Feasibility Study for an Evaluation of the In Vivo Cellular and Molecular Imaging Centers Program

Final Report

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Table of Contents

I. Introduction

Purpose of the Feasibility Study

The purpose of the Feasibility Study was to explore whether an Outcome Evaluation of the In Vivo Cellular and Molecular Imaging Centers (ICMIC) Program is both warranted and feasible, and, if warranted and feasible, to make recommendations regarding the design of the Outcome Evaluation.

About the ICMIC Program

The In Vivo Cellular and Molecular Imaging Centers (ICMIC) program is one of several specialized initiatives administered through the National Cancer Institute (NCI) Division of Cancer Treatment and Diagnosis (DCTD) Cancer Imaging Program (CIP). The ICMIC program is intended to capitalize on the extraordinary opportunity for molecular imaging to have an impact on the diagnosis and treatment of cancer patients non-invasively and quantitatively. Molecular imaging technologies can provide valuable laboratory tools for the interrogation of biological pathways relevant to cancer, as well as to provide imaging agents and technologies that will be directly utilized in the clinic. ICMICs are funded through the P50 Specialized Center mechanism. NCI also supported pre-ICMIC P20 Exploratory Awards that provide time and funds for investigators and institutions to prepare themselves, organizationally and scientifically, to establish an ICMIC. The P50 ICMIC award is for 5 years, with annual spending restricted to $2,000,000. A total of eight ICMICs have been established: three in 2000; two in 2002; two more in 2003; and one in 2005. Total program funding between FY2000 and FY 2006 has been $82.6 million. Additionally, a total of 16 three-year pre-ICMIC P20 planning grants were awarded; four (half of the total ICMIC awardees) have since gone on to successfully apply for and establish a full ICMIC.

The current goals of the ICMIC program are to:

1. Stimulate, facilitate and enhance high-quality research in the interdisciplinary research area of cancer imaging;
2. Direct cancer imaging research towards bettering imaging technologies that have potential clinical or laboratory applications;
3. Provide unique training and cross-training experiences for cancer-imaging researchers;

4. Support the formation of vibrant, multi-disciplinary communities of cancer imaging researchers at grantee institutions;
5. Enable the acquisition of physical infrastructure to facilitate cancer imaging research;
6. Build sufficient organizational infrastructure at ICMIC institutions to effectively coordinate cancer imaging research.

ICMIC awardees carry out these goals by providing:

- an organizational structure to facilitate efficient multi-disciplinary interactions to the betterment of molecular imaging technologies with eventual clinical impacts.
- funding for multiple simultaneous multidisciplinary research endeavors similar in scope to an R01 or P01 subproject.
- specialized resource facilities and services which lower the barrier of adopting highly cross-disciplinary techniques and technologies; providing ready access to expertise, equipment and reagents.
- availability of feasibility funds to test new ideas that are too immature to obtain traditional funding through other mechanisms such as R01s.
- specialized cross-disciplinary career development programs for both new and established investigators.

Additional information concerning the current program mission and goals (a program announcement released in 2006 is intended to change the program's implementation in future years) is available in PAR-04-069.

II. Activities and Methods

In order to determine whether an Outcome Evaluation was warranted and feasible, the Science and Technology Policy Institute (STPI) engaged in the following activities:

- **Consulting with Cancer Imaging Program staff,** including the ICMIC program officer and the CIP director.
- **Developing a provisional logic model** that describes the inputs, activities, outputs, outcomes, impacts, and external influences of the ICMIC program as currently

understood. It is fully expected that the logic model will be further developed and refined as part of a ICMIC Outcome Evaluation, should one occur.

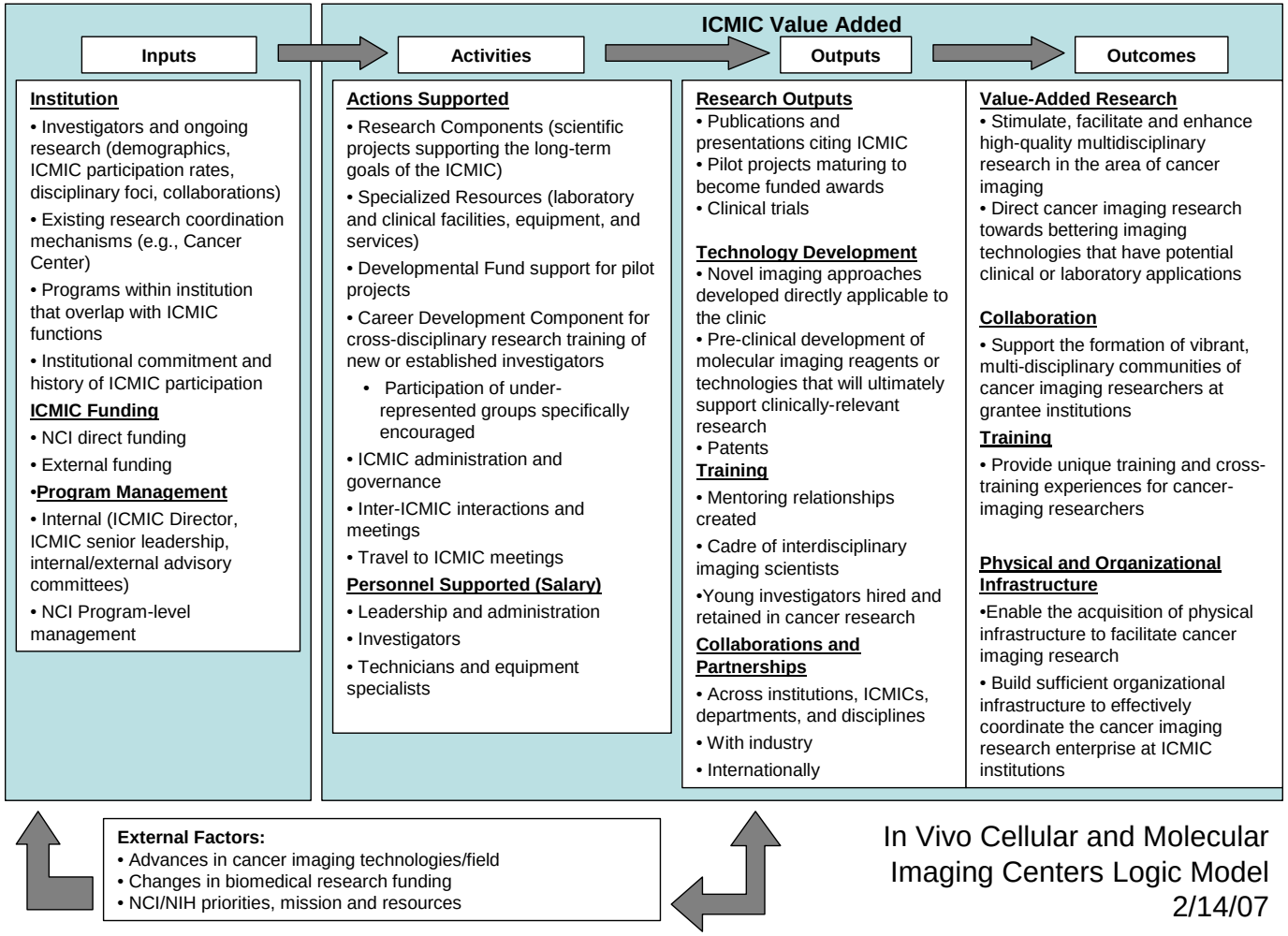
- **Reviewing and analyzing existing data on the ICMICs and potential comparison groups,** including all of the following:
    - RFAs, application and award data, and other historical documentation
    - Publications attributed to the program, compiled through a MEDLINE search and from program records
    - MEDLINE searches for "cancer imaging" publications of US institutions to assess the extent to which cancer imaging-related publications at ICMIC institutions were ICMIC-citing and to identify potential comparator institutions
    - Annual Progress Reports submitted by ICMIC Principal Investigators
    - Patent searches for patents by ICMIC-designated key investigators
    - Compilation of "imaging-related" clinical trials in the United States
- **Development of an Outcome Evaluation design.** Insights gained from the activities and analyses described above were used to decide that an outcome evaluation was feasible and warranted, and to develop recommendations for an Outcome Evaluation study design, including the following componentsInsights gained from the activities and analyses described above were used to develop recommendations for an Outcome Evaluation study design, including the following components:
    - Framework and overall approach
    - Study questions
    - Recommended metrics
    - Recommended data sources
    - Appropriate analytic methods

III. Development of the Program Logic Model

Reviews of administrative documents (e.g., the program RFA, application records) and discussions with CIP program staff were used to generate a program logic model (shown below as Figure 1) that was iteratively updated throughout the Feasibility Study. The logic model identifies critical inputs to the program (e.g., pre-existing capabilities at ICMIC institutions,

program management, funding for cancer imaging research), activities of awardees (e.g., Research Components, Specialized Resources, training activities), and ouputs and outcomes of those activities. Once the feasibility and necessity of pursuing an outcome evaluation was determined, the logic model served as the basis for generating study questions during the evaluation design phase.

Figure 1: Preliminary Logic Model for ICMIC Program



IV. Findings

Key Feasibility Study Results

Publication Analysis

Publications were identified through two sources: A MEDLINE search based on SAIR and ICMIC award numbers, conducted on August 8th, 2006, and electronic lists of publications provided by the ICMIC program officer in August 2006.[1] Lists were cross-checked to identify duplicates, remove non-MEDLINE-indexed publications (e.g., presentations, book chapters), and to standardize information provided in the electronic lists (e.g., missing PubMed ID numbers or publication dates).

The information was compiled into two databases (schema for main publications database shown as Appendix A, schema of citation database shown as Appendix B) and analyzed the publication information to identify:

- Institution of corresponding author (calculated from the MEDLINE "Affiliation" field)
- Identification of whether the institution was a SAIR institution or ICMIC or not (based on the list of SAIR and ICMIC grantees)
- Standardization of citation information (using CRISP searches for award numbers as necessary)

Counts of Publications

Of those publications, 105 are review articles, comments, or reports from conferences/meetings. For the purpose of the publication counts, only the 689 journal articles are reported below. Table 1 shows that there are 353 ICMIC publications, of which 239 (68%) are ICMIC-only, and 114 (32%) cite at least one ICMIC and one ICMIC grant. Of the publications, 287 (81%) were identified by the MEDLINE searches, while an additional 66 publications were identified solely from the records provided by the ICMIC program officer.

[1] As many ICMIC awards are co-located with Small Animal Imaging Research (SAIR) awards and a substantial fraction of ICMIC publications co-cite SAIRs, the ICMIC-SAIR linkage was incorporated into the FS analysis and a joint publication/citation database was created. The combined SAIR/ICMIC publications database includes 794 records.

Table 1: Publications by Program (excluding review articles)

Number of ICMIC publications that are:	
Not SAIR	239 (ICMIC only)
SAIR	114 (Both)
Total	353 (Any ICMIC)

Table 2 shows publications by year of publication date. As would be expected, there is a "ramp-up" period associated with each program. It appears from the table that publication productivity of the ICMICs is continuing to increase, and in 2006 may have exceeded 100 publications per year.

Table 2 – Count of ICMIC publications by year of publication

	2000	2001	2002	2003	2004	2005	2006 (through 8/8)	Total
Publications citing ICMIC (includes joint SAIR/ICMIC publications)	5	19	58	50	62	89	70	353
Number of ICMICs active in year	3	5	5	7	7	8	8	

Table 3 further subdivides publications by individual awardee. Table 3 suggests that there is not a standard pattern of ICMIC publications by institution, and there does not appear to be an average number of publications per ICMIC-year. Table 3 suggests that mature ICMICs average approximately ten publications per year (with Harvard an outlier high and University of Missouri an outlier at the low range); 15 publications (4% of ICMIC publications) listed as ICMIC-affiliated list 12 distinct non-ICMIC institutions (none international) as the corresponding author.

Table 3 – ICMIC publications by awardee and publication year

ICMIC awardee	2000	2001	2002	2003	2004	2005	2006	Total
Harvard/MGH	4	5	27	13	25	28	23	125
Johns Hopkins	0	0	1	4	5	10	3	23
Michigan	0	0	1	0	2	8	8	19
MSKCC		4	4	6	7	9	3	33
Stanford	0	0	0	1	3	7	17	28
UCLA		8	15	11	6	8	7	55
University of Missouri	0	0	1	2	4	5	4	16
Washington University	1	1	6	10	8	9	3	38
12 other institutions (plus one unknown)	0	1	3	3	1	5	2	15

Note: Highlighted years are those where ICMICs have been active – publications previous to start year may include pre-ICMIC publications designated as "ICMIC"

Table 4A shows journals in which ICMIC-affiliated articles have most often been published. Top journals include a mix of imaging-specific journals (e.g., Journal of Nuclear Medicine, Magnetic Resonance Medicine, Molecular Imaging), cancer journals (e.g., Cancer Research, Neoplasia), chemistry journals (e.g., Bioconjugate Chemistry, ChemBiochem) and general science journals (e.g., Proceedings of the National Academy of Sciences). Table 4B shows ICMIC-affiliated publications in "high-impact" biomedical journals. ICMIC publications appear in four of the ten "high-impact" journals -- with most articles in Proceedings of the National Academy of Sciences.

Table 4A – Publications by most common journal

Journal	Number of ICMIC publications (includes joint ICMIC-SAIR)
Cancer Res	29
Bioconjug Chem	28
Proc Natl Acad Sci U S A	25
J Nucl Med	23
Mol Imaging	19
Neoplasia	15
Mol Imaging Biol	11
Mol Ther	10
Chembiochem	9
Magn Reson Med	7
108 other journals	177

Table 4B – Publications by "high-impact journal"

"High-Impact" Journal	ICMIC
Nature	0
Science	2
N Engl J Med	0
Cell	0
Proc Natl Acad Sci U S A	25
J Biol Chem	4
JAMA	0
Lancet	0
Nat Genet	0
Nat Med	6

Note: List of "high-impact" journals taken from, Journal Status, Johan Bollen, Marko A. Rodriguez, and Herbert Van de Sompel, May 17, 2006. http://www.arxiv.org/PS_cache/cs/pdf/0601/0601030.pdf

Analysis of Awards Co-Cited With ICMIC Awards in Publications

For the purpose of this section, all 794 published articles in the ICMIC/ICMIC publications database were considered;[2] of the 794 publications, 707 cited one or more awards; nearly half (87 of 191 or 46%) of the publications identified through program officer-provided electronic lists did not include any citing awards. One use of citation data is to identify cross-citations between ICMIC publications and other NCI programs. Table 5 shows cross-citations associated with the ICMIC publications.

Tables 6A and 6B show co-citations of non-NCI awards for the ICMIC publications in the database. Table 6A suggests that ICMIC-non-NCI award co-citation is broad, whether in terms of the number of publications that cite non-NCI awards (101 of 330 ICMIC publications which had award citations or 31%) or the number of individual awards and citations cited. Table 6B considers co-citations by individual IC. The table shows that NHLBI and NIBIB awards are most likely to be co-cited with ICMIC awards.

[2] Note that 87 of the 105 review articles did not include citations; it was not feasible, however, to separate the citations of the remaining 18 from the citation analysis, and so they are included in the following section.

Table 5 – Award Co-citations between ICMIC and other NCI awards

Program	Award co-citations between ICMIC and:	Comments:
SPORE	12	6 of ICMIC-SPORE co-citations are UCLA ICMIC (2 with UCLA lung SPORE, 4 with UCLA prostate SPORE)
Cancer Center Support Grants	10	5 of ICMIC co-citations are UCLA
EDRN	0	None identified
NTROI	0	None identified
Mouse Models	4	3 co-citations are UCLA
Cancer Nanotechnology	1	New program – Harvard/MIT CCNE with Harvard/MGH ICMIC
Training (T32)	26	Mostly Harvard/MGH, UCLA
Training (K-series)	6	
Research (R01)	171	Mostly UCLA, MSKCC, Harvard/MGH
Research (P01)	50	Mostly Harvard/MGH, Michigan
Research (R21)	22	Predominantly Harvard/MGH
The Washington University radiolabeling R24	6	Mostly with Washington U ICMIC
Multiple awardees within program	0	No publications citing support from two or more ICMICs
Number of individual publications with citation data	330	
Total individual NCI awards cited	248	

Note: Such analyses likely understate collaboration, as not all publications include award citations and not all PIs are consistent in citing grants.

Table 6A: Award Co-Citations between ICMIC and non-NCI awards summary

Measure	Number
Publications citing any non-NCI awards	101
Distinct awards cited	106
Number of non-NCI award citations	174

Table 6B: Award Co-citations between ICMIC and non-NCI awards by non-NCI Institute or Center

IC	Number of individual awards from IC co-cited with ICMIC	Number of times those awards are co-cited with ICMIC
NCRR	6	7
NEI	2	10
NHGRI	1	1
NHLBI	28	45
NIA	3	3
NIAAA	1	1
NIAID	11	17
NIAMS	2	3
NIBIB	12	31
NICHD	4	4
NIDA	1	1
NIDDK	8	14
NIGMS	15	19
NIMH	3	3
NINDS	9	15

Table 7 adopts a different perspective, looking at award co-citation patterns from an institutional perspective, focusing on the publications of individual ICMICs. The University of Michigan and Stanford often co-cite between ICMICs and non-NCI awards, while MSKCC, UCLA, and Harvard/MGH were less likely to do so. Progress reports were read to identify the extent to which these co-citation trends are replicated in the written descriptions.

Table 7: Non-NCI Award Co-citation patterns of ICMIC awardee institutions

ICMIC	Number of times non-NCI awards are co-cited with ICMIC	Total ICMIC publications (from Table 3)	Non-NCI award citations per ICMIC publication
Harvard	50	125	0.4
Johns Hopkins	16	23	0.7
Michigan	28	19	1.5
MSKCC	3	33	0.1
Stanford	57	28	2.0
UCLA	11	55	0.2
University of Missouri	11	16	0.7
Washington University	36	38	0.9

Progress Report Analysis

Identification of Participants – Key Personnel, Total Participation, and Trainees/Career Development Awardees

ICMIC progress reports for the last available fiscal year (FY 2005) were mined to identify named personnel, which were collected into a participant database. The ICMIC awardees vary substantially in their definition of "key" personnel: the number of co-PIs, project leaders, and co-investigators, for example, ranges from 5 to 18 in the ICMICs. Furthermore, it is difficult to define the boundary of "all" personnel involved in an ICMIC award – in addition to the key personnel and the personnel (e.g., technicians, biostatisticians) directly employed using the ICMIC award, many investigators across institutions use ICMIC-supported facilities.

Lists of participants in formal training activities (e.g., postdocs, fellowships) and career development awardees were identified from the progress reports and compiled into a database. Lists of ICMIC-supported career development project participants appear to be complete and useful for the identification of recipients for tracing of outcomes of these training activities. Lists of developmental projects appear to be complete, but outcome data (e.g., whether project resulted in new ICMIC project or grant application) is not generally available and would need to be explored during an outcome evaluation. Documentation of ICMIC informal training activities (e.g., workshops, seminars, rotations through imaging laboratories) in progress reports was highly variable; it would be necessary to collect additional data (likely working with PIs) to identify participants in these activities.

As the ICMIC program goals include multidisciplinary research, collecting discipline/department information will be necessary; much initial data can be gleaned from the progress reports and Internet searches of institutions' directories, but additional information (e.g., CVs) would be valuable to collect for a full assessment of the degree to which interdisciplinary/multi-disciplinary research occurs.

Identification of Resources Generated

Lists of products and resources generated were compiled from the progress reports. ICMIC awardees are variable in their description of the resources or technologies that have been generated through their projects and institutions. To fully assess the translational research outputs and outcomes of ICMIC awardees and their institutions, additional data collection (e.g., through interviews) would be required.

Identification of ICMIC-Supported Infrastructure and Capabilities Provided

A list of ICMIC-supported imaging systems (e.g., PET, SPECT, MRI systems) and supporting tools (e.g., mini-cyclotrons for radiolabeling) was created using ICMIC progress report information. While progress reports appear to provide complete listings of physical infrastructure supported, they are more variable in discussing the capabilities provided by those systems and how they are used by ICMIC investigators. Assessment of capabilities would require additional data collection (e.g., from interviews with ICMIC investigators).

External Data Collection

MEDLINE Search for "Cancer Imaging" Publications

PubMED's E-Utils service was employed, in combination with further scripting techniques, to automate PubMED queries that would be otherwise too time consuming to reasonably collate. A "cancer imaging" query[3] was defined to identify publications that used imaging techniques in cancer research, and applied to general cancer research journals (e.g., *Cancer Research, Clinical Cancer Research*) and to imaging journals (e.g., *Journal of Nuclear Medicine, Molecular Imaging*) to assess the feasibility of identifying:

- The overall rate of growth in "cancer imaging" research publications as compared with the growth of all cancer research publications
- The fraction of an institution's "cancer" research that was "cancer imaging"
- The fraction of an institution's "cancer imaging" research that was ICMIC-identified and;
- Whether there were non-ICMIC institutions with "cancer imaging" strengths comparable to ICMIC institutions.

The feasibility analysis showed that:

- The rate of growth in the number of "cancer imaging" publications was on average 7% per year between 1997-2005, considerably higher than the overall growth in cancer research publications (5% per year 1997-2005).

[3] Cancer Imaging publications were defined as matching this query: "((Diagnostic Imaging OR Immunoassay OR Photometry OR Diagnostic Techniques OR Radioisotope OR Luminescent Proteins OR Luminescence OR biosensing techniques OR Fluorescent Dyes OR Positron Emission Tomography) AND (Cancer[SB]))"

- The twenty institutions[4] with the largest number of "cancer imaging" publications included all but one of the current ICMIC institutions (University of Missouri, Columbia). From the standpoint of overall "cancer imaging" publications, potential non-ICMIC comparator institutions include both large academic medical centers (e.g., MD Anderson, the University of Pennsylvania, UCSF, University of Pittsburgh) and hospitals with research strengths (e.g., Beth Israel Deaconess Medical Center, Brigham and Women's Hospital, Mayo Clinic).
- Based on PubMED identification numbers, the percentage of an institution's "cancer imaging" publications that cited the ICMIC award number could be determined.
- ICMIC-affiliated publications were focused on "cancer imaging." An average of ~79% of ICMIC affiliated-publications were "cancer imaging" related, ~20% involved "cancer" but not "imaging", and a few focused solely on imaging but were not cancer-related. Across all of the PUBMED search, only ~18% of the "cancer" publications were identified as "cancer imaging" related.
- In order to assess the institutionalization of cancer imaging at ICMIC institutions, the fraction of an institution's research publications that matched the "cancer imaging" query could be determined. On average between 1997 and 2005, 9% of ICMIC institutions' total cancer research publication count match the "cancer imaging" query. Exploration of several potential comparators (MD Anderson, UCSF, and Vanderbilt) revealed an average of 10% of their total cancer research publications also matched the "cancer imaging" query.
- Of the eight ICMIC institutions, the percentage of "cancer imaging" publications in 2005 that cited the ICMIC award varied between 6% for University of Misouri and 17% for MSKCC – for the eight institutions combined, the average was 10%.

[4] M.D. Anderson Cancer Center, Johns Hopkins, National Cancer Institute, UCLA, University of Pennsylvania, Massachusetts General Hospital, Stanford University, University of Michigan, Memorial Sloan-Kettering Cancer Center, University of California San Francisco, Washington University, University of Pittsburgh, Mayo Clinic, University of Washington, Duke University, Beth Israel Deaconess Medical Center, Vanderbilt University, University of Wisconsin, Brigham and Women's Hospital, Case Western Reserve University

Identification of Other Imaging Research (e.g., R01s, P01s) at ICMIC and non-ICMIC Institutions

The National Cancer Institute Cancer Research Portfolio (CRP, http://researchportfolio.cancer.gov/) was searched to identify NCI-funded awards with "imaging" characteristics.[5] The search identified current awards (as of August 2006) and awards active in FY 2000 (for an assessment of NCI-funded imaging awards at the "baseline" as the ICMIC program was beginning). One use of the search was to identify institutions that may be potential comparators. The twenty institutions with the largest number of "significant" imaging-related awards (e.g., R01, P-series, U-series) included seven of the eight ICMICs (again, all but University of Missouri, Columbia), large academic medical centers (e.g., University of Pennsylvania, Duke, UCSF, University of Washington, MD Anderson) and a research hospitals (Mayo Clinic).[6]

Comparing the "top 20" institutions with imaging awards currently active with those having imaging awards in FY 2000 suggests that there is substantial consistency – seventeen institutions were on the "top 20" list in both years (all but Northwestern, UC Davis, and University of Wisconsin from the FY 2005 list).

These data can be used for several purposes:

- Identification of "imaging" PIs at ICMIC institutions who are not identified as ICMIC participants
- Identification of "imaging" PIs at non-ICMIC institutions
- Identification of institutions with imaging strength as potential comparators

Patent Searches

Patent searches (using PatentLens) were performed for the ICMIC key investigators described above, identifying all patents with one or more ICMIC key investigators as authors. Patents were coded to determine whether they appeared to be ICMIC-related

[5] CRP search: Special Interest Category = "Molecular Imaging" OR "Diagnostic Imaging" OR "Magnetic Resonance Imaging"

[6] In descending order, "top 20" were: University of Pennsylvania; Duke University; Sloan-Kettering Institute for Cancer Research; Massachusetts General Hospital; University of Michigan at Ann Arbor; University of California San Francisco; University of Washington; Washington University; Stanford University; Johns Hopkins University; University of Chicago; University of Texas MD Anderson Cancer Center; University of Pittsburgh at Pittsburgh; University of Arizona; University of California Los Angeles; University of California Davis; Dartmouth College; Northwestern University; University of Wisconsin Madison; Mayo Clinic College of Medicine, Rochester

(e.g., application filed after ICMIC award, related to cancer imaging. Patent searches can identify inventions by ICMIC investigators during the timeframe awards were active– but were not able to identify which resources were specifically "ICMIC-influenced", as few patents cite the ICMIC award in their application. The patent searches revealed that imaging agents, diagnostic techniques, and new imaging tools/instruments were more likely to be idenitifed through the patent searches than were software algorithms or protocols for using/optimizing imaging tools.

Clinical Trials Search

Imaging-related clinical trials with one or more sites open in the United States (both currently accruing patients and closed to accrual) were downloaded from clinicaltrials.gov.[7] Trials were coded to identify whether the lead institution was a ICMIC institution; the trial PI was a ICMIC key investigator; and used trial descriptions to identify whether imaging was listed in the protocol rationale or design or whether a ICMIC-generated resource or finding was directly incorporated into the trial.

The clinical trials search was successful in identifying whether ICMIC institutions/key participants were involved in leading trials. One ICMIC key investigator (Sam Gambhir – Stanford ICMIC PI) was identified as an imaging trial PI. As might be expected given the design of the ICMIC program, this method proved less successful in identifying resources, techniques, or protocols that have been incorporated into the design of clinical trials. The Stanford trial is of [18]FHGD – a UCLA ICMIC-developed agent; progress reports suggest that several other agents were close to trials as well.

Identification of Other Imaging Infrastructure at ICMIC and non-ICMIC Institutions

STPI assembled multiple sources to identify imaging infrastructure and research at ICMIC and non-ICMIC institutions, including:

- NIH database search (e.g., CRISP) to identify list of core facilities in the Cancer Center and SPORE programs and "translational" P01 awards; and
- Downloads from the Cancer Research Portfolio (identifying awards with "imaging" character as described above)

[7] "Imaging-related" defined by searching clinicaltrials.gov for all trials mentioning, "imaging", which were then coded to assess whether the trial truly used imaging, and the nature of the trial (e.g., new imaging agent, imaging for diagnosis/staging/guide to treatment/assessor of treatment success).

The infrastructure database provided the names of institutions and awards with one or more "imaging-related" core facilities as of FY 2004. In addition to the ICMIC-supported core facilities, several institutions appear to fund "imaging" research capabilities through a variety of mechanisms:

- At ICMIC institutions:
    - Other imaging core capabilities at MSKCC (2 'imaging' P01 cores), University of Michigan ("Digital image processing" P01-funded core; "Tumor Imaging" CCSG-funded core), and UCLA (SPORE-funded core "Imaging Core")
- At non-ICMIC institutions:
    - P01-supported "imaging" cores at Duke, Harvard Medical School, Ohio State, University of Pittsburgh, University of Pennsylvania, University of Washington, Albert Einstein/Yeshiva University
    - Cancer Center Support Grant "imaging" cores at non-ICMIC institutions include Northwestern, Roswell Park, University of Pittsburgh (multiple cores), University of South Florida.
    - Other programs that fund imaging-related core infrastructure include NTROI (Boston University, UC Irvine, University of Pennsylvania) and SPORE (University of Alabama Birmingham)

Nevertheless, with only the names of core facilities – and no information about their size, capabilities, or use – they represent a starting point in identifying imaging infrastructure funded outside the ICMIC program rather than as complete list of capabilities or facilities.

Is a ICMIC Outcome Evaluation Warranted?

It was found that a ICMIC Outcome Evaluation is warranted for the following reasons:

- **The ICMIC program is ripe for an outcome evaluation.** Periodic evaluation is critical to informing program management and strategic priority-setting. The ICMIC program has proceeded through four funding cycles over eight years; a current PA and solicitation of applications is underway for the fifth cycle. There is sufficient record from the awardees of the first three cycles to observe

outcomes. The evaluation would also be timely, as a sixth cycle is intended to begin in FY 2008 and it is hoped that the evaluation could be completed before the close of calendar 2007.

- **ICMIC activities, outcomes and impacts are sufficiently varied and complex that in-depth analysis beyond Feasibility Study is worthwhile.** In constructing a preliminary logic model for the program, the primary goal was to accurately represent the ICMIC program with respect to inputs, activities, outputs, outcomes, impacts and external influences. The Feasibility Study, however, revealed that in-depth evaluation beyond the data collation-based efforts of a Feasibility Study would be required to understand and assess the outcomes of the program to date.
- **The ICMIC evaluation could influence the management of Centers programs across NCI.** ICMIC is one of several P50 Centers programs funded by NCI; the SPORE and Centers of Excellence in Cancer Communications Research also use the P50 Specialized Centers mechanism. An evaluation of one P50 program would provide benchmarks and insights that other programs could use in their own management. Several recently-created multiproject cooperative agreement programs (e.g., Network for Translational Research: Optical Imaging and Centers of Cancer Nanotechnology Excellence) aimed at translating discoveries into new interventions could potentially benefit from the insights of the evaluation as well.

As demonstrated in the preliminary logic model (Figure 1 above), a number of components of the ICMIC program are complex. This indicates that there are likely a variety of questions that could productively be answered by an Outcome Evaluation.

Is a ICMIC Outcome Evaluation Feasible?

STPI concluded that a ICMIC Outcome Evaluation is feasible, but there are significant challenges that must be considered in any successful evaluation design. Findings that support feasibility include the following:

- **Investigator Progress Reports can be used as a primary data source for several critical metrics.** As part of the Feasibility Study, the feasibility of using internal program documents was explored, with particular emphasis on the investigator progress reports. In general, it was concluded that the progress reports can be used as a systematic source of data on participants, core facilities,

and resources generated by the program. The reports also contain a wealth of descriptive and anecdotal data in a variety of other areas that may prove useful in providing context for the evaluation. The results of the analysis of the progress reports are discussed at length below.

- **Additional NIH databases can be used as complementary data sources.** Extensive use can also be made of NIH databases, particularly for program inputs and outputs. The two explored in depth as part of the Feasibility Study were the Cancer Research Portfolio (used to identify other imaging-related awards funded by NCI) and MEDLINE.

Major challenges include the following:

- **The choice of the unit of analysis for the evaluation is a difficult one.** First, there appears to be significant variation among ICMIC institutions with respect to the extent to which a) ICMIC awards involve all participants in cancer imaging at their institutions; b) the level of non-ICMIC funding for cancer imaging research at their institutions; and c) the integration of ICMIC resources into the larger institutional context (e.g., the role of the Cancer Center or other Centers programs/P01s/R01s in imaging research). Second, the publication analysis and the analysis of progress reports suggest that a substantial fraction of ICMIC publications involve support from multiple sources. Therefore, considering the ICMIC award as the unit of analysis leaves the difficulty of disentangling ICMIC-funded research from other sources of research support of individual ICMIC-participating investigators.
- **Much of the information contained in the progress reports is not suitable as a stand-alone data source for the evaluation.** As described above, the progress reports do contain information that can be used as part of an Outcome Evaluation, but many of the tables and narratives are not currently structured in a manner conducive to systematic reporting.
- **While ICMIC appears to be a prime candidate for a quasi-experimental, intervention-comparison design, the small number of ICMIC awardees and the age of the program suggest that statistical power will not be sufficient to draw conclusions.** On the surface, ICMIC appears to be exactly the type of program amenable to an intervention-comparison design. At the award-comparison level, P50 Centers programs can be compared to each other; the

research performed through P50s can be compared to imaging-related P01s or bundles of imaging R01s. At the institutional level, there are many institutions with strength in cancer imaging that have never received ICMIC (or even pre-ICMIC) awards, suggesting that institutional comparisons may be feasible as well. While substantial Feasibility Study effort was devoted to exploring comparative issues and the utility of quasi-experimental designs, both methodological and practical limitations suggest that a fully-executed quasi-experimental design will not be effective.

V. Recommendations for Design and Execution of ICMIC Outcome Evaluation

Recommended Approach to Evaluation Design

There are three generic families of evaluation design that would ordinarily be considered for evaluation of a program such as ICMIC:

- **Longitudinal** designs focus on changes in a program and its outcomes over time;
- **Cross-Sectional** designs aim to produce a current "snapshot" of a program and its outcomes;
- **Quasi-Experimental** approaches use comparison groups to draw conclusions about effects of the program.

In order to determine the option best suited to the ICMIC Outcome Evaluation, the following four assessment criteria were applied:

1. Potential relevance of results to program and strategic planning;
2. Feasibility of collecting required data;
3. Potential payoff in terms of providing evidence for ICMIC effect that will be compelling to stakeholders;
4. Risk of failure to detect differences and/or produce results that can be interpreted with confidence.

The longitudinal category was eliminated from consideration based on the first criterion; questions about evolution of the program over time would be academically interesting but, because of historical shifts in cancer imaging research and the state of knowledge/clinical practice, it is not clear that the program's past is relevant in moving forward. The advantages and disadvantages of the remaining two approaches for the ICMIC evaluation were then considered more carefully. These are summarized below:

Advantages of Cross-Sectional Approach

- Well-suited to address a broad range of evaluation questions including process and outcome;
- Units of analysis can include the program, institution, and ICMIC as relevant;
- Current state of the program is likely most relevant moving forward.

Disadvantages of a Cross-Sectional Approach

- Evidence linking ICMIC to outcomes would be more qualitative than quantitative;
- Design not well-adapted for rigorous comparisons.

Advantages of a Quasi-Experimental Approach

- When sample size is adequate and appropriate confounders are included in the analysis, provides strong quantitative evidence.
- Comparison groups can be identified, and expectations are that comparisons could be meaningfully stated.

Disadvantages of a Quasi-Experimental Approach

- Since there are 8 current ICMIC institutions and a large number of relevant input variables, statistical power to detect differences will be low;
- Requires extensive new data collection about inputs and outputs at institution level, and much of this information may be unknown to the institutions themselves;
- External comparison institutions may have little incentive to cooperate.

Applying the criteria discussed above, the following matrix (Table 8) was developed:

Table 8: Generic Evaluation Planning and Decision Criteria

Criterion	Cross-Sectional	Quasi-Experimental
1. Relevance of results to program planning	High	High
2. Feasibility of collecting required data	High	Medium
3. Potential payoff in terms of providing evidence for ICMIC effect that will be compelling to stakeholders	Medium to Low	High
4. Risk of failure to detect differences and/or produce results that can be interpreted with confidence	Medium	High

Based on this evidence, it was recommended that the overall approach to the design of the proposed ICMIC Outcome Evaluation should be quasi-experimental (of an intervention-comparison form) in nature. Such an approach would most directly address the fundamental evaluation question of the difference/value added provided by the ICMIC P50 approach relative to other possible mechanisms for funding cancer imaging (e.g., SPORE or imaging P01s for research, R25Ts or T32s for training). Given the risks in the intervention-comparison design, however, the proposed evaluation design is therefore structured to mitigate these risks by employing a "weight of the evidence" approach to identify whether on many or all indicators ICMIC-hosting institutions have superior outcomes to non-ICMIC institutions.

Details of Recommended Design for ICMIC Outcome Evaluation

The details of the recommended evaluation design are discussed at length in the Proposal for Set-Aside Funds, to which this Feasibility Study Report is attached. What follows, therefore, is a brief overview of the design parameters. Please consult the full proposal for additional details.

Unit of Analysis

The main unit of analysis for the ICMIC evaluation will be the grantee or comparator institution (See Table 9A for research comparators, Table 9B for training comparators). The evaluation will focus on all three institutions that received P50 awards only and four of the five institutions[8] that received P20 awards and transitioned to P50 awards (Table 9A, columns A and B). Four of the 11 institutions that received pre-ICMIC P20 awards only (Table 9A, column C) will also be selected for inclusion to address study questions relevant to the pre-ICMIC institutions. For certain outcome variables (e.g., publications) where data can meaningfully be aggregated across institutions, the ICMIC program as a whole will serve as an alternate unit of analysis.

For analysis of variables where type of institution (e.g. large academic medical center, small academic medical center, research hospital) or presence of other large cancer-related awards (e.g. Cancer Center Support Grants) is expected to influence outcomes, the grantee institutions will be divided into sub-groups. Where possible, data will also be collected on comparator institutions in each sub-group, although for reasons identified in the feasibility study and referenced below it will be necessary to employ a "weight of the evidence" approach rather than relying on any particular comparison to make an ultimate judgment about value added. Non-ICMIC institutions with strengths in imaging have been identified (Table 9A, column D), and for certain study questions the P20-only ICMIC institutions can be used as comparators for P50 ICMIC grantees (Table 9A, column C).

There are a small number of institutions (Table 9B) with T32 or R25T training awards that are focused on cancer imaging training (based on the Cancer Research Portfolio search), including three ICMIC institutions and two non-ICMIC institutions. Given the small number of these training awards, comparisons will be attempted, but there may not be sufficient sample size to identify synergies between ICMIC-supported training and other NCI-supported cancer imaging training programs.

[8] Stanford will not be included because its ICMIC transitioned from P20 to P50 in 2005, which leaves insufficient time for outcomes to be seen.

Table 9A: Potential ICMIC Comparator Institutions: Research

A: ICMIC P50 only	*B: Pre-ICMIC P20+P50*	*C: Pre-ICMIC P20 only*	*D: Other institutions with imaging strengths*
Large Academic Medical Centers with Imaging Strength			
• UCLA [a, c]	• Michigan-Ann Arbor [c] • Washington University [c] • JHU [c] • Stanford [b, d]	• University of Pennsylvania [b, c] • Duke [c] • UC San Diego [c] • Vanderbilt [a, c] • UC Irvine [c] • Case Western [c] • UT/SW Medical Center • USC [c]	• UC San Francisco [c] • University of Washington/Fred Hutchinson[c] • University of Pittsburgh [c] • University of Chicago [c] • UNC Chapel Hill [c]
Research Hospitals with Imaging Strengths			
• MGH [b] • MSKCC [a, c]			• Mayo Clinic/Rochester [c] • Beth Israel Deaconess/Boston • MD Anderson [c]
Smaller Academic Medical Centers			
	• University of Missouri-Columbia	• University of Iowa [c] • Indiana U-Purdue [c] • University of Wisconsin-Madison [c]	• Wake Forest University [b, c] • University of Hawaii [c]

Notes:

a Has R25T training award.

b Has T32 training award.

c Has Cancer Center Support Grant.

d Not included in evaluation

Table 9B: Potential ICMIC Comparator Institutions: Training

Group	*Institutions with ICMIC Awards*	*Potential non-ICMIC comparator institutions from Table 9A*
Has R25T	UCLA, MSKCC	Vanderbilt
Has T32	MGH	University of Pennsylvania
Has neither	JHU, University of Michigan, University of Missouri-Columbia, Washington University	Rest of comparison group

Evaluation Design

As described above, the overall approach to the design of the proposed ICMIC Outcome Evaluation will be quasi-experimental, of an intervention-comparison form (as opposed to a pre-post form). The weight-of-the-evidence approach to the recommended intervention-comparison design is recommended for several reasons:

1. First, the small number of ICMIC awards (and the variable influence of ICMIC awards within home institutions) suggests that statistical power may be insufficient to detect differences between ICMIC and non-ICMIC institutions.
2. Second, while it appears feasible to identify comparator institutions, it is not evident that information could be consistently collected regarding independent variables that may influence cancer research and cancer imaging. Examples of important variables for which comparison data are unlikely to be available include number of investigators carrying out research and level of infrastructure and core support.
3. Finally, it may be problematic that ICMIC awards do not necessarily account for a sizable fraction of the cancer imaging research occurring at awarded institutions. To the extent that this is true, it may be difficult to distinguish the impact of an ICMIC award at a given institution.

The design for this study will emphasize documenting a broad range of program activities and outcomes and will attempt to link activities to outcomes through both quantitative and qualitative data collection. However, the ultimate assessment of "value added" will rely more on expert judgment informed by a synthesis of the available evidence rather than econometric comparison for any given outcome measure.

Data Sources

- ***Archival Data Organized:***
    - Publications from ICMIC awardees, ICMIC institutions, and potential comparators (from MEDLINE, ICMIC program staff)
    - Lists of ICMIC key personnel (from ICMIC progress reports)
    - Lists of ICMIC training and career development efforts (from ICMIC progress reports)
    - Lists of resources generated (e.g., imaging databases, new imaging agents) from ICMIC awards (from ICMIC progress reports)
    - Lists of ICMIC-supported infrastructure (from progress reports)
    - Patents by ICMIC key personnel (patent search)

- Imaging-related clinical trials from ICMICs and potential comparators (from clinicaltrials.gov)
- NIH database search to develop inventory of cancer imaging infrastructure

- ***New Data to Be Collected:***
  - Bibliometric data for the MEDLINE –indexed publications collected from ICMICs and comparison institutions (assessment of research quality, interdisciplinarity).
  - Interviews with ICMIC PIs and up to 9 comparator PIs to address issues of translational successes, the development of 'communities' of imaging investigators at ICMIC and comparator institutions, integration of research into clinical trials, and imaging infrastructure and capabilities.
  - Interviews with ICMIC investigators and up to 9 investigators at comparator institutions who are not PIs to addresses issues of the development of imaging 'communities' of investigators, translational success, and integration of research into clinical trials, use of ICMIC-supported imaging infrastructure and capabilities.
  - Interviews with 9 trainees and 9 career development awardees at ICMIC institutions to gain insight into the influence of ICMIC-based training and career development awards, if any, on their research and careers.
  - Curriculum vitae of cancer imaging investigators at ICMIC and comparator institutions (for multi-disciplinarity assessment, training assessment)
  - Expert panel/focus group (for interpretation of results, comparability between ICMIC institutions and non-ICMIC institutions, attribution). The goal of the focus group would be to convene the expert panel supporting the evaluation, along with several ICMIC principal investigators, likely during summer 2007 and potentially linked to a cancer imaging meeting (e.g., the combined AMI/SMI meeting in Providence, Rhode Island in early September 2007) to discuss initial results in advance of the data synthesis and reporting steps.

Appendix C (attached) relates the evaluation's high-level study questions to specific study questions/measures and data sources.

Sampling strategies are necessary for several interview groups, especially:

- Cancer imaging PIs at comparator institutions[9]
- Cancer imaging investigators at ICMIC institutions and comparators
- Recipients of ICMIC training funds

[9] All PIs at ICMIC will be interviewed; interview groups are sufficiently small as to not require OMB clearance.

- Recipients of ICMIC career development funds

As only nine investigators from each group will be interviewed, interview subjects will be chosen from each group listed above in order to maximize representation across a range of key dimensions (e.g. gender, seniority, field of training).

Appendix A: Schema of ICMIC/SAIR Publications Database

Column	Field	Comments
A	Search	MEDLINE Search (ICMIC/SAIR or both) or electronic list (and which)
B	SAIR Publication (STPI Coded)?	Is this a SAIR publication (TRUE/FALSE)?
C	ICMIC Publication (STPI Coded)?	Is this an ICMIC publication (TRUE/FALSE)?
D	Home Institution (STPI Coded)?	Is the institution of the corresponding author a SAIR/ICMIC awardee (TRUE/FALSE)?
E	Institution of Corresponding Author (STPI Coded)	Institution of Corresponding author (coded from column T)
F	PMID	PubMed ID
G	PubModel	Electronic or paper publication
H	ISSN	of journal
I	Volume	
J	Issue	
K	Year	
L	Month	
M	Day	
N	Journal Title	
O	ISO Journal	
P	Medline Journal	
Q	Title	of publication
R	Pages	
S	Abstract	
T	Affiliation	of corresponding author
U	Publication Type	
V	Review (STPI Coded)?	Is publication a review, comment, or meeting report (TRUE/FALSE)?
W	Language	
X	Journal Country	
Y	Keywords	
Z	(Keyword-)Associated Words	
AA	Grant Agency-Grant Number	
AB	Number of References cited	
AC-	Is the author list complete?	
AD	Author information	Three columns per publication (last name, first name and initial, first initials)

Appendix B: Schema of Citations in ICMIC/SAIR Publications Database

Column	Field	Comments
A	Search	MEDLINE Search (from database A)
B	SAIR/ICMIC home institution (STPI Coded)?	Is the institution of the corresponding author a SAIR/ICMIC awardee (from database A, TRUE/FALSE)?
C	Institution of Corresponding Author(STPI coded)	Institution of Corresponding author (from database A)
D	Is NCI?	NCI award (TRUE/FALSE)?
E	Is SAIR?	SAIR (TRUE/FALSE)?
F	Is ICMIC?	ICMIC (TRUE/FALSE)?
G	Is Mouse Models?	MMHCC (TRUE/FALSE)?
H	Is EDRN?	EDRN (TRUE/FALSE)?
I	Is CCNE?	Nanotechnology center (TRUE/FALSE)?
J	PMID	PubMed ID (from database A)
K	As cited grant number	From database A
L	Cleaned grant number	STPI Coded: Standardized as possible
M	IC	NIH IC

Appendix C: Relationship of Outcomes, Study Questions, and Data Sources

Key Questions (s) to be addressed	Information Required	Information Source(s)	Data Collection Methods	Data Analysis Methods	Limitations	Potential Conclusions from Analyses
Has the ICMIC Program affected the **quantity or quality of research outputs** in the area of cancer-related molecular imaging at ICMIC institutions?	Number of imaging publications for ICMIC and comparator institutions	MEDLINE	Download	Descriptive Statistics; Qualitative Analysis	Will not capture multi-institution collaborations	Characterization of ICMIC outcomes
	Impact of imaging publications for ICMIC and comparator institutions	MEDLINE; Citation Data; ICMIC Researchers; Other Experts	Download; Interviews/Focus Group	Bibliometrics; Qualitative Analysis	Will not capture multi-institution collaborations	Characterization of ICMIC outcomes
	Success/of pilot projects funded by ICMIC	Progress Reports; Other Program Documents; ICMIC Researchers; Other Experts	Document Review; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis		Characterization of ICMIC outcomes
	Perceptions of researchers regarding quality/leadership of ICMIC researchers/groups	ICMIC Researchers; Other Experts	Interviews/Focus Group	Qualitative Analysis		Characterization of ICMIC outcomes
	Role of ICMIC in developing research	ICMIC Researchers; Other Experts	Interviews/Focus Group	Qualitative Analysis; Process Tracing; Comparison with non-ICMIC data		Judgment about value added based on weight of evidence

Key Questions (s) to be addressed	Information Required	Information Source(s)	Data Collection Methods	Data Analysis Methods	Limitations	Potential Conclusions from Analyses
Has the ICMIC Program affected **discovery, development, and translation** of imaging-related technologies that will have eventual impact in the clinic or in the laboratory?	Number and type of imaging-related clinical trials associated with the institution	Clinical Trials.gov; Progress Reports; MEDLINE; NIH databases; ICMIC Researchers	Download; Document Review; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis	Data may be incomplete; also may be difficult to attribute	Characterization of ICMIC outcomes
	Number and type of imaging-related technologies in pre-clinical development	Progress Reports; MEDLINE; ICMIC Researchers	Download; Document Review; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis	Data may be incomplete	Characterization of ICMIC outcomes
	Number of imaging-related technologies used in the laboratory associated with the institution	Progress Reports; MEDLINE; ICMIC Researchers	Download; Document Review; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis	Data may be incomplete	Characterization of ICMIC outcomes
	Role of ICMIC in developing translational outcomes	ICMIC Researchers; Other Experts	Interviews/Focus Group	Qualitative Analysis; Process Tracing; Comparison with non-ICMIC data		Judgment about value added based on weight of evidence
Has the ICMIC Program affected the **number and/or the quality of multi-disciplinary collaborations** related to cancer imaging?	Number and identity of ICMIC researchers	Progress Reports	Document Review	(For Use in Identifying Collaborations)	Data may be incomplete	Characterization of ICMIC outcomes
	Number of collaborations including ICMIC researchers	MEDLINE	Download	Bibliometrics	Will capture only collaborations that result in publications	Characterization of ICMIC outcomes
	Characteristics of participants (e.g. fields of training, other NIH support, seniority, etc.)	Curriculum vitae; NIH Databases	Download	CV Analysis; Descriptive Statistics	All CVs may not be available	Characterization of ICMIC outcomes

Key Questions (s) to be addressed	Information Required	Information Source(s)	Data Collection Methods	Data Analysis Methods	Limitations	Potential Conclusions from Analyses
	Goals of collaboration and relative roles of participants	ICMIC Researchers	Interviews/Focus Group	Qualitative Analysis	May not be generalizable to all collaborations	Characterization of ICMIC outcomes
	Investigator perceptions of quality/productivity/ usefulness of collaborations	ICMIC Researchers	Interviews/Focus Group	Qualitative Analysis	May not be generalizable to all collaborations	Characterization of ICMIC outcomes
	Role of ICMIC in developing or enhancing collaborations	ICMIC Researchers; Other Experts	Interviews/Focus Group	Qualitative Analysis; Process Tracing; Comparison with non-ICMIC data		Judgment about value added based on weight of evidence
Has the ICMIC Program led to the creation or enhancement of **multi-disciplinary communities** of cancer imaging investigators at ICMIC institutions?	Career trajectories (or anticipated career trajectories) of ICMIC-affiliated trainees and junior faculty	Progress Reports; NIH Databases; ICMIC Researchers	Document Review; Download; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis	May be too early to measure this outcome	Characterization of ICMIC outcomes
	Mentoring relationships created or enhances	ICMIC Researchers	Interviews/Focus Group	Qualitative Analysis	Unlikely to capture all; will be anecdotal	Characterization of ICMIC outcomes
	Perceptions of researchers regarding community breadth, size, cohesiveness, importance	ICMIC Researchers	Interviews/Focus Group	Qualitative Analysis		Characterization of ICMIC outcomes
	ICMIC role in building community	ICMIC Researchers; Other Experts	Interviews/Focus Group	Qualitative Analysis; Process Tracing; Comparison with non-ICMIC data		Judgment about value added based on weight of evidence

Key Questions (s) to be addressed	Information Required	Information Source(s)	Data Collection Methods	Data Analysis Methods	Limitations	Potential Conclusions from Analyses
Has the ICMIC Program enhanced or built **infrastructure** for cancer-related molecular imaging research at the institutional level?	Existing physical infrastructure related to imaging	Infrastructure Database; Progress Reports; ICMIC Researchers	Document Review; Download; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis		Characterization of ICMIC outcomes
	Users/uses for physical infrastructure	ICMIC Researchers	Interviews/Focus Group	Qualitative Analysis		Characterization of ICMIC outcomes
	Funding sources for physical infrastructure	ICMIC Researchers; Progress Reports	Document Review; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis		Characterization of ICMIC outcomes
	Level of satisfaction with physical infrastructure	ICMIC Researchers	Interviews/Focus Group	Qualitative Analysis		Characterization of ICMIC outcomes
	Number and characteristics of graduate students /fellows/postdocs	ICMIC Researchers; Progress Reports; Curriculum Vitae	Document Review; Download	Descriptive Statistics		Characterization of ICMIC outcomes
	Funding sources for training	ICMIC Researchers; Progress Reports	Document Review; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis		Characterization of ICMIC outcomes
	Level of satisfaction with training opportunities	ICMIC Researchers	Interviews/Focus Group	Qualitative Analysis		Characterization of ICMIC outcomes
	Degree of organizational infrastructure	ICMIC Researchers; Progress Reports	Document Review; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis		Characterization of ICMIC outcomes
	Funding sources for organizational infrastructure	ICMIC Researchers; Progress Reports	Document Review; Interviews/Focus Group	Descriptive Statistics; Qualitative Analysis		Characterization of ICMIC outcomes

Key Questions (s) to be addressed	Information Required	Information Source(s)	Data Collection Methods	Data Analysis Methods	Limitations	Potential Conclusions from Analyses
	Level of satisfaction with organizational infrastructure	ICMIC Researchers	Interviews/Focus Group	Qualitative Analysis		Characterization of ICMIC outcomes
	Role of ICMIC in developing infrastructure	ICMIC Researchers; Other Experts	Interviews/Focus Group	Qualitative Analysis; Process Tracing; Comparison with non-ICMIC data		Judgment about value added based on weight of evidence