PET Utilization Under Taiwan's Universal Health Insurance Program

Taiwan's National Health Insurance (NHI) program began covering ^{18}F-FDG PET for selected oncologic indications in 2004. Delay in acquisition of high-tech equipment, scarcity of high-tech resources, and long waiting periods for such services had been reported in similar universal health care system coverage in Canada (*1*). Little has been published regarding PET utilization under Taiwan's universal health care system. Here we report the results of a study of initial trends in ^{18}F-FDG PET utilization in the management of patients with cancer after expansion of coverage. We used datasets based on the entire population in Taiwan to analyze resulting variations in patterns of utilization. This empirical assessment of potential variations in resource utilization may provide useful information for future research aimed at improving the quality of care for patients with cancer.

Background

The NHI program is a government-run, single-payer entity administered by the Bureau of National Health Insurance (BNHI) and compensates a mixed public and private delivery system predominantly on a fee-for-service basis (*2*). The program provides coverage for a wide range of services, including primary care services, ambulatory and inpatient care, prescription and certain over-the-counter drugs, as well as protection from catastrophic medical costs. NHI classifies all types of cancer as catastrophic illnesses and reimburses all medical services related to cancer care, including diagnostic workup, established treatment, and management of potential complications. Because of compulsory enrollment, NHI has maintained an overall coverage of >97% of the population in Taiwan since its inception in 1995 (*3*). More than 90% of Taiwan's health care providers contract with the BNHI to offer services covered by NHI, which allows the insured freedom of choice among providers.

In 2004, the Taiwan Joint Commission on Hospital Accreditation certified 17 of Taiwan's top medical institutions as medical centers, and, among a total of 516 hospitals that passed accreditation, 67 were certified as regional teaching hospitals (*4*). The claims records show that all medical centers and a minority of the regional teaching hospitals (18/67) provide PET imaging services to patients with cancer. NHI began covering ^{18}F-FDG PET examinations for selected oncologic indications in mid-2004. These indications include staging and therapeutic response monitoring of breast cancer; diagnosis and staging of colorectal cancer, head and neck cancers (excluding brain tumor and primary thyroid cancer), non–small cell lung cancer (NSCLC), lymphoma, esophageal cancer, and melanoma; differential diagnosis of single pulmonary nodules (suspected lung cancer); and restaging of recurrent thyroid cancer.

Approach

We used deidentified claims-related datasets produced for investigational purposes by the National Health Research Institutes (NHRI) from data submitted to the BNHI. To select patients who underwent PET scanning, we used a file containing a cohort of 1 million persons randomly selected from the entire insured population of ~23 million in 2005. A deidentified version of the registry of patients with catastrophic illness was used to select those with malignancy. For insurance purposes, all types of cancer are classified as catastrophic illnesses. Provider information was obtained from the registry of contracted medical facilities.

We focused on common cancers that accounted for the vast majority of PET utilization in Taiwan and found 5,678 patients with head and neck, breast, lung, colorectal, or esophageal cancers or lymphoma who received care at a provider of PET imaging services in the study time frame (2004–2007). Diagnostic codes in the *International Classification of Disease*, Ninth Revision, Clinical Modification (ICD-9-CM) were used to identify the status of malignancy, type of cancer, and other clinical conditions, including codes for comorbidities.

Descriptive statistics regarding cancer type, hospital accreditation level, and organizational type were presented by geographical location. We compared utilization of PET with that of other noninvasive diagnostic imaging (MR, CT, and ultrasound imaging) in the study population. We also compared various patient and provider characteristics between patients who underwent PET scanning and those who did not. In addition to cancer type, we attempted to analyze other clinical factors, including stage or extent of cancer and status of multiple cancers and comorbidities. A multivariate logistic regression model was used to evaluate the relationship between the likelihood of undergoing PET scanning and selected patient and provider characteristics. SAS software version 9.1 (SAS Institute Inc.; Carey, NC) was used, and statistical significance was defined at the conventional level of 0.05 in a 2-tailed test.

Results

In the period from 2004 to 2007, 40 facilities provided PET imaging services to the selected oncologic population (Table 1) (all tables cited in this article are available online only at http://jnm.snmjournals.org); 14 were in the northern region, 12 each in the central and southern regions, and 2 in the eastern region. The majority of the northern facilities (8/14) were medical centers, whereas most of the facilities in the central and southern regions were not. Most of the facilities operated as nonprofit organizations, except those in the central region, where half (6/12) were for-profit organizations. The common cancers in the select patient population were, in descending order of frequency: breast, colorectal, head and neck cancers, NSCLC, lymphoma, and esophageal cancer (accounting for 31%, 26%, 20%, 15%, 5%, and 3% of the study population, respectively [Table 2]).

The northern region had the majority (55%) of the study population, followed by the central (22%), southern (18%), and eastern (5%) regions. The northern region had disproportionately more patients with breast and colorectal cancers, whereas the southern region had disproportionately more patients with head and neck cancers and NSCLC. Four types of cancer accounted for the vast majority (84%) of oncologic ^{18}F-FDG PET scans, with head and neck cancers, colorectal cancer, NSCLC, and breast cancer accounting for 25%, 21%, 20%, and 18% of total scan volume, respectively. More than one third (36%) of the scans

performed in the southern region were for head and neck cancers. (Compared with Western countries, Taiwan is notable for its relatively high prevalence of head and neck cancers, especially in southern Taiwan. In the current study, head and neck cancers accounted for one quarter of the oncologic PET examinations covered by NHI overall.) Eleven percent of the study population who received care at a provider of PET imaging services underwent ^{18}F-FDG PET examination. Esophageal cancer and lymphoma had high scan rates of 22% and 20%, respectively, whereas breast cancer had a low scan rate of 7%. The northern region had the lowest scan rate for breast cancer (5%).

Approximately one fifth (21%) of all oncologic ^{18}F-FDG PET scans were repeat scans, with lymphoma as the most common indication for repeat scanning. Thirty percent of patients with lymphoma underwent repeat scans. On univariate analysis, certain patient and provider characteristics were associated with higher utilization (Table 3). For NSCLC, these included patients younger than 65 y of age, those with higher income or multiple cancers, and those who received care at an eastern facility or at a regional or district hospital. Younger patients with colorectal cancer were also more likely to undergo PET scanning. Regardless of cancer type, patients who received care at regional or district hospitals were more likely to undergo PET examination than those who received care at or were referred to medical centers.

On multivariate logistic regression, some of these relationships remained statistically significant (Table 4). Cancer type strongly influenced the likelihood of undergoing PET examination: patients with esophageal cancer were more likely to be scanned than those with breast cancer. Patient age, status of multiple cancers and hospital accreditation level were independent factors associated with the likelihood of undergoing PET scanning. The same was true for geographic location: patients who received care at eastern facilities were more likely to be scanned than those in the northern region.

Overall, the number of PET scans per million insured persons increased from 273 in 2005 to 378 in 2006 and to 413 in 2007—a 51% increase over 2 y (Fig. 1). Even with this increase, PET utilization represented only 4% of the number of noninvasive imaging studies performed (including MR, CT, and ultrasound). In the northern region, the rise in PET utilization was characterized by a 57% increase in 2006, followed by a 7% decrease in 2007. The central region saw a delayed surge, with a 2% decrease in 2006 and a 62% increase in 2007. The pace of rising utilization in the southern region fell between those of the northern and central regions, with consecutive yearly increases of 36% in 2006 and 17% in 2007.

Discussion

Prior research found strong empirical evidence of an association between third-party payment programs and increased likelihood of adoption and use of advanced medical technology (*5*). The current study provides empirical evidence of the association between NHI coverage and increased PET utilization in patients with cancer. The data indicate that the oncologic PET utilization rate per million increased by 51% over the 2-y period. This level of increase cannot be explained by changes in the incidence rates of the selected cancers over the same time frame.

Even with this increased usage, PET represented only 4% of noninvasive imaging studies performed, including MR, CT, and ultrasound imaging. Although the total increase in utilization from

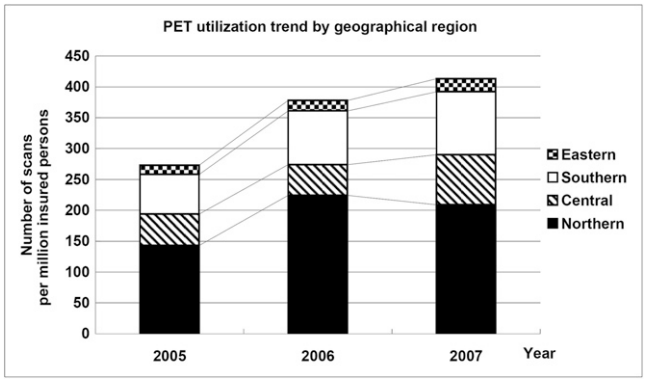

FIGURE 1. PET utilization trend by geographical region in Taiwan

2005 to 2007 was comparable among the various regions in Taiwan, significant regional differences were seen in the rapidity of response to expanded insurance coverage. The data suggest that the northern region had the essential elements enabling it to respond promptly and vigorously to the expanded coverage, with not only the major portion of Taiwan's oncologic burden in terms of patient population but also the largest number of providers, most of which were accredited as medical centers. In the central region, a substantial increase in the number of PET imaging system installations in 2007 occurred when 4 separate regional hospitals, previously without this technology, joined the 4 medical centers in providing this service. A new installation was also added at 1 of these medical centers, all of which were already equipped with PET imaging technology. These new installations coincided with the regional surge of PET utilization in the same year.

Various patient and provider characteristics were found to be associated with the likelihood of undergoing PET examination. The strong influence of cancer type is to be expected, because the examination may serve different roles in different cancers. Patient age and status of multiple cancers are also independent factors associated with the likelihood of undergoing the scan. These associations are reasonable, because younger patients and those with multiple cancers may more likely benefit from this examination. Alternatively, the association between the likelihood of undergoing the scan and status of multiple cancers may result from the potential of the scan to uncover synchronous malignancies. Although ^{18}F-FDG PET is known for its superiority in detecting distant metastases (*6*), we were unable to show a statistically significant relationship in the claims data between stage of cancer and likelihood of undergoing PET scan. This may be the result of inherent inadequacies in the source data, in terms of coding for the extent of the disease.

The data indicate that patients who received care at regional or district hospitals are more likely to undergo PET examination than those who received care at or were referred to medical centers. The same is true for patients who received care at eastern facilities, compared to those who received care at northern facilities. Although these relationships may not have simple explanations, it is worth noting that regional and district hospitals, as well as eastern facilities, serve only a small minority of the study population.

One report estimated the number of dedicated PET scanners required to support demand in the United Kingdom to be 0.82 per

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New Web Site Focuses on Member Benefits

Since its launch in June 2006, SNM's molecular imaging Web site has grown into a powerful resource for molecular imaging professionals, referring physicians, patients and advocates, and the general public. Our mission has been to educate the public while serving the needs of the professional molecular imaging community.

Last July, Molecular Imaging Center of Excellence (MICoE) members voted to approve changes to the center's operating procedures, including a new mission and vision. The center's board of directors recently approved a new strategic plan, and this year, the center will begin charging dues of $15/y. These dues will help support a number of programs, including the continued growth of valuable online resources designed specifically for our members.

I would like to invite all members to log in to their SNM account and visit www.snm.org/cmiit, a members-only microsite designed specifically for molecular imaging professionals. (CMIIT reflects the MICoE's planned name change—also approved in the July vote—to the Center for Molecular Imaging Innovation and Translation [CMIIT], which is taking effect this fall.) This site-within-a-site puts valuable member benefits within easy clicking range. Materials at www.snm.org/cmiit include selected monthly journal references; our quarterly newsletter, *MI Gateway*; PDFs of *JNM*'s Focus on Molecular Imaging; video, audio, and PowerPoint presentations; pages designed specifically for optical, ultrasound, and MR imaging professionals; and quick links to the public MI site.

Alan B. Packard, PhD

Materials targeted to referring physicians, patients, and the public are unaffected by this change. Visit www.molecularimagingcenter.org (or www.snm.org/mi) for access to our public discussion forums, patient fact sheets, the Word and Image of the Month, general information on molecular imaging, MI News, the calendar of events, our speakers bureau, and reprints of Newsline's Molecular Imaging Update. Members will need their 6-digit SNM member number to log in. Those who do not know their member numbers or passwords can click the "Forgot Password" link and immediately receive that information by e-mail. Assistance is available at 703-652-6776. We trust that the benefits in this new area will make it a strong home base for our members.

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million population (2,026 scans/million population/y) for all oncologic indications (*7*). These estimates were based on a model calculating the number of dedicated PET scanners required to support the demand for PET studies in lung cancer. This was then extended to all oncologic indications for PET. The number of PET scans required for lung cancer was calculated using lung cancer incidence rates and a decision tree and was estimated to be 29,886 per year in the UK, with 38,070 new cases per year, 82% of which were estimated to be NSCLC. In our analysis, the data indicate that the number of PET scans reimbursed by NHI for lung cancer in Taiwan in 2007 was approximately 20% of the estimated level required, using the UK algorithm adjusted for Taiwan's lung cancer incidence rates. Although our study does not account for PET scans not reimbursed by NHI, records in the claims database likely reflect the vast majority of all PET examinations performed for the selected oncologic indications. The seemingly low level of utilization for lung cancer may reflect differences in determinations of cost effectiveness between disparate health systems. Other important factors influencing the level of utilization may include cost control measures, such as the imposition of global budgets before insurance coverage expansion. Although global budgets do not necessarily control the quantity of service provided, these constraints may limit the number of PET scans performed, because of the significant incremental cost of this examination. More direct means of utilization control take the form of quotas, in terms of the number of examinations allowed in a certain time frame. Preferences of patients and referring physicians may also affect utilization levels.The results of our study depend on the quality of claims datasets managed by NHRI and are limited by the accuracy and completeness of the data submitted to BNHI. Our current study does not account for the stage of cancer (as a result of of inadequate coding of the extent of cancer in the datasets used). The addition of adequately coded staging information may affect the results of our study. Because our study is based on a sample of the full claims database, there is a small chance that a repeat analysis using a different sample dataset or the full database could produce different results. Our study does not provide evidence regarding the cost effectiveness or potential benefits in improved clinical outcomes associated with adoption of this advanced medical imaging technology.

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valuable summaries of pertinent literature. The Newsline editor recommends several reviews accessioned into the PubMed database in late July and August. In an article e-published on August 12 ahead of print in *Antiviral Research*, Bray et al. from the National Institutes of Health provided an overview of "Radiolabeled antiviral drugs and antibodies as virus-specific imaging probes" using PET and SPECT techniques. van Dongen and Vosjen from the VU University Medical Center (Amsterdam, The Netherlands) reviewed on August 14 ahead of print in *Cancer Biotherapy and Radiopharmaceuticals* "Immuno-positron emission tomography: shedding light on clinical antibody therapy." Heidenreich et al. provided an article on "Imaging studies in metastatic urogenital cancer patients undergoing systemic therapy: recommendations of a multidisciplinary consensus meeting of the Association of Urological Oncology of the German Cancer Society" in the July issue of *Urologia Internationalis* (2010;85:1–10). In a review e-published on August 3 ahead of print in *Bone*, Snoeks et al. from Leiden University Medical Center (The Netherlands) reviewed "Optical advances in skeletal imaging applied to bone metastases." Cerchia and de Franciscis from the Istituto per l'Endocrinologia e l'Oncologia Sperimentale del CNR (Naples, Italy) on August 16 reported ahead of print in *Trends in Biotechnology* on advances in "Targeting cancer cells with nucleic acid aptamers." Hu et al. from Northwestern University (Evanston, IL) summarized advances in "High-performance nanostructured MR contrast probes" on August 6 ahead of print in *Nanoscale*. Tolmachev et al. from Uppsala University (Sweden) described on July 26 ahead of print in *Lancet Oncology* the prospects and challenges of "Radiolabelled receptor-tyrosine-kinase targeting drugs for patient stratification and monitoring of therapy response."

Erratum

In the August issue of Newsline, the final sentence of the literature brief summarizing an article in the *British Journal of Cancer* by Ströbel et al. on sunitinib in metastatic thymic carcinomas should have ended with the following sentence: "The authors concluded that 'sunitinib is an active treatment for metastatic thymic carcinomas' and that 'a panel of molecular analyses may be warranted for optimal patient selection.'" The Newsline editor thanks sharp-eyed reader Ted Silberstein, MD, for pointing out the erroneous substitution of the word "thyroid" in that sentence.

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Conclusion

PET utilization increased substantially after expansion of insurance coverage in Taiwan. However, PET examinations still accounted for only a small fraction of noninvasive diagnostic imaging studies performed. Although regional levels of PET utilization were commensurate with oncologic burden, significant regional variations in patterns of utilization were noted.

ACKNOWLEDGMENTS

This study was supported partly by the Department of Health, Executive Yuan, Taiwan, Republic of China (grant numbers NSC 95-2625-Z-039-002, NSC 96-2625-Z-039-003, NSC 97-2625-M-039-003); China Medical University Hospital (grant number 1MS1); Taiwan Department of Health, Clinical Trial and Research Center of Excellence (grant number DOH99-TD-B-111-004); and China Medical University Hospital study projects (DMR-95-076 and DMR-95-077). We wish to thank Mr. Te-Zen Fong of GE Healthcare for providing information on PET scanner installations in Taiwan and Dr. Te-Chun Hsieh for reviewing the list of indications for ^{18}F-FDG PET, covered by Taiwan's NHI program.

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