

# A Critical Appraisal of the Use of ICD-9-CM Codes to Classify Comorbidity and Complications

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**Abstract:** Patients with cancer often have other medical conditions referred to as comorbidity. Comorbidity may impact on treatment, outcome, and evaluation of quality of care. There are several different ways to capture comorbid health information. The Commission on Cancer (CoC) added the collection of comorbidity information and the occurrence of complications as defined by the ICD-9-CM codes from the hospital discharge attestation sheet as a new data element in *Facility Oncology Registry Data Standards*. In this commentary, the authors describe the new proposal, and offer a suggestion for an alternative approach.

**Key words:** comorbidity, health policy, outcomes, registries, medical records

## Introduction

Patients with cancer often have other chronic medical conditions. These other conditions are referred to as comorbidities.<sup>1</sup> Comorbidities may impact on etiology/screening,<sup>2</sup> diagnosis,<sup>2,3</sup> and prognosis<sup>4,5</sup> for patients with cancer. For example, Satariano and Ragland<sup>4</sup> studied the effect of comorbidity and stage of disease on 3-year survival in 936 women with primary breast cancer. They found the severity of comorbidity was a strong predictor of survival in patients with breast cancer, independent of the extent of tumor spread. As a result of the impact of comorbidity on survival, these authors suggest that trials that assess the efficacy of screening should routinely include measures of comorbidity. Because of its impact on prognosis and treatment selection, comorbidity will impact on the assessment of treatment effectiveness<sup>6</sup> and quality of care research.<sup>7</sup> Comorbidity is especially common in elderly patients with cancer.<sup>8,9</sup> Accurate risk adjustment<sup>10</sup> is necessary for a variety of health services research functions, including comparison of outcomes of different treatments and outcomes of the same treatments delivered at different facilities. Precise comorbidity information, along with patient demographics, social characteristics, type and morphologic stage of the

tumor, is essential for comprehensive risk adjustment in cancer.

The Commission on Cancer (CoC) recognizes the importance of comorbidity in the evaluation of quality of care and assessment of outcomes.<sup>11</sup> In the recently released "Facility Oncology Registry Data Standards" ("FORDS") manual, the CoC describes the data items that must be included in a hospital-based cancer registry program starting with cases diagnosed on or after January 1, 2003. Comorbidity and complications are 2 new data elements that the CoC has mandated for inclusion in hospital cancer registry programs. The detailed instructions for coding comorbid conditions and complications during the patient's hospital stay for the treatment of the index cancer using the ICD-9-CM codes are provided in the Table 1 — Comorbidities and Complications (from Commission on Cancer).

The focus of this essay is to present the CoC proposal, critique the methodology, and offer a suggestion for an alternative approach. The authors recognize the importance of comorbidity to cancer care and statistics and applaud the CoC for its decision to include comorbid health information in the National Cancer Data Base (NCDB). However, the authors have identified 5 main problems with the proposal that they believe will significantly limit mean-

*"Registering Multiple Primary Tumors in Central Cancer Registries"*

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**Table 1. Comorbidities And Complications (From Commission on Cancer)**

<p><b>Description</b></p> <p>Records the patient's pre-existing medical conditions and/or complications during the patient's hospital stay for the treatment of this cancer using ICD-9-CM-CM codes. Both are considered secondary diagnoses.</p> <p><b>Rationale</b></p> <p>Pre-existing medical conditions and/or complications may affect treatment decisions and influence patient outcomes. Information on comorbidities is used to adjust outcome statistics when evaluating patient survival and other outcomes. Complications may be related to the quality of care.</p> <p><b>Instructions for Coding:</b></p> <ul style="list-style-type: none"> <li>• Comorbid conditions and complications can only be reported for patients that have inpatient hospitalizations at your facility. Comorbid conditions and complications should be reported for patients receiving outpatient care or treated in oncology clinics at your facility when available</li> <li>• Report the comorbid conditions and complications associated with the first hospitalized treatment for this cancer. This will often, not always, be a hospitalization for surgery.</li> <li>• Consult the patient record for the Discharge Abstract. Comorbid and complications are found under secondary diagnoses on the discharge abstract. Information from the billing department at your facility may be consulted when a discharge abstract is not available.</li> <li>• Code the comorbid conditions and complications in the sequence in which they appear in patient record as secondary diagnoses.</li> </ul>	<ul style="list-style-type: none"> <li>• Comorbidities are pre-existing medical conditions or conditions that were present at the time the patient was diagnosed with this cancer, i.e., chronic conditions such as COPD, diabetes, and hypertension. Comorbid conditions are identified by ICD-9-CM-CM codes 001-139.8 and 240-999.9.</li> <li>• Do not record any neoplasms (ICD-9-CM-CM codes 140-239.9) listed as secondary diagnoses for this data item.</li> <li>• Complications are conditions that occur during the hospital stay, while the patient is being treated for the cancer, i.e., post-operative urinary tract infection or pneumonia. Complications are identified by the ICD-9-CM-CM 'E' codes which classify environmental events, circumstances, and conditions as the cause of injury, poisoning, and other adverse effects. Only 'E' codes which describe adverse effects occurring during medical care are collected in this data item and include ICD-9-CM-CM codes E870-E879.9 (misadventures to patients during surgical and medical care) and E930-E949.9 (drugs, medicinal and biological substances causing adverse effects in therapeutic use).</li> <li>• Do not record other causes of injury and poisoning (ICD-9-CM-CM codes E800-E869.9, E880-E929.9, or E950-E999).</li> <li>• Do not record factors influencing health status and contact with health services (ICD-9-CM-CM codes VO1-V82.9).</li> <li>• If no comorbid conditions and complications were documented, then code 00000 in this data item, and leave the remaining "Comorbidities and Complications" data items blank.</li> <li>• If fewer than 6 comorbid conditions and complications are listed, then code the diagnoses listed, and leave the remaining "Comorbidities and Complications" data items blank.</li> </ul>
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ingful use of the collected information. These problems cannot be avoided nor can they be "corrected for" using statistical methods.

### **Key Commission On Cancer Instructions for Coding Comorbidity and Complications and Critical Appraisal**

**1. "Comorbid conditions and complications must be reported for patients that have inpatient hospitalizations at your facility. Comorbid conditions and complications should be reported for patients receiving outpatient care or treated in oncology clinics at your facility when available."**

According to the COC proposal, the cancer registrar is to consult the patient record discharge abstract to identify comorbidities using the secondary diagnosis ICD-9 codes. When the discharge abstract is not available information from the billing department may be consulted. Patients who receive care in the outpatient setting generally do not have a patient record discharge abstract created by trained medical record technicians. Instead, the outpatient record will only contain those codes pertinent to the care being given in the outpatient setting and not include comorbid ailments. Unlike the inpatient hospitalization, outpatient reimbursement is generally not affected by the presence of comorbid ailments. Therefore, there is no incentive for the professional or administrative support staff to include comorbid ailments in the outpatient billing record, no matter how severe the comorbid ailments may be.

Increasingly, cancer patients are receiving all of their care at outpatient facilities, surgicenters, and settings other than the traditional inpatient hospital. This is certainly the situation for patients with cancers of the lung, breast, and prostate; 3 of the most frequently diagnosed cancers. In 2002 at Barnes-Jewish

Hospital, 26% of analytical cases reported to NCDB were outpatient only. Numerous health services researchers<sup>12,13</sup> have noted that a significant percentage of patients in the SEER-Medicare Linked Data Base do not have inpatient hospitalizations at the time of diagnosis or even one year before. Andrew Stewart, MA of the CoC, stated at the 2002 Annual Meeting of the National Cancer Registry Association,<sup>14</sup> "We anticipate that only 60% of patients will be hospitalized and have ICD-9-CM face sheets available". The increasing use of outpatient-only cancer care in the future will further exacerbate the lack of inpatient admissions from which to determine comorbidity.

The main problem with this selective identification of comorbid ailments based on how cancer care is provided is the introduction of bias. As a result of the nonrandom use of inpatient hospitalization, comorbid ailments will not be identified at the same rate among patients receiving care in the outpatient setting as in the inpatient setting. The decision to provide inpatient hospitalization is not a random event and those patients who receive inpatient care are likely to be quite different from patients who receive outpatient care. These differences may include site of tumor, stage of tumor, and severity of illness. Each of these features is a key component of risk adjustment. If a significant number of records are missing information on comorbidity because this information is only ascertained from hospital records, and hospitalization is related to severity of cancer and treatment, unbiased risk adjustment and reporting are not possible. For example, consider the situation of 2 patients with Stage III oral cavity cancer. Suppose the initial treatment for the first patient is outpatient radiation therapy and for the second patient it is surgery. The use of radiation therapy was selected for the first patient based primarily on the fact that he had significant medical comorbidities that prohibited the use of surgery. However, because

he was not hospitalized, the NCDB is unlikely to indicate comorbid conditions even though he does have significant comorbid ailments. This misclassification will prevent valid risk adjustment to compare outcomes among patients receiving inpatient surgery or outpatient radiation therapy.

**2. "Code the comorbid conditions and complications in the sequence in which they appear in patient record as secondary diagnoses."**

The hospital discharge face sheet is medicolegal, used for reimbursement purposes, and is not a clinical document. According to the Uniform Hospital Discharge Dataset,<sup>15</sup> the principal diagnosis is "... the condition established after study to be chiefly responsible for occasioning the admission of the patient to the hospital". According to these same rules, the secondary diagnosis (es) is (are) "... those conditions that affect the episode of hospital care in terms of any of any the following: clinical evaluation; therapeutic treatment; further evaluation by diagnostic studies; procedures, or consultation; extended length of stay; or increased nursing care and/or monitoring".

At Barnes-Jewish Hospital, a maximum of 9 secondary diagnoses can be listed and a computer software program assigns the sequencing order of all comorbid conditions and complications. The sequencing order is generally selected to maximize reimbursement and may not necessarily reflect the relationship between these conditions and treatment and outcomes of cancer care. In fact, conditions listed on the face sheet may have only a minor relationship to treatment selection and outcomes for cancer and yet the CoC instructions direct the registrar to list these conditions as comorbidities. For example, at the 2002 NCRA Annual Meeting,<sup>14</sup> a case scenario was presented of a woman with a primary tumor of the breast, asthma, and migraine headache. Based on our work<sup>16</sup> and the work of others,<sup>9,13,17</sup> neither asthma nor migraine is likely to impact on diagnosis, therapy, or prognosis for a cancer patient. Furthermore, we have also identified newly diagnosed cancer patients with secondary diagnoses of hypercholesterolemia, esophageal reflux, gout, urinary incontinence, incontinence of feces, skin sensation disturbance, diarrhea, constipation, hiccup, and backache. The registrars are mandated to collect this information. The inclusion of these conditions will require additional work for the registrars with very little possibility of improving the utility of cancer statistics. In addition, many medical conditions that *do* impact on treatment and outcome for cancer patients, such as depression, alcoholism, AIDS, and morbid obesity, are frequently not included on the face sheet for reasons of insurance, privacy, or social stigma.

The cancer registrars are required to record the first 6 comorbid conditions and complications from the discharge face sheet. The requirement to restrict comorbid assessment and complications to the first 6 secondary diagnoses will inevitably lead to a biased assessment of comorbidity for the sickest patients and those experiencing complications. Consider the situation of the sickest patients who will have more than 6 secondary diagnoses. The restriction of comorbid assessment to the first 6 diagnoses will inevitably lead to systematic underreporting of comorbidities for these patients. Finally, it is standard medical record practice that complica-

tions on the face sheet are reported after all medical diagnoses. Therefore, inaccurate and misleading risk adjustment may result for patients with multiple medical comorbidities who also experience complications of treatment. In short, the methodology recommended by the CoC will lead to the systematic underreporting of comorbidities and complications among those patients with multiple comorbidities.

**3. "Comorbidities are preexisting medical conditions or conditions that were present at the time the patient was diagnosed with cancer. Comorbid conditions are identified by ICD-9-CM codes 001-139.8 and 240-999.9."**

The ICD-9-CM system was developed to classify diseases into clinically appropriate groups based on organ system and etiology. There are over 15,000 ICD-9-CM codes representing a huge range of conditions, from relatively minor, conditions (e.g., migraine) that shouldn't impact cancer treatment to major conditions (e.g., renal failure) that probably will affect care and outcome. The CoC approach provides registrars with no guidance for identifying what might be a cogent comorbid condition from this large and wide-ranging list of ICD-9-CM codes.

The ICD-9-CM system does not classify the pathophysiological derangement associated with each condition or combinations of conditions. For example, oncologists, health care professionals, patients, and their families all recognize the important clinical distinctions between stable congestive heart failure (CHF) and acute worsening of previously stable congestive heart failure. Despite the profound clinical differences in these 2 situations and the impact these differences have on treatment and prognosis of cancer, both situations would receive an ICD-9-CM code of 428.0. Because of this lack of clinical specificity, many clinicians do not believe that the ICD-9-CM coding system accurately reflects the clinical situation.<sup>18,19</sup> Malenka et al,<sup>20</sup> Newschaffer,<sup>21</sup> and van Doorn et al<sup>22</sup> all found that chart-based assessment of comorbidity performed better than the ICD-9-CM approach. Furthermore, several studies<sup>23-27</sup> have found that the use of administrative data based on the ICD-9-CM system may be insufficiently comprehensive and accurate for comorbid conditions to adjust adequately for patients' risk of poor outcomes.

In 1948, Pierre Denoix introduced the TNM staging system<sup>28</sup> and thus began the process of classifying or staging cancer patients based on the morphologic size of their tumor. No longer was it satisfactory for clinicians to refer simply to the organ system involved (i.e., lung cancer). Instead they now had a nomenclature that would allow them to refer to the morphologic severity of the tumor, such as Stage I Cancer of the Lung or Stage III Cancer of the Prostate. In a similar way, we need to include the clinical or pathophysiological severity of the comorbid ailment. We believe it is clinically incomplete to refer to a disease using a simple label, such as 'congestive heart failure' or 'arrhythmia'.

**4. "Do not record any neoplasms (ICD-9-CM-CM codes 140-239.9) listed as secondary diagnoses for this data item."**

Many patients with cancer will have one or more previous

cancers and these previous cancers are considered comorbidities. In our ongoing research project, we collect detailed comorbid health information from 9 cancer centers around the country<sup>29</sup> and we found that of the 10,027 cancer patients, 1073 (11%) had a prior neoplasm. Next to hypertension (39%), the most common comorbid ailment for cancer patients was another neoplasm.

The CoC requirement not to collect information on neoplasm seems unwise since the coexistence of another cancer or even the history of a previous cancer has profound prognostic and therapeutic implications. However, it is true that the data field "Sequence Number" indicates whether the patient has other cancers. Therefore, since the CoC is a central registry it may have information about previous cancers even if the previous cancers were diagnosed and treated at another facility. Therefore, it may be theoretically possible for the CoC to combine the previous record(s) with the index cancer to generate a complete picture of comorbidity. Unfortunately, the compilation of multiple records to determine time frames and other important issues is challenging and may require visual inspection of the record. At the individual hospital, information about previous cancers diagnosed and treated elsewhere will not be available and so severity of comorbidity for the index cancer cannot be determined. Comorbidity assessment will only be possible at the central level or at the hospital level if all cancers were diagnosed and treated at one hospital.

**5. "Complications are conditions that occur during the hospital stay, while the patient is being treated for the cancer. Complications are identified by the ICD-9-CM 'E' codes, which classify environmental events, circumstances, and conditions as the cause of injury, poisoning, and other adverse events."**

To perform quality of care assessment, the CoC has mandated the collection of information related to complications associated with treatment during hospitalization. To use information about the development of complications as a measure of quality of care, it is imperative that the complications be identified correctly.

In a retrospective study of 991 patients who underwent surgery, Romano et al<sup>30</sup> investigated the accuracy of reporting of postoperative complications in administrative data as compared with actual chart review and whether accuracy varied systematically across hospitals, and whether serious complications are more consistently reported. The weighted sensitivity, specificity, and positive and negative predictive values for reported complications between chart review and ICD-9 reporting were 35%, 98%, 82%, and 84%, respectively. The weighted sensitivity was 30% for serious, 40% for minor, and 10% for questionable complications. Only reoperation, bacteremia/sepsis, postoperative infection, and deep vein thrombosis were reported with at least 60% sensitivity. Half of the difference in risk-adjusted complication rates between low and high outlier hospitals was attributable to reporting variation. The authors concluded that ICD-9-CM complications were underreported and the validity of using coded complications to compare provider performance is questionable.

When analyzing complications from administrative data

sources it is important not to misclassify complications as pre-existing chronic comorbid ailments.<sup>31,32,30</sup> The CoC proposal states that complications of cancer care will be identified on the discharge face sheet through the use of the 'E' code. According to the UHDDS,<sup>15</sup> the only cases assigned an E code are those where the physician clearly identifies a cause and effect relationship in the medical record. For medical liability and other reasons, physicians are reluctant to place such clear and unambiguous statements in the medical record. Therefore, coders rarely use E codes. The CoC's decision to use E codes to define complications will lead to significant underreporting of complications and misclassification of both complications and comorbidities since both are listed on the discharge abstract without a consistent means of differentiating between the two.

### **Alternative Approach for the Inclusion of Comorbidity Information**

An alternative approach to the use of the ICD-9-CM system proposed by the CoC is to train cancer registrars to identify the cogent comorbid ailments and complications and require them to collect this information during their usual chart abstraction process. Cancer registrars are already reviewing the medical record, including sources beyond just the inpatient hospitalization record (i.e., outpatient reports, specialty consult dictation notes, etc.), to collect the demographic, tumor, treatment, and follow-up information mandated by the CoC. During the chart abstraction process, the registrars are able to identify the significant pre-existing medical conditions and complications of inpatient hospitalization. With support from the National Cancer Institute, my colleagues and I have developed a comorbidity education program designed specifically to train cancer registrars to collect comorbidity information from the review of the medical record.<sup>33,34</sup> This training program includes an introductory video, "The Whole Picture: Coding Comorbidity", coding book, training scenarios, and examination. The program originally required 3 days, but has been shortened to less than 2 days. Depending on the educational level, experience, and background of the registrar, the program can be completed in even less time. Registrars who participated in the training program were found to code comorbidity with a very high degree of accuracy and required, on average, only 2<sup>1/2</sup>-3 additional minutes to obtain the information. We developed a Web-based version of the training program that will allow registrars to learn comorbidity coding from their workstations and incorporate additional features, such as online support, answers to frequently asked questions (FAQs), and bulletin boards. As with our success in training registrars to identify and classify severity of comorbidity, we believe registrars can be trained to recognize complications of care in a valid and cost-effective manner.

### **Conclusion**

The use of ICD-9 codes from an administrative and financial database is widely accepted as a valid method to ascertain comorbid health information in health services research. It is also widely accepted that a chart-based abstraction is more accurate and valid than a claims-based approach. The exact methodology for ascertaining comorbidity information (i.e., claims-based or chart-based) is determined by the clinical setting and goals of the collection. In the situation of cancer reg-

istrars already performing chart review for demographic, tumor, and treatment information, we believe a chart-based approach to comorbidity is more appropriate.

The CoC and other national cancer organizations have taken a bold step to include comorbid health and complications information in hospital-based cancer data bases. Accurate comorbid information will improve the conduct and generalizability of clinical trials, evaluation of results from observational research, population-based epidemiological studies, and patient-physician communication. The use of ICD-9-CM codes to define the comorbid health status of cancer patients is not wholly unreasonable. However, considering that well-trained cancer registrars must already review a variety of medical record sources for detailed tumor, treatment, and cancer-care related information, it seems inappropriate to have cancer registrars simply transcribe the ICD-9-CM codes from the discharge face sheet. A system based on the training of cancer registrars to identify a finite number of *cogent comorbidities and complications* through chart review seems more efficient and accurate. Our previous research<sup>29</sup> demonstrated that cancer registrars can be easily trained to review all aspects of the medical record and identify the cogent comorbid conditions. In our opinion, the present program mandated by the CoC will lead to inaccurate and misleading comorbidity and complication information and that a chart-based approach provides a more accurate and reliable method.

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### References

1. Feinstein AR . The pre-therapeutic classification of co-morbidity in chronic disease. *J Chron Dis*. 1970;23:455-469.
2. Gonzalez EC, Ferrante JM, Van D, Pal N, Roetzheim RG . Comorbid illness and the early detection of cancer. *Southern Medical Journal* 2001;94:913-920.
3. Havlik RJ, Yancik R, Long S, Ries L, Edwards B . The National Institute on Aging and the National Cancer Institute SEER collaborative study on comorbidity and early diagnosis of cancer in the elderly. *Cancer*. 1994;74:2101-2106.
4. Satariano WA, Ragland DR . The effect of comorbidity on 3-year survival of women with primary breast cancer. *Ann Intern Med*. 1994;120:104-110.
5. Piccirillo JF, Feinstein AR . Clinical symptoms and comorbidity: significance for the prognostic classification of cancer. *Cancer*. 1996;77:834-842.
6. Desch CE, Penberthy L, Newschaffer CJ, et al . Factors that determine the treatment for local and regional prostate cancer. *Medical Care*. 1996;34:152-622.
7. Hewitt M, Simone J. *Ensuring Quality Cancer Care*. National Cancer Policy Board; Washington, DC; 1999.
8. Yates JW . Comorbidity considerations in geriatric oncology research. *CA: A Cancer Journal for Clinicians*. 2001;51:329-336.
9. Yancik R, Ganz PA, Varricchio CG, Conley B . Perspectives on comorbidity and cancer in older patients: approaches to expand the knowledge base. *Jo Clin Oncol*. 2001; 19:1147-1151.
10. Iezzoni LI: *Risk Adjustment for Measuring Health Care Outcomes* Ann Arbor, MI: Health Administration Press; 1994.
11. Morrow M, Sylvester J, and DesHarnais S. CoC and NCDB to Examine Approaches to Classifying Comorbidities. *News From The Commission on Cancer*. 11[5], 2-3, American College of Surgeons. Chicago, IL, 2000.
12. Bach PB, Cramer LD, Warren JL, Begg CB . Racial differences in the treatment of early-stage lung cancer. *NEJM*. 1999;341:1198-1205.
13. Klabunde CN, Potosky AL, Legler JM, Warren JL . Development of a comorbidity index using physician claims data. *J Clin Epidemiol*. 2000;53:1258-1267.
14. Stewart, A. *Facility Oncology Registry Data Standards. What's New: Clinical Enhancements*. Presented at: National Cancer Registry Association Annual Meeting; May 24, 2002; Nashville, TN.
15. Uniform Hospital Discharge Data Set (UHDDS). National Committee on Vital and Health Statistics. Hyattsville, Md, 2002. *National Center for Health Statistics*.
16. Piccirillo JF . Purposes, problems, and proposals for progress in cancer staging. *Arch Otolaryngol Head Neck Surg* 1995;121:145-149.
17. Yancik R, Havlik RJ, Wesley MN, et al . Cancer and comorbidity in older patients: a descriptive profile. *AEP* 1996;6:399-412.
18. Jollis JG, Ancukiewicz M, DeLong ER, Pryor DB, Muhlbaier LH, Mark DB . Discordance of databases designed for claims payment versus clinical information systems. *Ann Intern Med*. 1993;119:844-850.
19. Benesch C, Witter DMJ, Wilder AL, Duncan PW, Samsa GP, Matchar DB . Inaccuracy of the International Classification of Diseases (ICD-9-CM) in identifying the diagnosis of ischemic cerebrovascular disease. *Neurology*. 1997;49:660-664.
20. Malenka DJ, McLerran D, Roos N, Fisher ES, Wennberg JE . Using administrative data to describe casemix: a comparison with the medical record. *J Clin Epidemiol*. 1994;47:1027-1322.
21. Newschaffer CJ, Bush TL, Penberthy LT . Comorbidity measurement in elderly female breast cancer patients with administrative and medical records data. *J Clin Epidemiol*. 1997;50:725-733.
22. van Doorn C, Bogardus ST, Williams CS, Concato J, Towle VR, Inouye SK . Risk adjustment for older hospitalized persons: a comparison of two methods of data collection for the Charlson index. *J Clin Epidemiol*. 2001;54:694-701.
23. Roos LLJ, Nicol JP, Cageorge SM . Using administrative data for longitudinal research: comparisons with primary data collection. *J Chron Dis*. 1987;40:41-49.
24. Wennberg JE, Roos N, Sola L, Schori A, Jaffe R . Use of claims data systems to evaluate health care outcomes. Mortality and reoperation following prostatectomy. *JAMA*. 1987;257(7):933-936.
25. Romano PS, Mark DH . Bias in the coding of hospital discharge data and its implications for quality assessment. *Medical Care*. 1994;32:81-90.
26. Romano PS, Roos LL, Luft HS, Jollis JG, Doliszny K . A comparison of administrative versus clinical data: coronary artery bypass surgery as an example. Ischemic Heart Disease Patient Outcomes Research Team. *J Clin Epidemiol*. 1994;47:249-260.
27. Hawker GA, Coyte PC, Wright JG, Paul JE, Bombardier C . Accuracy of administrative data for assessing outcomes after knee replacement surgery. *J Clin Epidemiol*. 1997;50:265-273.
28. Denoix PF, Schwartz D . Regeles generales de classification des cancers et de presentation des resultats therapeutiques. *Academie De Chirurgie (Paris)*. 1959;85:415-424.
29. Johnston AS, Piccirillo JF, Creech CM, Littenberg B, Jeffe D, Spitznagel ELJ . Validation of a comorbidity education program. *J Reg Mgmt*. 2001;28:125-131.
30. Romano PS, Chan BK, Schembri ME, Rainwater JA . Can administrative data be used to compare postoperative complication rates across hospitals? *Medical Care*. 2002;40:856-867.
31. Iezzoni LI, Daley J, Heeren T, et al . Identifying complications of care using administrative data. *Med Care* 1994;32:700-715.
32. Iezzoni LI, Shwartz M, Ash AS, Mackiernan Y, Hotchkin EK . Risk adjustment methods can affect perceptions of outcomes. *Am J Med Qual*. 1994;9:43-48.
33. Piccirillo JF, Creech CM, Zequeira R, Anderson S, Johnston AS . Inclusion of comorbidity into oncology data registries. *J Reg Mgmt*. 1999;26:66-70.
34. Piccirillo JF, Costas I, Claybour P, Borah AJ, Grove L, Jeffe D . The measurement of comorbidity by cancer registries. *J Reg Mgmt*. 2003;30:8-14.