GENESEE/FINGER LAKES REGION
PET CAPACITY AND UTILIZATION REPORT

December 2015

SECTION ONE: INTRODUCTION

This report provides information on the availability and utilization of Positron Emission Tomography scanners in the Finger Lakes region of New York. The majority of the data comes from survey data reported by the current providers of PET scans in the region and covers the 2014 calendar year. The data reported by providers and summarized in this report are used by the Finger Lakes Health Systems Agency in its role in the state Certificate of Need law and by the Community Technology Assessment Advisory Board (CTAAB) in its role as advisor to area insurers to evaluate PET capacity and utilization.

Background

Positron Emission Tomography (PET) is an imaging technology that can reveal both anatomic *and* physiologic information in various tissue sites. The physiologic information is what distinguishes it from MRI and CT imaging which provide primarily anatomic information. PET uses radiotracers composed of organic compounds (such as glucose, ammonia and water) labeled with positron-emitting isotopes. These radiotracers can be metabolized in ways which signal disease processes; for example the high rate at which cancer cells metabolize glucose is captured as a "hot spot" in the scanned image.

While PET has been around for nearly forty years, it was primarily limited for much of that time to assessing brain function, such as seizures. However, in 1995 the federal Medicare program approved payment for studies of cardiac perfusion. In 1999, the Health Care Financing Administration approved reimbursement for a number of new clinical indications, all having to do with cancers. Additional considerations were added over time. The charts in Appendix I list the PET clinical uses currently approved for federal reimbursement; please note, however, that not all indications are accepted by all insurers. The second chart lists the conditions under which certain procedures are always covered, not covered nationally or covered only in specific settings.

Medicare's new reimbursement authorizations made possible the financial support of a PET scanner locally in 2000, and a number of applicants came forward requesting CTAAB approval to provide PET services[1].

In June 2000, CTAAB approved provision of up to 5 days of mobile service (1 full-time machine[2]) for the area, to be phased in over time. Additional providers were subsequently approved for Rochester, the central Finger Lakes counties and for United Memorial Medical Center in Batavia in 2005.

[1] Before 2000, scans were obtained in Buffalo.

[2] A "full time" machine is a machine that is operational five days a week. A machine that is operation one day a week would be 0.2 units, two days a week would be 0.4 units, and so on.

In October 2003, CTAAB approved installation of a fixed PET scanner which also had a CT scanner built into it[3], to be operated jointly by two area radiology providers, one of which would be replacing its mobile PET service. Additionally, CTAAB recommended to insurers that providers be permitted to replace their present PET service with the same capacity/utilization of PET/CT service. All local PET providers but one now utilizes PET/CT equipment.

SECTION TWO: CAPACITY

Inventory[4]

As of December 31, 2014, there are five PET delivery sites in the region. Three of the sites are in Rochester, while the other two are in Clifton Springs, and Elmira respectively. Currently there are a total of five scanners of which two are mobile. To date, none are CON-approved sites. The area now has the equivalent of 3.6 full time units operating. There is also mobile capacity at UMMC in Batavia; while not included in this analysis, it is part of the CTAAB region and is considered in those reviews.

TABLE 1: Inventory of PET machines in the Genesee/Finger Lakes region

Site	Units (FTE)	Mobile/Fixed	CON Approved	Ownership
Arnot Health System	0.4	M	N	Alliance Healthcare Radiology
Rochester Regional Health Systems	1.0	F	N	Alliance Imaging
University of Rochester	1.0	F	N	Radiologists of the University of Rochester
Borg and Ide Imaging	1.0	F	N	Borg-Ide Imaging
Clifton Springs	.2	M	N	Alliance Imaging

[3] For more information on PET/CT scanners, see Appendix II.

[4] Inventory tables contain information collected from current and past PET Surveys

TABLE 2: PET equipment

Site	**Manufacturer***	**Type***	**Radiopharmaceutical Vendor** (Distance from Site)
Arnot Health System	GE	C	PetNet Albany – 200 mi
Rochester Regional Health Systems	Philips-True Flight	C	Cardinal Health Rochester – 10 mi
University of Rochester	Philips	C	Cardinal Health Rochester – 0 mi
Borg and Ide Imaging	GE Discovery LS	C	IBA Molecular Albany –220 mi
Clifton Springs	GE	P	PetNet Albany – 200 mi
P – PET only C – Combined PET and CT			

Equipment Replacement

As previously noted, CTAAB has historically indicated that it will not endorse additional fixed units for the region, but would recommend to insurers that providers be permitted to upgrade their present PET capacity to PET/CT capacity. To our knowledge, all but one unit in the region is now a PET/CT.

The units at Borg & Ide and at Science Park were replaced in 2010 and 2013 respectively; replacements have occurred at the mobile sites, but information is not available on when those replacements have taken place.

Although not regulated by either the Certificate of Need or CTAAB processes, a commercial firm initiated operation of a cyclotron in Rochester during 2005. This provides short-lived radio-pharmaceuticals[5], permitting studies such as cardiac muscle viability, not previously feasible.

Staffing

Manipulation and interpretation of PET scans requires specialized training on the part of the radiologist for quality assurance. Across the sites there are roughly thirty-seven radiologists authorized to interpret PET images. Arnot Health System has seven authorized radiologists; Rochester Regional Health Systems has three; Western NY Pet has one; University of Rochester has eleven; and Borg and Ide have four authorized radiologists. Information was not provide on the number of radiologists currently approved to interpret images at Clifton Springs Memorial Hospital and Clinic.

[5] For a discussion of short-lived radiopharmaceuticals, please see Appendix IV.

Table 3 describes the number of days each scanner is staffed and the hours of operation per day. This provides one measure of availability of this service. Providers in the Finger Lakes Region only provide weekday scans. The respondents indicated a scan takes 45 to 90 minutes of machine time. Using this information, we are able to generate an estimate for the capacity of scans for the region.

TABLE THREE: PET Service Staffing

Site	**Days/ Week**	**Hours/Day**	**Estimated Capacity**[6] Based on Current Hours/Staff	**Max Capacity**[7] Based on Current Hours/Staff
Arnot Health System	2	8	11.5/week	21/week
Rochester Regional Health Systems	7	9	15/week	36/week
University of Rochester	5	10-12	76/week	77/week
Borg and Ide Imaging	5	8.25	12/week	55/week
Clifton Springs	2	10	12/week	13/week

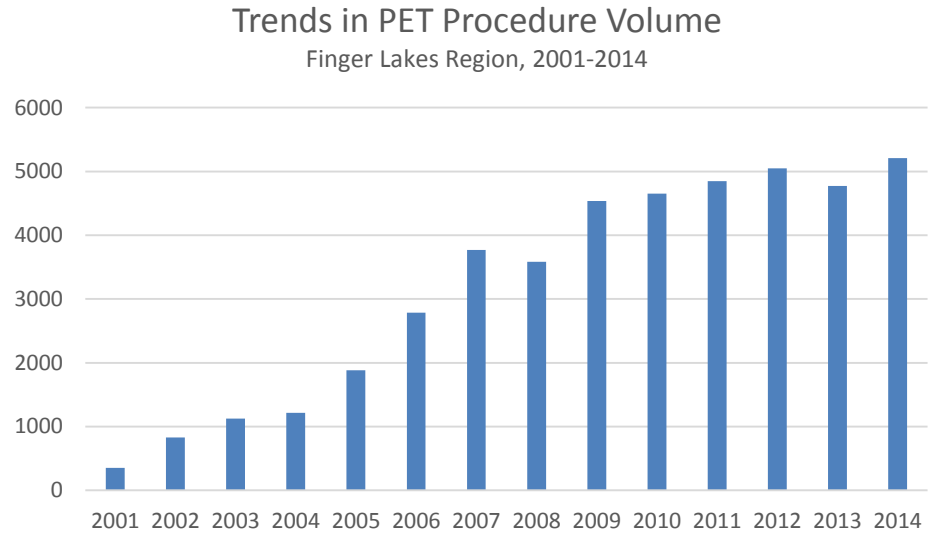
Just over half of the current providers indicate that patients are generally able to be scheduled on the next available service day for their scanner for patients that are considered emergent cases (recall that some of the scanners are mobile units available only on certain days of the week). For non-emergent patients the waiting period is longer; on average a non-emergent patient will have to wait 3 days.

SECTION THREE: UTILIZATION

As previously noted, PET scans were nominally available to area patients prior to the year 2000 due to Buffalo's three early machines, but numbers of scans performed were minimal. With the installation of local PET capacity in 2001 and the expansion of indications, the number of scans performed has increased substantially. The number of scans conducted by Finger Lakes providers has grown from 1,216 scans in 2003 to 5,146 scans for 2014. The Finger Lakes Region is made up of the following providers: Arnot, Rochester Regional Health Systems, University of Rochester, Borg & Ide, and Clifton Springs Hospital and Clinic.

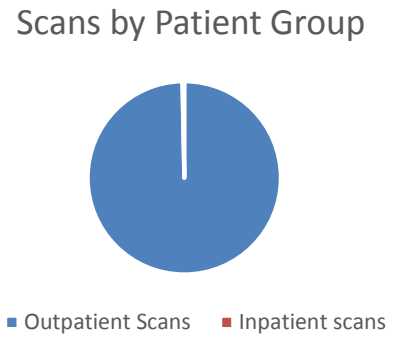
[6] Information was provided by 2014 PET survey
[7] Calculation based on a 45 minute scan

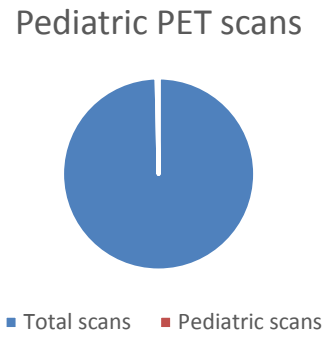
Growth of the Finger Lakes Region is illustrated in the graph below. It is noted that there has been much change in the volume of PET procedures over the years. With the expansion of indicators, we saw relatively quick growth of the technology overtime. However, this was not the case in the last few years.



The enlargement of clinical indications for PET scans suggests that one should anticipate ongoing growth in utilization. We have seen ongoing growth but at a decreasing rates over time.

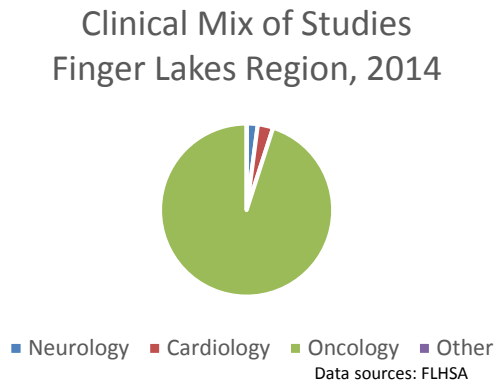
The makeup of the patient population has been predominately outpatient. Across the Finger Lakes region, 99.7% of the total patients who complete PET scans are outpatients. Of the 5,146 scans that were taken in this region, a total of 5,131 were outpatients. There have been no ED patients in the past several years that have utilized the PET technology. Pediatric utilization has also been very low. Pediatric scans make up less than 1% of the PET scans taken in this region. This has not changed over the course of the last three years. Of the total scans taken this year there were only 15 that were pediatric patients.

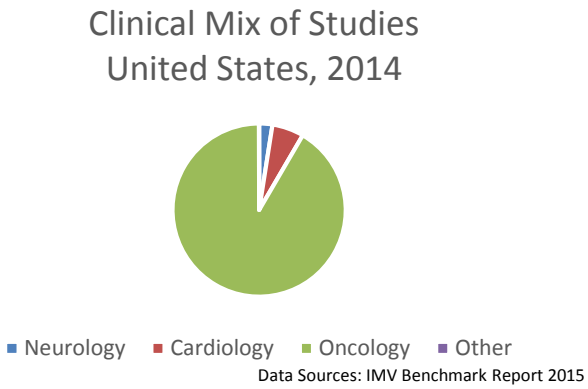




Utilization by Indication

The respondents provided data on which indications generate requests for PET imaging. Nationally, most scans are performed for oncology indications. Regional providers perform fewer non-oncology studies than nationally due to the large distance to the source of the radio-pharmaceuticals (Albany) used for some of those studies. Although the Rochester-based cyclotron, which produces such radio-pharmaceuticals, came on line in 2005, the number of non-oncology scans has not yet expanded substantially; it is only used by two providers. While there have been some non-oncology scans performed each year, there is not yet a trend in the proportion of scans done for studies other than oncology.

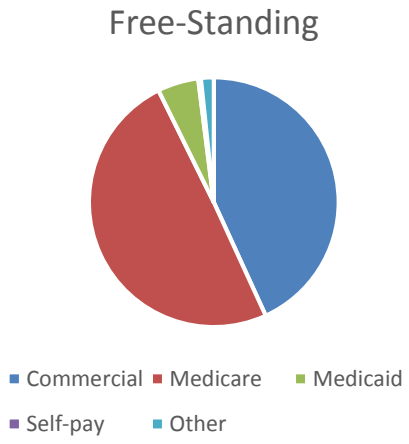


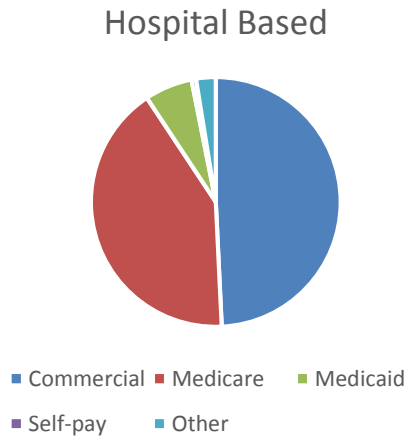


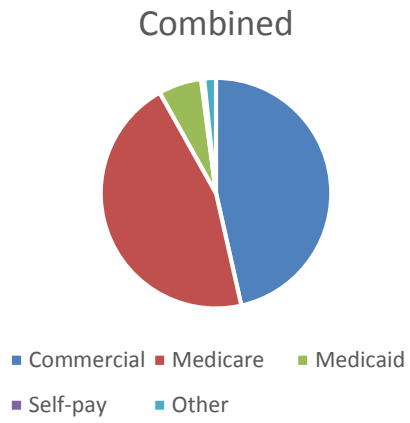
Utilization by Payment Type

Approximately 43% of PET scan patients are covered by Medicare, while almost 45% are covered by private insurance. All hospital-based facilities in the region provide services to Medicaid clients; overall, approximately 6% of scans are for Medicaid patients. Two providers exhibited some degree of private pay in 2014.

Payer Mix for PET Scans, 2014



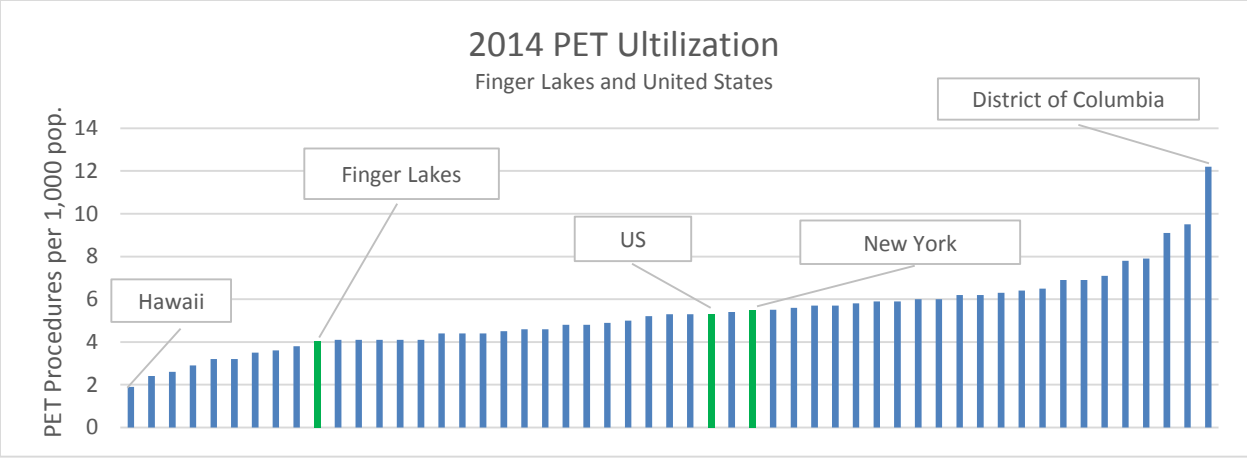




SECTION FOUR: CAPACITY ANALYSIS

Community Need

As seen previously, the number of PET scans performed on local scanners rose rapidly initially, but in most recent years we see that this trend no longer holds. Over the course of the last six years we have seen the number of PET scans begin to stabilize; changes in PET volume have been minimal. It continues that both machine capacity and clinical approval for obtaining a scan are being tightly controlled in the Finger Lakes region, to avoid some of the excesses observed during the initial distribution of other high-tech equipment. Has the community been successful in that strategy? Alternately, has it overly constrained use of this technology? As seen in this graph[8] utilizing local data and data from the 2015 PET Survey of IMV Medical Information Division, the local use rate has consistently been well below the national rate, and grew only minimally in the past year.



[8] Data sources: FLHSA Annual PET Surveys; IMV National PET Surveys

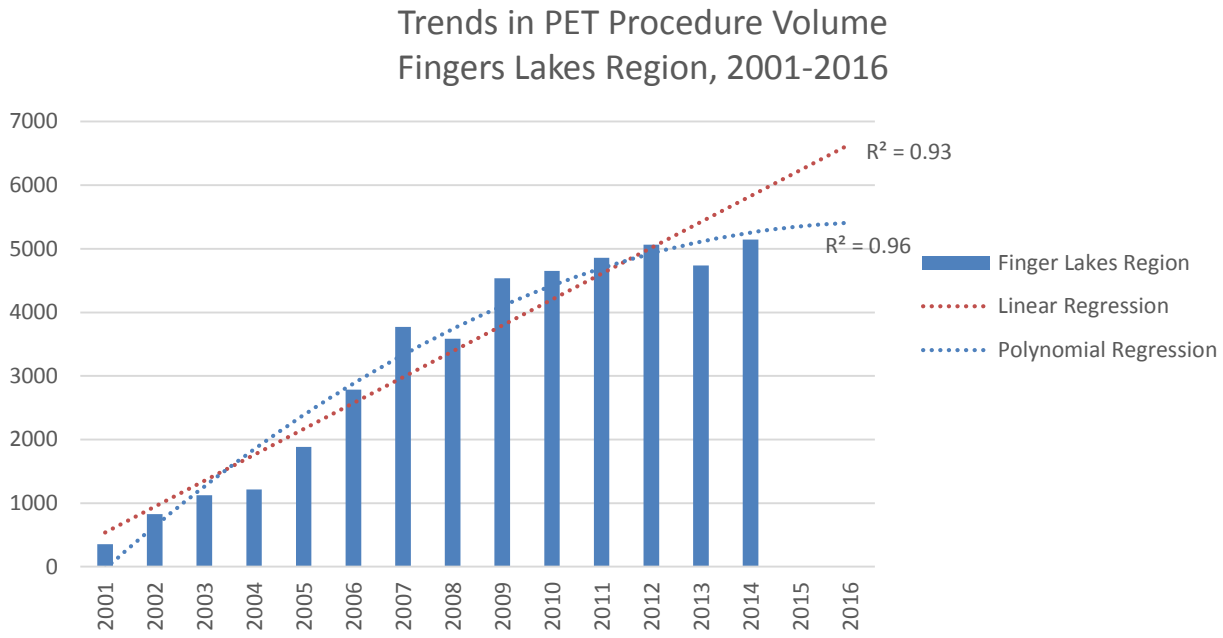
In fact, compared to other U.S. states, the Finger Lakes region in 2014 had a use rate well below majority states, comparable to the eleventh lowest state. Further, the region's utilization relative to other states has increased slightly in the past three years.

Clinical Need

The clinical indications for PET scanning have continued to expand due to the expansion of proven diagnosis. As a result it is no longer possible to estimate clinical need for this service based on this information. Instead, FLHSA has reviewed and updated the estimate of regional demand by analysis on historical utilization trends. This provides a more relative estimate of the future demand for PET scans.

Regional Demand

Local demand has now exceeded the early estimates of clinical need. The following chart demonstrates that, if utilization trends continue, the region may experience demand for PET scans between 5,350 and 6,225 scans in 2015 and between 5,400 and 6,650 in 2016.



We expect a 7% growth in PET scans in the year 2015 and a 4% growth in scans from 2015 to 2016. This is similar to the change that we have seen over the past several years. The average absolute change in PET volume has been 5% over the last five years, with the greatest changes being a 6% decrease in volume 2012-2013 and a 9% increase in volume that was experienced 2013-2014.

Scans Per Machine

All of the providers have indicated they can provide on average 9 scans per day (the PET/CT units can perform scans more quickly than PET alone, leading to higher capacity). It should be noted that length of time the scanners are staffed and patient population vary. Therefore, with 5 days per week/260 days per year of service can provide approximately 2,340 scans/machine/year if fully scheduled. At 90% scheduling efficiency, a scanner would provide approximately 2,106 scans per year. Presumably, additional scans could be performed if hours of operation were extended. (In fact, most units in the region are scheduled for use more than 8 hours per day, with one unit scheduled 13 hours per day.)

Community Need Conclusion

The above analysis suggests that, while the clinical "need" is no longer easily discerned, the current utilization data would indicate that the Rochester area is "demanding" nearly two full-time machines. The Rochester area has slightly more than three full-time machine equivalents in use and, by expansion of number of days used at current mobile sites, capacity could be expanded to as much as five FTE units. It appears that there is not a need to add additional capacity to the area at this time.

Likewise, in the Southern Tier the provider-estimated capacity is greater than the present demand for PET services. Further, the mobile service at Arnot Ogden can grow to meet demand. Additional capacity and sites are not needed at this time.

Conclusion

PET scanning has an expanding clinical utility. The Finger Lakes region is well equipped to take advantage of that expanding clinical use. Regional utilization rates for PET are well below national averages, however. With the availability of a cyclotron in the region in 2005, consideration should be given to developing a local consensus on clinical indications, including indications using short-lived radiopharmaceuticals. There is no need for additional capacity at this time. The same is true for the PET/MRI further discussed in appendix III. Based on clinical and community need as well as an assessment of the two technologies, PET/MRI and PET/CT, it is noted that there is no need for additional capacity. However, due to the decrease in radiation levels with the advancement of the technology, there is an advantage to the new technology.

Appendix I

Medicare PET Coverage Indications		
Clinical Condition	**Effective Date**	**Coverage**
Solitary Pulmonary Nodules (SPNs)	January 1, 1998	Characterization
Lung Cancer (Non-Small Cell)	July 1, 2001	Diagnosis, staging and restaging
Esophageal Cancer	July 1, 2001	Diagnosis, staging and restaging
Colorectal Cancer\	July 1, 1999	Determining location of tumors if rising CEA level suggests recurrence
Colorectal Cancer	July 1, 2001	Diagnosis, staging and restaging
Lymphoma	July 1, 1999	Staging and restaging only when used as an alternative to Gallium scan
Lymphoma	July 1, 2001	Diagnosis, staging and restaging
Melanoma	July 1, 1999	Evaluating recurrence prior to surgery as an alternative to a Gallium scan
Melanoma	July 1, 2001	Diagnosis, staging and restaging; Non-covered for evaluating regional nodes
Breast Cancer	October 1, 2002	As an adjunct to standard imaging modalities for staging patients with distant metastasis or restaging patients with locoregional recurrence or metastasis; as an adjunct to standard imaging modalities for monitoring tumor response to treatment for women with locally advanced and metastatic breast cancer when a change in therapy is anticipated.
Head and Neck Cancers (excluding CNS and thyroid)	July 1, 2001	Diagnosis, staging and restaging
Myocardial Viability	October 1, 2002	FDG PET for the determination of myocardial viability as a primary or initial diagnostic study prior to revascularization, or following an inconclusive SPECT. Studies performed by full and partial ring scanners are covered.
Myocardial Viability	October 1, 2001	Primary or initial diagnosis, or following an inconclusive SPECT prior to revascularization. SPECT may not be used following an inconclusive PET scan

Medicare PET Coverage Indications		
Clinical Condition	**Effective Date**	**Coverage**
Thyroid Cancer	October 1, 2003	Restaging of recurrent or residual thyroid cancers of follicular cell origin that have been previously treated by thyroidectomy and radioiodine ablation and have a serum thyroglobulin >10ng/ml and negative I-131 whole body scan performed.
Refractory Seizures	July 1, 2001	Covered for pre-surgical evaluation only
Perfusion of the heart using Rubidium 82* tracer	March 14, 1995	Covered for noninvasive imaging of the perfusion of the heart.
Perfusion of the heart using ammonia-13* tracer.	October 1, 2003	Covered for noninvasive imaging of the perfusion of the heart

*Not FDG-PET.

Indication	**Covered** [9]	**Nationally Non-covered** [10]	**Coverage with Evidence Development** [11]
Brain			X
Breast -Diagnosis -Initial staging of axillary nodes -Staging of distant metastasis -Restaging, monitoring [12]	 X X	 X X 	
Cervical -Staging as adjunct to conventional imaging -Other staging -Diagnosis, restaging, monitoring *	 X 	 	 X X

[9] Covered nationally based on evidence of benefit. Refer to National Coverage Determination Manual Section 220.6 in its entirety for specific coverage language and limitations for each indication.

[10] Non-covered nationally based on evidence of harm or no benefit.

[11] Covered only in specific settings discussed above if certain patient safeguards are provided. Otherwise, non-covered nationally based on lack of evidence sufficient to establish either benefit or harm or no prior decision addressing this cancer. Medicare shall notify providers and beneficiaries where these services can be accessed, as they become available, via the following:

- Federal Register Notice
- CMS coverage Web site at: www.cms.gov/coverage

[12] In this case and the other uses in this table, "monitoring" refers to response to treatment when a change in therapy is anticipated

Colorectal -Diagnosis, staging, restaging -Monitoring *	X		 X
Esophagus -Diagnosis, staging, restaging -Monitoring *	X		 X
Head and Neck (non-CNS/thyroid) -Diagnosis, staging, restaging -Monitoring *	X		 X
Lymphoma -Diagnosis, staging, restaging -Monitoring *	X		 X
Melanoma -Diagnosis, staging, restaging -Monitoring *	X		 X
Non-Small Cell Lung -Diagnosis, staging, restaging -Monitoring *	X		 X
Ovarian			X
Pancreatic			X
Small Cell Lung			X
Soft Tissue Sarcoma			X
Solitary Pulmonary Nodule (characterization)	X		
Thyroid -Staging of follicular cell tumors -Restaging of medullary cell tumors -Diagnosis, other staging & restaging -Monitoring *	X		 X X X
Testicular			X
All other cancers not listed herein (all indications)			X

EFFECTIVE JANUARY 28, 2005: This manual section lists Medicare-covered uses of PET scans effective for services performed on or after January 28, 2005. Except as set forth below in cancer indications listed as "coverage with evidence development", a particular use of PET scans is not covered unless this manual specifically provides that such use is covered. Although this section 220.6 lists some non-covered uses of PET scans, it does not constitute an exhaustive list of all non-covered uses.

For cancer indications listed as "coverage with evidence development" CMS determines that the evidence is sufficient to conclude that an FDG PET scan is reasonable and necessary only when the provider is participating in, and patients are enrolled in, one of the following types of prospective clinical studies that is designed to collect additional information at the time of the scan to assist in patient management:

- A clinical trial of FDG PET that meets the requirements of Food and Drug Administration (FDA) category B investigational device exemption (42 CFR 405.201);
- An FDG PET clinical study that is designed to collect additional information at the time of the scan to assist in patient management. Qualifying clinical studies must ensure that specific hypotheses are addressed; appropriate data elements are collected; hospitals and providers are qualified to provide the PET scan and interpret the results; participating hospitals and providers accurately report data on all enrolled patients not included in other qualifying trials through adequate auditing mechanisms; and, all patient confidentiality, privacy, and other Federal laws must be followed.

Effective December 18, 2009: Change in coverage framework. Move from four-part framework of diagnosis, staging, restaging, and monitoring response to treatment to a two-part framework. New framework differentiates FDG PET imaging, which is used to inform initial antitumor treatment strategies. Two-part framework includes initial treatment strategy and subsequent treatment strategy.

Effective March 7, 2013: Local Medicare Administrative Contractors may determine coverage within their jurisdiction for the PET using radiopharmaceuticals for oncologic imaging.

Source: www.cms.hhs.gov/mcd/, national coverage determinations, PET, accessed 12/16/2015

Appendix II

PET/CT

A recent development in PET scanning is the fusing of PET scans with scans from other imaging modalities. This can be done by overlaying images from different machines using computer software, and/or by combination or fusion of images from two machines combined onto a single structural frame. Presently, the latter is a combination of a PET scanner and a CT scanner, or PET/CT.

Value of PET/CT incremental of PET

The radioactive decay of radiopharmaceuticals used in PET scanning produces more energetic rays than in many other nuclear medicine modalities, providing a higher resolution image than in those other modalities. The PET images, however, do not have the spatial resolution of MRI or CT scans. The concept of PET/CT, then, is to use the PET scanner to provide metabolic or physiologic information, and the CT scanner to provide anatomic data. By melding or fusing the two images, unique information are created on where a tumor is located. As stated by a local provider, "Providing metabolic data in an anatomic context allows more accurate and intuitive diagnosis, staging, and treatment, resulting in improved outcomes and overall lower costs."

Software programs are available to perform merges of CT and PET scans taken at different times and on separate machines, but the record of their success in fusion is an issue of contention in the field

In PET/CT, the CT scan is exactly co-registered with the PET image. This makes it possible to very accurately locate abnormalities seen on the PET images by using the high-resolution anatomic data. A local commenter states, "Pathological foci can more easily be located, such as determining whether an abnormal lymph node lies in the mediastinum or lung hilum. By accurately localizing lesions seen on the PET images, biopsies are more likely to yield accurate information."

Importantly, the fused image information can be directly downloaded to radiation therapy treatment planning software, allowing for highly accurate planning. Further, the CT-imaged anatomy landmarks can be used to accurately and reproducibly focus the radiation therapy equipment, allowing for treatments which maximize the radiation directed to the cancer and minimize the radiation to surrounding healthy tissue.

Many of the improvements to patient care attributed to PET/CT are, in fact, a result of PET vs other modalities. However, there are also articles which directly compare PET/CT with PET plus CT or MRI. Even with small sample sizes, many of these studies are able to demonstrate changes in patient treatment using PET/CT, and some are able to show improvements in outcomes. Presently, the literature supports use of PET/CT for head & neck cancers and for certain lung cancers. Emerging literature also argues for use of PET/CT in a number of cancers of the pelvis. Together, these sites comprise more than half of all oncology indications for PET; over time, one can anticipate that additional PET/CT indications will be demonstrated. There is no consensus to date on whether all radiation therapy treatment planning should be based on a PET/CT fused image. If that became a clinical standard, it would have major implications for the community need for PET/CT capacity.

By the Fall of 2003, CTAAB had recommended the introduction of PET/CT in the Rochester community. Further, it recognized that PET/CT would likely supplant stand-alone PET over time, and recommended that current PET providers be permitted to upgrade their present capacity to PET/CT.

PET/CT, the Attenuation Correction and Productivity

All current PET scanners perform attenuation correction, which is necessary to adjust for the absorption of emitted gamma photons within the body. In regular PET, this is generally done immediately before the PET scan by measuring the absorption from an external radiation source as it moves about the body. The new PET/CT scanners use a high resolution thin slice CT scan, obtained immediately prior to the PET scan, to perform attenuation correction. This provides more accurate attenuation correction, resulting in higher quality PET images. It also reduces the time required for a PET scan by 15-25 minutes. A typical scan, which currently averages 60 minutes, in PET/CT may be done in 30 to 45 minutes. This results in a substantial increase in productivity and in community capacity to perform PET scans, as well as improvements to patient comfort.

Appendix III

PET/MRI

More recent development in PET scanning is the fusion of PET scans with scans from other imaging modalities. As with the PET/CT, this is done by overlaying images from different machines using computer software, and/or by combination or fusion of images from two machines combined onto a single structural frame. This most recent technology is the combination of the PET scanner and the MRI scanner, known as the PET/MRI.

Value of PET/MRI

The concept of PET/MRI, is to use the PET scanner to provide metabolic or physiologic information, and the MRI scanner to provide information on anatomy and function through the use of a magnetic field and its interactions with protons. Blending the two technologies has presented some advancements in the field of imaging. The axial magnetic fields employed in MR, reduces the positron range in the trans-axial plane resulting in an improvement of the spatial resolution of the PET scanner. Research suggests,

> Hybrid PET/MRI presents many advantages in comparison with its counterpart PET/CT in terms of improved soft-tissue contrast, decrease in radiation exposure, and truly simultaneous and multi-parametric imaging capabilities. However, the lack of well-established methodology for MR-based attenuation correction is hampering further development and wider acceptance of this technology.

Findings from a recent literature review suggest that the two technologies, PET/MRI and PET/CT, are quite comparable. A pediatric study of the two forms of imaging concluded that there was a 73% dose reduction compared to the PET/CT[13]. One of the implications for the PET/MRI is that the MR component is a radiation-free alternative to the CT component of the PET/CT. Although the MRI adds no radiation, it is important to mention that radiation continues from the PET element of the modality. Imaging between the two modalities, however, did not show advancements with the PET/MRI, but more of a parallel between the two.

In respect to detection, it was found that there was no significant difference between the PET/MRI and PET/CT. In the pediatric study, the PET/CT was able to detect lesions at a greater rate than the PET/MRI. Among 18 pediatric patients with proven and suspected solid malignant tumors and an average age of 14 years, the PET/CT was able to detect 62 areas of focal uptake in comparison to the PET/MRI which picked up 61. This illustrates that although there is better lesion detection in the PET/CT, the two technologies are not very different. Compared to the PET/CT, the new advancement in the PET/MRI is able to provide better soft-tissue contrast without the use of ionizing radiation, but fails to surpass the PET/CT when evaluating pediatric malignant lymph nodes and small lung metastases (Schafer, et al., 2014).

Furthermore, research continued to suggest a strong correlation between the two. Articles stated that there was no significant difference in estimates for metabolic parameters. Standardized Uptake Value (SUV) and Metabolic Tumor Volume (MTV) were the two measures that were investigated; each were

[13] Schäfer, J., Gatidis, S., Schmidt, H., Gückel, B., Bezrukov, I., Pfannenberg, C., . . . Schwenzer, N. (n.d.). Simultaneous Whole-Body PET/MR Imaging in Comparison to PET/CT in Pediatric Oncology: Initial Results. Radiology, 273(1), 220-231.

found to be relatively similar across modalities.[14] In terms of staging, results were the same. For patients with head and neck tumors, the PET/MRI was suggested to be more accurate in staging than the PET/CT; researchers were able to accurately determine tumor stage compared to histology in 56 of 64 patients and 55 of 64 patients, respectively.[15] Although, the PET/MRI was able to accurately detect the lymph node stage in one more patient than the PET/CT, it was noted that the PET/CT demonstrated superior correlation with respect to the assessment of diameter than the PET/MRI. The difference however, was so slight that it was concluded that there was statistically no diagnostic advantage to the PET/MRI in the assessment for primary tumor.

Lastly, similar to the PET/CT, improvement in design and technological capacity has allowed for the move from sequential testing to simultaneous acquisition. However, computer software exists that allows for images taken separately to be combined.

[14] Schlittenbauer, T., Zeilinger, M., Nkenke, E., Kreiβel, S., Wurm, M., Lell, M., . . . Beck, M. (2015). Positron Emission Tomography- Computed Tomography Versus Positron Emission Tomography- Magnetic Resonance Imaging for Diagnosis of Oral Squamous Cell Carcinoma: A Pilot Study. Journal of Crano-Maxillo-Facial Surgery, 1-7.
[15] Covello, M., Cavaliere, C., Aiello, M., Cianelli, M., Mesolella, M., Iorio, B., . . . Nicolai, E. (2015). Simultaneous PET/MR Head-Neck Cancer Imaging: Preliminary Clinical Experience and Multiparametric Evaluation. European Journal of Radiology, 84, 1269-1276.

Appendix IV

Availability of Short-Lived Radiopharmaceuticals

Unlike the radiopharmaceuticals used in other nuclear medicine modalities which produce lower-energy emissions but which last hours to a day or so, the materials used in PET have "half-lives" measured in minutes. A "half-life" is the length of time in which one-half of the radioactive material will have decayed to another, usually inert, state. FDG, an analog of glucose and the primary agent used in the majority of PET studies, has a half-life of 110 minutes. Carbon-11, another agent used in some studies, has a 20-minute half-life. The following table shows how the hypothetical radioactivity of FDG declines with time:

Time From FDG Creation	**Hypothetical Dose**
0 minutes	16 units
110 minutes (1 hr. 50 min)	8 units
220 minutes (3 hr. 40 min)	4 units
330 minutes (5 hr. 30 min)	2 units
440 minutes (7 hr. 20 min)	1 unit

Thus, FDG effectively cannot be stored beyond a day. Carbon-11 functionally has to be supplied within one hour.

Radiopharmaceuticals are produced in large systems called cyclotrons. While less complex than in the past, Cyclotrons still cost 1 to 2 million dollars to buy and cost around a million dollars per year to operate. The region's current PET scanners generally are obtaining FDG from an Albany cyclotron, requiring 3 or more hours travel time to the Rochester or Elmira PET scanners. There are at least two cyclotrons in Buffalo. One independent company installed a cyclotron in Rochester in 2005, but to date it is only utilized by one provider. To date the potential clinical impact of a Rochester-based cyclotron has not been achieved, but short-lived radiopharmaceuticals should be more readily available, facilitating local use of PET techniques which require such materials.