier replaced the Unique Physician Identifier Number as the required identifier for Medicare services and a crosswalk was not available at the time of this analysis.

We identified port insertion based on CPT codes (Appendix Table 1). We exclusively included port insertion prior to the initiation of chemotherapy, given that port use is more likely to be discretionary during this time interval compared to after treatment begins.¹¹

Statistical analyses

For patients receiving treatment from hospital outpatient facilities compared with those receiving treatment from physicians' offices, we assessed whether there were differences in **the proportion of patients who had ports** prior to the initiation of chemotherapy. We used chi-square statistics to compare cohort characteristics by setting. We used unadjusted and adjusted logistic regression to evaluate the association between the setting of care and the likelihood of port insertion. Adjusted models included patient, disease, and treatment characteristics.

Our main analysis focused on assessing **individual** provider variation in use of ports. One of the challenges in examining providers' practice patterns and variation between providers can be the limited number of eligible patients per provider.²⁸ Considering this challenge, we

sought to assess whether providers' prior behavior would predict their future behavior and thus help to reveal practice patterns. We studied whether implanting a port in a given patient increases the likelihood that a provider will implant a port in the following patient. The underlying premise is that, in providers with high frequencies of port insertion, a patient with insertion is more likely to be preceded by a patient with insertion; the converse is true for providers with low frequencies of port insertion. This premise leads to a positive test of association between prior and future use of port. We chronologically ordered patients assigned to each provider by chemotherapy start date and then identified pairs of consecutive patients. We used a logistic model, adjusted for patient demographic, disease, and treatment characteristics, year of diagnosis, and treatment setting. We estimated the probability of a patient receiving a port as a function of port use by the provider's prior patient.

The primary physician decision maker for port use is unknown in this dataset, and could be a medical oncologist, a surgeon, or both. In our main analysis, we used the provider associated with the first chemotherapy claim, assumed to be a medical oncologist. We also conducted a sensitivity analysis where we assigned each patient to the surgeon who performed his or her cancer-directed surgery. For this analysis we ordered surgeons' patients by surgery date.

To assess another dimension of provider variation, we conducted an additional analysis for high-volume providers, defined as those with 10 or more patients assigned. **For this sub-set of providers, we** assessed the extent of variation in port use between individual providers using a non-linear random-effects model with logit link function. This approach models the logit probability of port insertion as a linear function of patient demographic, disease, and treatment variables, and a random provider effect.²⁹⁻³² This model explicitly incorporates the assumption that underlying tendencies in providers' behavior lead to differences in port insertion rates. A test of whether the estimated variance of the random effects is significantly different from zero provides indication of significant unexplained variation across providers. Furthermore, providers whose estimated random effects are significantly different from zero are identified as outliers.

All analyses were conducted separately by cancer site in order to account for differences between patients and treatments. Analyses were performed in SAS (Version 9.2, Cary, NC). We considered a two-sided p-value <0.05 to be statistically significant. NCI approved the use of the SEER-Medicare database for this study, which was deemed exempt by the MSK Institutional Review Board. The funding source had no role in the study.

RESULTS

The study cohort included more than 18,000 patients with breast cancer (N=6,591), colorectal cancer (N=7,590), lung cancer (N=3,300), or pancreatic cancer (N=971) (Table 1). Patients who received chemotherapy in physicians' offices and those who received chemotherapy in hospital outpatient facilities had similar disease profiles in general, but differed by certain patient demographic characteristics. For example, higher percentages of non-white patients and patients in census tracts with lower median incomes were seen in hospital outpatient facilities (Appendix Table 2).

In each of the four cancer sites, patients who received chemotherapy in hospital outpatient facilities were less likely to receive a port than patients who received chemotherapy in physicians' offices, independent of demographic, disease, and treatment characteristics. The adjusted odds ratio (AOR) varied from 0.50 to 0.75 across cancer sites (Table 2).

The likelihood of port insertion in a given patient was related to the use of a port in a provider's previous patient receiving chemotherapy (Table 3). Of the 2,836 unique providers in the sample, 62% (N=1,679) were identified as the accountable provider for at least 2 patients in the dataset. Over 71% of accountable physicians had specialty codes listed as oncology, hematology, or internal medicine. When a provider's last patient received a port, the next patient was about twice as likely to receive a port than if the provider's last patient did not (AORs from 1.71 to 2.25, $p<0.001$ for all cancers). This finding held when combining cancer types and when stratified by setting. Setting remained a significant predictor of port use in the combined model. The predicted probability of port use was higher for patients whose provider's prior patient received a port compared to those whose provider's prior patient did not, in both treatment settings (Table 4). When we reassigned the decision maker as the patient's surgeon, we found similar results; when a surgeon's prior patient received a port, the next patient was more likely to receive a port than if the surgeon's prior patient did not.

An analysis of the 354 providers (12% of all providers in the sample) who were accountable for at least 10 patients suggested residual between-provider variation in the likelihood of port insertion, adjusted for patient demographic, disease, and treatment characteristics ($P<0.0001$). Fifty seven physicians (16%) were identified as outliers, indicating an increased propensity towards port insertion, beyond what was explained by their patients' characteristics.

DISCUSSION

In this study of older adults who received chemotherapy for one of four common cancers, a provider's prior behavior was strongly associated with future behavior regarding the likelihood of inserting a port for delivery of cancer chemotherapy. This result held when accounting for patient characteristics. Findings from a random effects model also demonstrated between provider variation in port use. Collectively, these findings **support our hypothesis** that providers have certain tendencies to use or not to use ports for chemotherapy administration.

Given our **observations** and those from prior studies demonstrating complications associated with port use,^{7,13,33} some of **the observed use of implanted ports in our dataset is likely** unwarranted. As such, there may be room for standardization to ensure an appropriate match between the method of chemotherapy administration and the patient. Certainly, for some patients, port use is necessary or preferred.^{8,10,11} But for other patients, the expected costs and harms may outweigh the benefits.¹¹ It will be important to better understand the drivers of providers' decision making in order to influence their behavior and develop effective initiatives to reduce unwarranted use. Initiatives might include developing more explicit standards for selecting appropriate patients for port use, developing relevant

quality measures, and providing feedback to individual providers. It also might be achieved by aligning financial incentives with desired behavior, such as through episode-based payment models.³⁴ Future research to assess patient and cost outcomes related to the practice variation observed can also help to optimize decision making.

This study also highlights the potentially meaningful impact of the setting of chemotherapy administration on port use.²⁷ The effect of treatment setting remained significant, even after accounting for a provider's prior behavior. We found differences in patient case-mix between those receiving chemotherapy in hospital outpatient facilities compared to physicians' offices, which have been identified previously.²⁷ But after taking these characteristics into account, the differences in port use by setting remained. Setting effects may reflect unmeasured differences in patient characteristics or provider factors, such as those that relate to responsiveness to financial incentives.²⁷ In a study examining the influence of changes in chemotherapy payment on ordering behavior, the authors found that the physicians' office setting was more responsive to changes in incentives than hospital outpatient facilities.²⁷ In our example, the port insertion procedure is associated with payment (Medicare reimbursement of \$1,198 for physicians' office procedure) and physicians may have relationships with surgeons or interventional radiologists who perform the insertion procedure.³⁵ Compared to hospital outpatient facilities, physicians' offices may also not have as many skilled nurses available for temporary IV catheter insertions, the nurses may have higher workloads, or the nurses may fear extravasation.³⁶ The reasons for the observed differences between settings are unknown and will require further study.

Our approach to examining provider practice patterns builds on the existing literature that demonstrates that providers may have tendencies toward providing certain services.^{5,6,37,38} Findings from this study demonstrate that provider tendencies are highly predictive of future behavior in the context of use of ports for chemotherapy administration. Our approach assessing the predictive value of providers' prior behavior can reveal provider level tendencies and can help to assess the use of other services that might be overused **or used often** under **discretionary** circumstances. Examples might include routine follow-up tests, screening, referrals to specialists, or hospitalizations for common conditions.³⁸ Identifying likely users of these services can help direct interventions to reduce overuse **to those at highest risk of unwarranted use**. In the case of implanted ports, it would include providers who have used the service for a prior patient.

Our examination of variation in provider practice confirms the difficulty of making inferences about individual providers' tendencies when most providers have very low patient volume. In this setting, traditional approaches to examine between-provider variability such as random effects models lead to unstable results. Providers with small sample sizes are moved towards the population average, resulting in limited sensitivity to detect unusual practices.^{39,40} Based on our analysis restricted to providers with 10 patients or more, we found evidence of unexplained variation between providers' use of port. However, only 13% of all providers (having 25% of all patients assigned to them) met the threshold for inclusion, raising questions about the generalizability of these results. We propose that the magnitude of the association between port insertion in a prior and a future patient is directly related to inter-provider variability and can serve to estimate this variability while making

more efficient use of the available data. The properties of this proposed relationship warrant further study.

There may be other unmeasured associated factors that contributed to the observed variation in port receipt and provider practice patterns. There are circumstances in which port use would be considered clinically appropriate such as when the patient has difficulty to access veins and venous access is needed on an ongoing basis.⁷ In this analysis we did not consider the specific chemotherapy agents and regimens. We were interested in assessing variation in port use between settings and providers and the predictive value of prior use. While chemotherapy selection may be in part provider driven, chemotherapy options available for the patient population of interest should not be a function of the provider or setting. We accounted for patient demographic, disease, and treatment characteristics, and our main findings were consistent across cancer types.

Several limitations of our dataset should be noted. If multiple providers were involved in a patient's care and treatment decisions, our assignment of a single accountable provider to each patient may have been imprecise. We assigned patients to the provider associated with their first chemotherapy claim, and this approach yielded similar assignments as an approach based on the majority of chemotherapy claims. We also conducted a sensitivity analysis where we reassigned the patient's decision maker as his or her surgeon. Results were similar. While some patients may be incorrectly classified as having a port, it is unlikely that it would be systematic or influence the results. Codes for port insertion **were updated** in 2004 because of concerns about specificity; **these updates may temper concerns**.^{22,23} This study only included information from patients who are ages 66 years and older, and it is not clear whether providers' tendencies and setting-specific patterns differ in younger patients.

In patients receiving chemotherapy, port use was less likely for those treated in the hospital outpatient facility setting compared to the physicians' office setting. At the provider level, port insertion in a patient was a strong predictor of the likelihood of insertion in the next patient treated. These patterns suggest provider-driven behavior, which demonstrate an opportunity for standardization in the use of ports for chemotherapy administration. They also support future exploration of physician tendencies to use or not to use services that are commonly overused. Identifying likely users can inform the development of targeted interventions to increase appropriate use and reduce unwarranted variation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding: This work is supported in part by the Cancer Center Support Grant [P30 CA 008748].

REFERENCES

1. Fisher ES, Wennberg DE, Stukel TA, et al. The implications of regional variations in Medicare spending. Part 1: the content, quality, and accessibility of care. *Ann Intern Med.* 2003; 138:273–87. [PubMed: 12585825]

2. Krein SL, Hofer TP, Kerr EA, et al. Whom should we profile? Examining diabetes care practice variation among primary care providers, provider groups, and health care facilities. *Health Serv Res.* 2002; 37:1159–80. [PubMed: 12479491]
3. Weiner JP, Parente ST, Garnick DW, et al. Variation in office-based quality. A claims-based profile of care provided to Medicare patients with diabetes. *JAMA.* 1995; 273:1503–8. [PubMed: 7739076]
4. Song Y, Skinner J, Bynum J, et al. Regional variations in diagnostic practices. *N Engl J Med.* 2010; 363:45–53. [PubMed: 20463332]
5. Eisenberg JM. Physician utilization. The state of research about physicians' practice patterns. *Med Care.* 1985; 23:461–83. [PubMed: 3925250]
6. Fung V, Schmittiel JA, Fireman B, et al. Meaningful variation in performance: a systematic literature review. *Med Care.* 2010; 48:140–8. [PubMed: 20057334]
7. Schiffer CA, Mangu PB, Wade JC, et al. Central venous catheter care for the patient with cancer: American Society of Clinical Oncology clinical practice guideline. *J Clin Oncol.* 2013; 31:1357–70. [PubMed: 23460705]
8. Ignatov A, Hoffman O, Smith B, et al. An 11-year retrospective study of totally implanted central venous access ports: complications and patient satisfaction. *Eur J Surg Oncol.* 2009; 35:241–6. [PubMed: 18329836]
9. de Gramont A, Bosset JF, Milan C, et al. Randomized trial comparing monthly low-dose leucovorin and fluorouracil bolus with bimonthly high-dose leucovorin and fluorouracil bolus plus continuous infusion for advanced colorectal cancer: a French intergroup study. *J Clin Oncol.* 1997; 15:808–15. [PubMed: 9053508]
10. Kreis H, Loehberg CR, Lux MP, et al. Patients' attitudes to totally implantable venous access port systems for gynecological or breast malignancies. *Eur J Surg Oncol.* 2007; 33:39–43. [PubMed: 17029869]
11. Bow EJ, Kilpatrick MG, Clinch JJ. Totally implantable venous access ports systems for patients receiving chemotherapy for solid tissue malignancies: A randomized controlled clinical trial examining the safety, efficacy, costs, and impact on quality of life. *J Clin Oncol.* 1999; 17:1267. [PubMed: 10561188]
12. Goolsby TV, Lombardo FA. Extravasation of chemotherapeutic agents: prevention and treatment. *Semin Oncol.* 2006; 33:139–43. [PubMed: 16473651]
13. Maki DG, Kluger DM, Crnich CJ. The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. *Mayo Clin Proc.* 2006; 81:1159–71. [PubMed: 16970212]
14. Kamboj M, Sepkowitz KA. Nosocomial infections in patients with cancer. *Lancet Oncol.* 2009; 10:589–97. [PubMed: 19482247]
15. Du XL, Chan W, Giordano S, et al. Variation in modes of chemotherapy administration for breast carcinoma and association with hospitalization for chemotherapy-related toxicity. *Cancer.* 2005; 104:913–24. [PubMed: 15991239]
16. Freil AC, Shiloach M, Weigelt JA, et al. American College of Surgeons Guidelines Program: a process for using existing guidelines to generate best practice recommendations for central venous access. *J Am Coll Surg.* 2008; 207:676–82. [PubMed: 18954779]
17. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. *Clin Infect Dis.* 2011; 52:e162–93. [PubMed: 21460264]
18. Akl EA, Kamath G, Yosucio V, et al. Thromboprophylaxis for patients with cancer and central venous catheters: a systematic review and a meta-analysis. *Cancer.* 2008; 112:2483–92. [PubMed: 18404702]
19. Warren JL, Klabunde CN, Schrag D, et al. Overview of the SEER-Medicare data: content, research applications, and generalizability to the United States elderly population. *Med Care.* 2002; 40:IV-3–18.
20. Warren JL, Harlan LC, Fahey A, et al. Utility of the SEER-Medicare data to identify chemotherapy use. *Med Care.* 2002; 40:IV-55–61.
21. Cooper GS, Virnig B, Klabunde CN, et al. Use of SEER-Medicare data for measuring cancer surgery. *Med Care.* 2002; 40:IV-43–8.

22. American College of Radiology: Major Restructuring of Central Venous Access Codes for 2004. 2003.
23. Wright SB, Huskins WC, Dokholyan RS, et al. Administrative databases provide inaccurate data for surveillance of long-term central venous catheter-associated infections. *Infect Control Hosp Epidemiol.* 2003; 24:946–9. [PubMed: 14700411]
24. Klabunde CN, Potosky AL, Legler JM, et al. Development of a comorbidity index using physician claims data. *J Clin Epidemiol.* 2000; 53:1258–67. [PubMed: 11146273]
25. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *J Clin Epidemiol.* 1993; 46:1075–9. discussion 1081-90. [PubMed: 8410092]
26. Virnig BA, Warren JL, Cooper GS, et al. Studying radiation therapy using SEER-Medicare-linked data. *Med Care.* 2002; 40:IV-49–54.
27. Colla CH, Morden NE, Skinner JS, et al. Impact of payment reform on chemotherapy at the end of life. *J Oncol Pract.* 2012; 8:e6s–e13s. [PubMed: 22942834]
28. Greenfield S, Kaplan SH, Kahn R, et al. Profiling care provided by different groups of physicians: effects of patient case-mix (bias) and physician-level clustering on quality assessment results. *Ann Intern Med.* 2002; 136:111–21. [PubMed: 11790062]
29. Normand SLT, Glickman ME, Gatsonis CA. Statistical methods for profiling providers of medical care: Issues and applications. *Journal of the American Statistical Association.* 1997; 92:803–814.
30. Shahian DM, Normand SL, Torchiana DF, et al. Cardiac surgery report cards: Comprehensive review and statistical critique. *Annals of Thoracic Surgery.* 2001; 72:2155–2168. [PubMed: 11789828]
31. Goldstein H, Spiegelhalter DJ. League tables and their limitations: Statistical issues in comparisons of institutional performance. *Journal of the Royal Statistical Society Series a-Statistics in Society.* 1996; 159:385–409.
32. Bratzler DW, Normand SL, Wang Y, et al. An administrative claims model for profiling hospital 30-day mortality rates for pneumonia patients. *PLoS One.* 2011; 6:e17401. [PubMed: 21532758]
33. Lipitz-Snyderman A, Sepkowitz KA, Elkin EB, et al. Long-Term Central Venous Catheter Use and Risk of Infection in Older Adults With Cancer. *J Clin Oncol.* 2014
34. Bach PB, Mirkin JN, Luke JJ. Episode-based payment for cancer care: a proposed pilot for Medicare. *Health Aff (Millwood).* 2011; 30:500–9. [PubMed: 21383369]
35. Centers for Medicare & Medicaid Services. Physician fee schedule search. 2014. Available from: <https://www.cms.gov/apps/physician-fee-schedule/search/search-criteria.aspx>
36. Martin S, Larson E. Chemotherapy-handling practices of outpatient and office-based oncology nurses. *Oncol Nurs Forum.* 2003; 30:575–81. [PubMed: 12861318]
37. Landon BE, Reschovsky J, Reed M, et al. Personal, organizational, and market level influences on physicians' practice patterns: results of a national survey of primary care physicians. *Med Care.* 2001; 39:889–905. [PubMed: 11468507]
38. Sirovich B, Gallagher PM, Wennberg DE, et al. Discretionary decision making by primary care physicians and the cost of U.S. Health care. *Health Aff (Millwood).* 2008; 27:813–23. [PubMed: 18474975]
39. Ding VY, Hubbard RA, Rutter CM, et al. Assessing the accuracy of profiling methods for identifying top providers: performance of mental health care providers. *Health Serv Outcomes Res Methodol.* 2013; 13:1–17. [PubMed: 23565050]
40. Austin PC, Alter DA, Tu JV. The use of fixed- and random-effects models for classifying hospitals as mortality outliers: a Monte Carlo assessment. *Med Decis Making.* 2003; 23:526–39. [PubMed: 14672113]

Table 1

Cohort characteristics, older adult patients diagnosed with cancer (2005-2007)

	Breast Cancer	Colorectal Cancer	Lung Cancer	Pancreatic Cancer
Total no. (%)	6,591	7,590	3,300	971
Age (yr)				
66-69	2,359 (36)	1,776 (23)	904 (27)	248 (26)
70-74	2,058 (31)	2,180 (29)	1,130 (34)	282 (29)
75-79	1,358 (21)	2,020 (27)	860 (26)	264 (27)
80-84	608 (9)	1,186 (16)	338 (10)	149 (15)
85	208 (3)	428 (6)	68 (2)	28 (3)
Sex - male	N/A	3,895 (51)	1,722 (52)	475 (49)
Race - white (vs other)	5,644 (86)	6,513 (86)	2,949 (89)	858 (88)
Married - yes	3,384 (51)	4,549 (60)	2,042 (62)	654 (67)
Urban/rural - metro (vs non-metro)	5,546 (84)	6,348 (84)	2,806 (85)	839 (86)
Charlson comorbidity index				
0	4,385 (67)	4,727 (62)	1,570 (48)	560 (58)
1	1,518 (23)	1,849 (24)	1,066 (32)	268 (28)
2	688 (10)	1,014 (13)	664 (20)	143 (15)
Stage of disease				
Insitu	166 (3)	N/A	N/A	N/A
Localized	2,684 (41)	1,182 (16)	1,195 (36)	97 (10)
Regional	3,349 (51)	4,430 (58)	1,704 (52)	668 (69)
Distant	363 (6)	1,891 (25)	372 (11)	191 (20)
Unknown	29 (<1)	87 (1)	29 (1)	15 (2)
Setting of first chemotherapy administration				
Physician office	5,115 (78)	6,042 (80)	2,261 (69)	687 (71)
Hospital outpatient facility	1,476 (22)	1,548 (20)	1,039 (31)	284 (29)
Prior cancer diagnosis	944 (14)	1,276 (17)	812 (25)	148 (15)
Radiation therapy ^I	997 (15)	831 (11)	642 (19)	336 (35)

Percentages may not add to 100% due to rounding.

^IPrior to chemotherapy initiation

Table 2

Implanted port use by setting of chemotherapy receipt

	Physicians' Office (ref)		Hospital Outpatient Facility		Unadjusted Odds Ratio ¹ [95% CI]	Adjusted Odds Ratio ^{1, 2} [95% CI]
	Total N	Port Use	Total N	Port Use		
		no. (%)		no. (%)		
Breast Cancer	5,115	2,229 (44)	1,476	588 (40)	0.86 [0.76-0.97]	0.75 [0.66-0.85]
Colorectal Cancer	6,042	3,408 (56)	1,548	757 (49)	0.74 [0.66-0.83]	0.62 [0.55-0.70]
Lung Cancer	2,261	533 (24)	1,039	175 (17)	0.66 [0.54-0.79]	0.64 [0.53-0.79]
Pancreatic Cancer	687	222 (32)	284	57 (20)	0.53 [0.38-0.73]	0.50 [0.35-0.71]

¹ Likelihood that a patient will receive a port if chemotherapy administered in a hospital outpatient facility compared to a physician's office setting.

² Adjusted for: age, sex, race, a modified Charlson comorbidity index, marital status, median income of Census tract of residence, geographic region, metropolitan location, stage, prior cancer, year of diagnosis, and radiation therapy prior to chemotherapy

Table 3

Likelihood of patient receiving a port if his/her provider's prior patient received a port

	Number of providers ¹	Mean (median) number of patients per provider	Adjusted Odds Ratio ² [95% CI]
Breast Cancer	905	4 (3)	2.25 [1.91-2.67]
Colorectal Cancer	1,020	4 (4)	2.01 [1.74-2.32]
Lung Cancer	494	3 (2)	1.71 [1.20-2.42]
All Cancers ³	1,679	7 (5)	2.04 [1.87-2.23]

¹Includes providers with at least 2 patients.²Likelihood of patient receiving a port if provider's prior patient received a port. Logistic model, adjusted for age, sex, race, a modified Charlson comorbidity index, marital status, median income of Census tract of residence, geographic region, metropolitan location, stage, prior cancer, year of diagnosis, radiation therapy prior to chemotherapy, and setting. All differences statistically significant at p<0.001 level.³**Pancreatic cancer is included in All Cancers. The model for pancreatic cancer did not converge (110 providers).**

Table 4

Predicted probability of port use, by setting and receipt of a port by the provider's prior patient

Predicted probability ¹	
<i>Hospital outpatient facility setting</i>	
Provider's prior patient received a port	0.490
Provider's prior patient did not receive a port	0.299
<i>Physicians' office setting</i>	
Provider's prior patient received a port	0.575
Provider's prior patient did not receive a port	0.388

¹ Predicted probability that an individual patient will receive a port given the setting and use of a port by the provider's prior patient, adjusted for age, sex, race, a modified Charlson comorbidity index, marital status, median income of Census tract of residence, geographic region, metropolitan location, stage, prior cancer, year of diagnosis, radiation therapy prior to chemotherapy.