Functional MRI (fMRI) workflow in the clinical environment

James Reuss[1], PhD, Cathy Elsinger[2], PhD (co-chair)
[1]Prism Clinical Imaging, [2]NordicNeuroLab

Quantitative Imaging Biomarkers Alliance RSNA

Purpose

The aim of this study, sponsored by the RSNA Quantitative Imaging Biomarker Alliance [1] fMRI section (QIBA-fMRI), was to survey functional MRI (fMRI) practitioners in order to better understand the extent to which there is consistency in clinical practice workflow and methodology surrounding its use. The QIBA-fMRI committee will use the results to inform its creation of a profile for use of fMRI as a quantitative biomarker, particularly regarding recommendations for best practices in clinical workflow. Poll participants have the option of participating in future field testing of the QIBA Profile developed.

Materials and Methods

A general workflow for fMRI consists of the following steps: patient assessment, patient training, testing & acquisition, post-processing, clinical interpretation & reporting, and clinical application (e.g. radiation treatment planning, surgical navigation, etc.) [2] Although fMRI is frequently cited (322,139 results in PubMed as of 1/1/2013), detailed description of clinical fMRI workflow in the literature is very limited [3]. In response, authors designed a poll to assess: a) who is engaged in the various steps of fMRI workflow b); what tools (hardware, software) are used at each step; c) what techniques are employed in fMRI workflow (algorithms, corrections, etc.); d) how resulting mapping is used clinically; and e) what complementary methods (e.g. other imaging) are combined with fMRI to meet clinical needs. A prototype paper poll was circulated among ASFNR fMRI working group members at the 2012 conference. Reception was strongly favorable, and the ASFNR leadership requested broader distribution. Utilizing SurveyMonkey [4], the expanded poll was converted to an online format [5] by RSNA staff, simplifying broader dissemination. Email invitations were sent through ASFNR management to the membership list effective December, 2012.

Results

Paper and online responses were merged and tabulated, with at most one respondent per fMRI facility. Open answer responses were also permitted and recorded. Questions 4-5 shall be referred to hereafter as "Ordering; 6-8 as "Personnel;" 9-11 as "Paradigms;" and questions 13-15 as "Methods."

Of the 36 respondents, 30 (86%) currently conduct clinical fMRI studies, with an average duration of 8 years

Descriptive statistics for Ordering, Personnel, Paradigms and Methods were computed on a site-wise basis as well as weighted by the number of cases performed. The former approach is useful for per-site characteristics such as the types of scanners, software packages, etc., whereas the latter is a more meaningful way to look at the impact of fMRI on the clinical population, and per-patient effort. When comparison revealed interesting differences between the analyses, we divided the poll results into low-census and high-census groups (less than or equal versus greater than the median # cases performed per year = 45).

Most exams are ordered for mapping of tumor cases, followed by epilepsy (Fig 1), though high-census sites showed more ordering for other reasons (16%) versus low-census sites (4%). In the high-census sites, more ordering takes place by non-neurosurgeons. Mapping is primarily of motor and language areas.

Neuroradiologists and MR technologists are conducting the majority of patient training and exams, with physicists contributing primarily to post-processing of image data. In high-census sites, neuroradiologists perform substantially less patient training and testing by neuroradiologists, with an overall larger role played by physicists and other personnel (Fig. 2).

High-census sites tended to employ a wider variety in Paradigm types (e.g. Memory/Cognitive and Vision); however, the number of paradigms performed per type was almost the same (Fig. 3). The frequency of other scans used are about the same (Fig. 4). but interestingly, lower-census sites were more likely to perform tractography than high-census sites (with the reverse true of DTI in general), Other differences in Methods may be due to differences in the hardware and software employed. High-census sites were more likely to export fMRI activation maps for surgical navigation and other reasons.
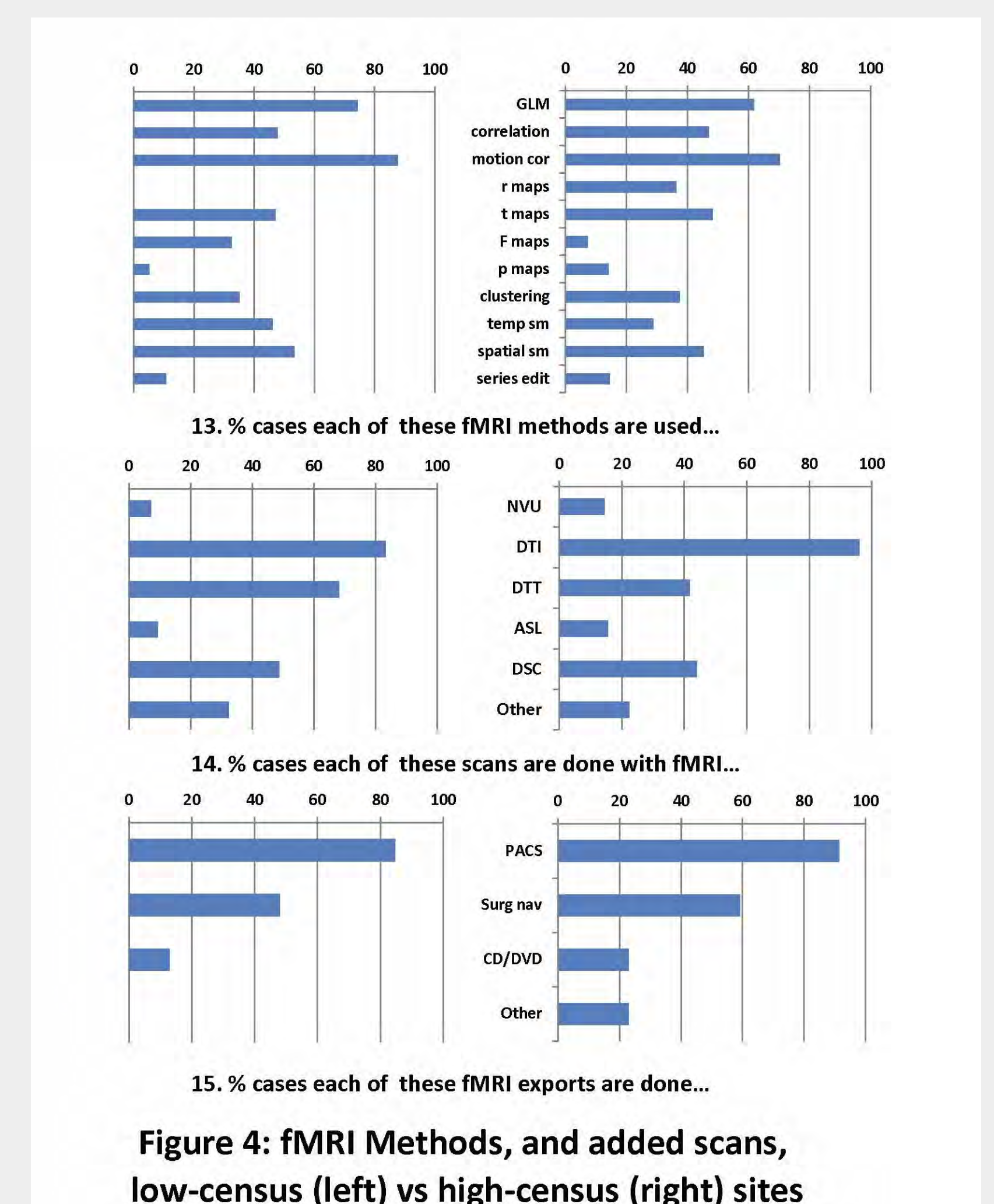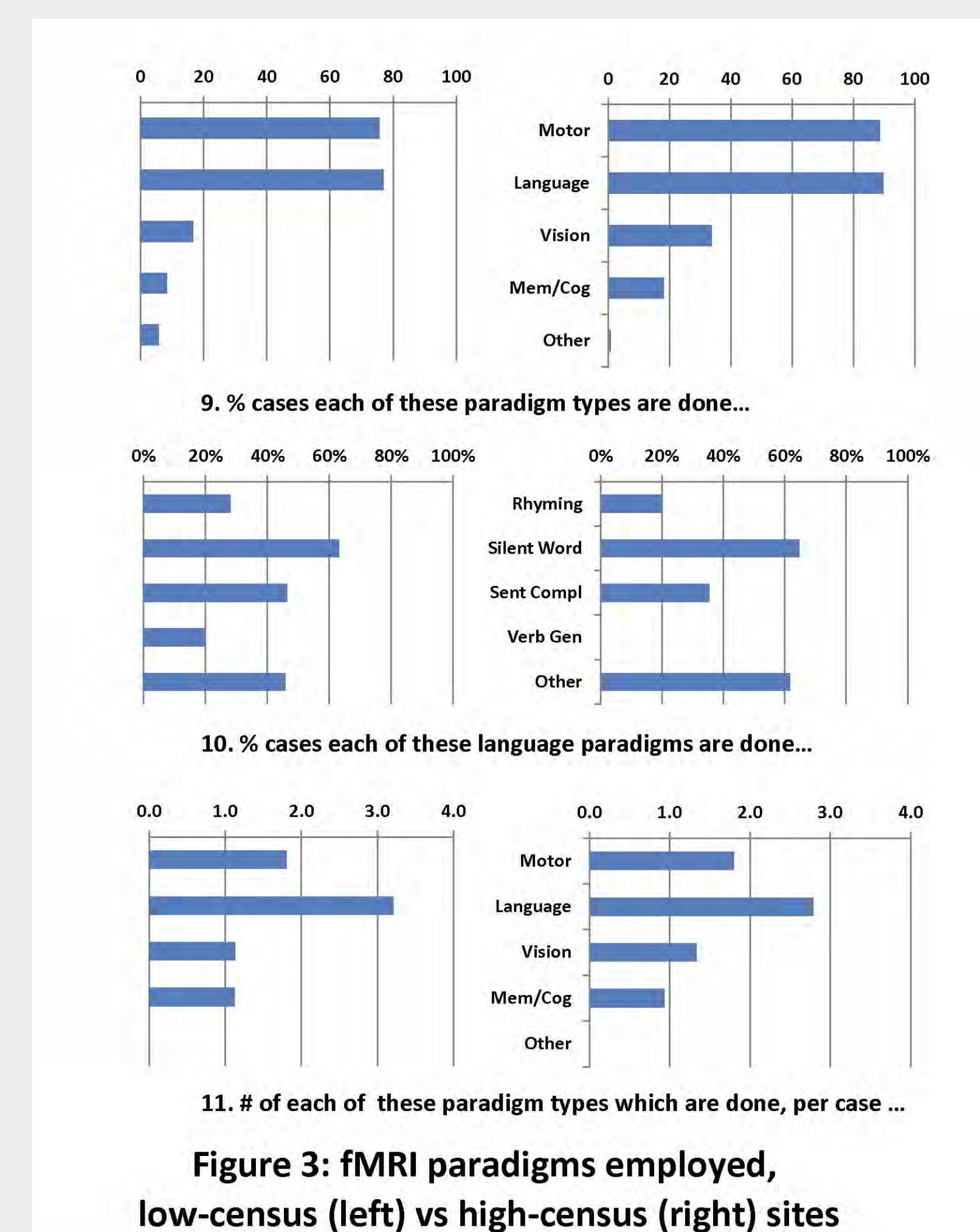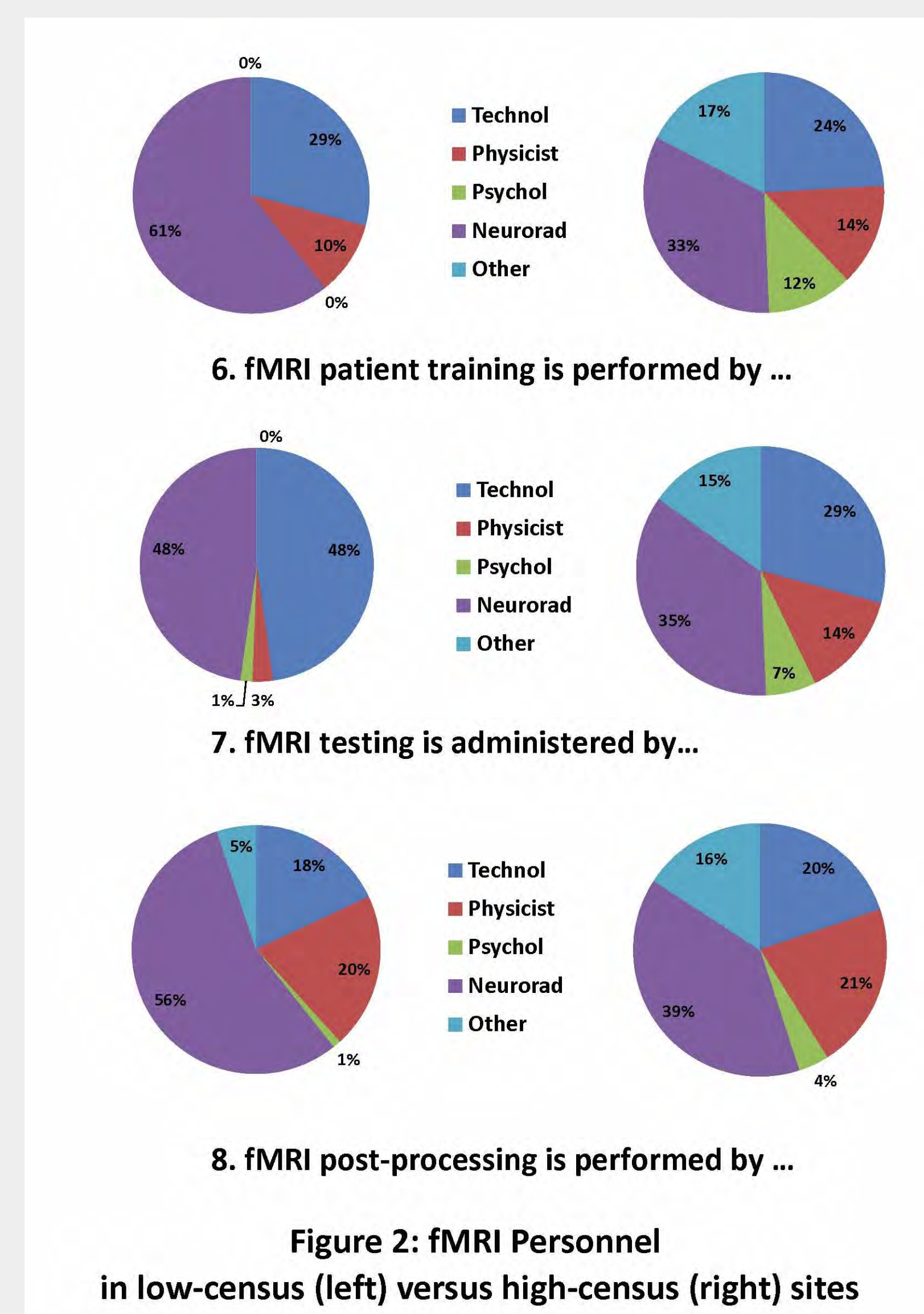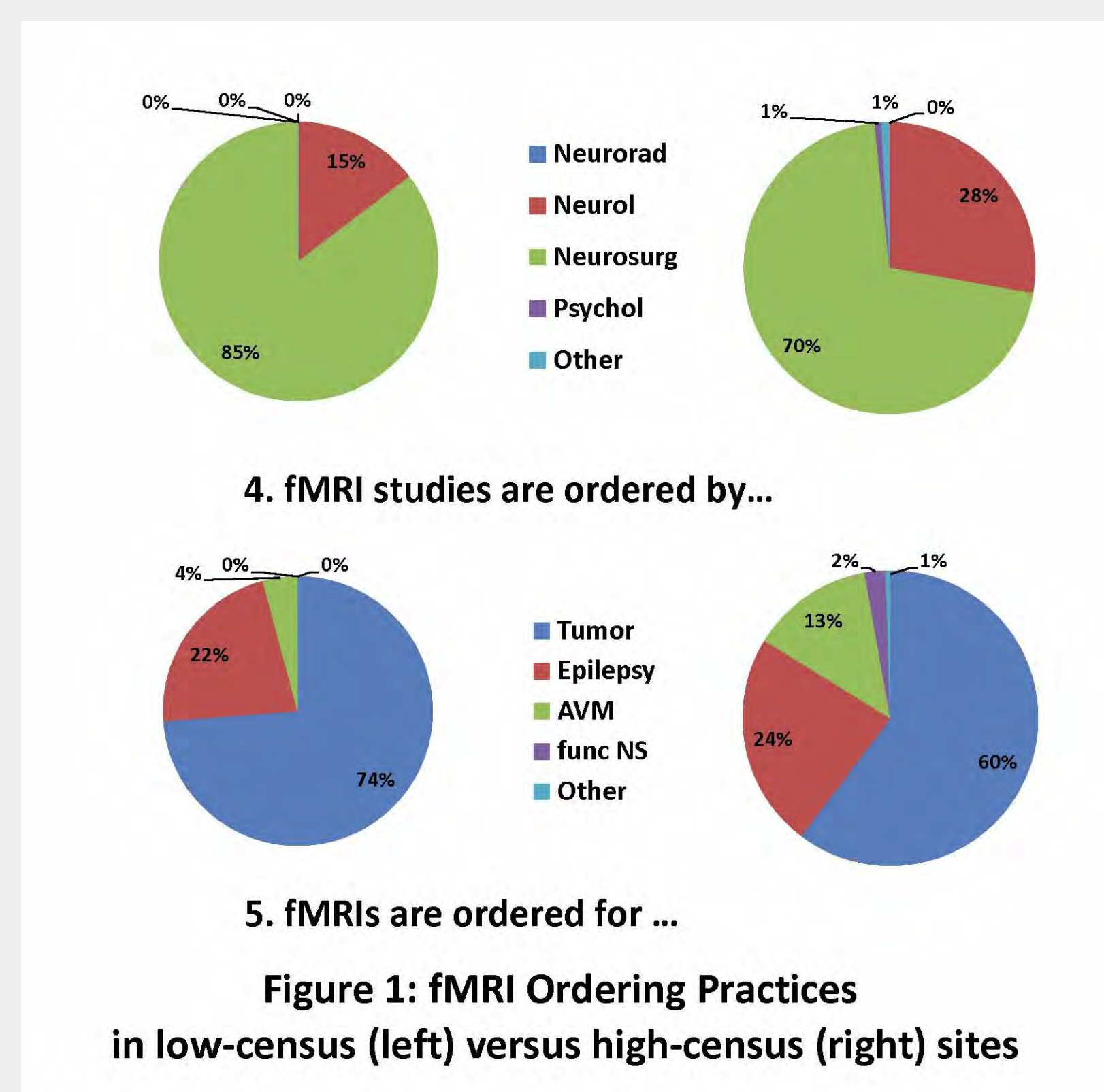
Discussion

As fMRI becomes standard of care for many centers, best practice guidelines are crucial to enhance not only workflow for staff, but exam quality for optimal results and best patient care. The information provided by this survey will inform our QIBA profile development and eventual distribution of a set of guidelines for users and industry – providing tools and methodology for achieving reliable and reproducible fMRI exams.

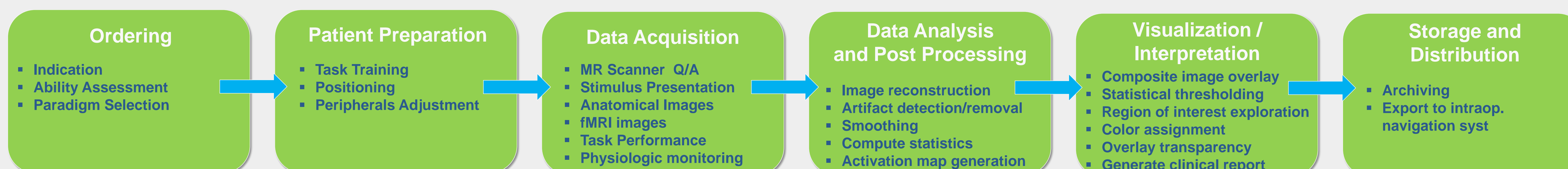Readers are invited to complete the poll (see "Please Participate!").

1. http://qibawiki.rsna.org/index.php?title=Main_Page
2. http://qibawiki.rsna.org/index.php?title=FMRI_tech_ctte#Workflow_Documents
3. Using the strategy: "Magnetic Resonance Imaging"[Mesh] AND (functional[All Fields] OR "fmri"[All Fields]) AND (workflow[All Fields]) AND ("humans"[MeSH Terms] AND English[lang])
4. http://www.surveymonkey.com/
5. http://www.surveymonkey.com/s/QIBA_fMRI_Workflow_Poll

Figure 1: fMRI Ordering Practices in low-census (left) versus high-census (right) sites

4. fMRI studies are ordered by...
5. fMRIs are ordered for ...

Figure 2: fMRI Personnel in low-census (left) versus high-census (right) sites

6. fMRI patient training is performed by ...
7. fMRI testing is administered by ...
8. fMRI post-processing is performed by ...

Figure 3: fMRI paradigms employed, low-census (left) vs high-census (right) sites

9. % cases each of these paradigm types are done...
10. % cases each of these language paradigms are done...
11. # of each of these paradigm types which are done, per case ...

Figure 4: fMRI Methods, and added scans, low-census (left) vs high-census (right) sites

13. % cases each of these fMRI methods are used...
14. % cases each of these scans are done with fMRI...
15. % cases each of these fMRI exports are done...

The Clinical fMRI Workflow

Ordering
- Indication
- Ability Assessment
- Paradigm Selection

Patient Preparation
- Task Training
- Positioning
- Peripherals Adjustment

Data Acquisition
- MR Scanner Q/A
- Stimulus Presentation
- Anatomical Images
- fMRI images
- Task Performance
- Physiologic monitoring

Data Analysis and Post Processing
- Image reconstruction
- Artifact detection/removal
- Smoothing
- Compute statistics
- Activation map generation

Visualization / Interpretation
- Composite image overlay
- Statistical thresholding
- Region of interest exploration
- Color assignment
- Overlay transparency
- Generate clinical report

Storage and Distribution
- Archiving
- Export to intraop. navigation syst

Please Participate!
If your institution does not appear on the list of respondents, you are cordially invited to complete the poll!

Scan the QR code:

Responding as of 3/1/2013
All Children's, St. Petersburg FL   MCW, Milwaukee WI
BIDMC HMS   MSKCC, New York NY
Cedar Sinai MC   Montefiore Einstein
Central Du Page Hospital   NYU, New York NY
Children's Hospital, Philadelphia PA   Oregon Health Sci U
Duke U, Emory U   Ohio State U Col Med
Henry Ford, Detroit MI   U of IA, IL, KY, MI, PA (Shadyside)
Indiana U School of Med   U TN (Le Bonheur), VA
MGH, Boston MA   U UT, WI (Madison)
Mayo, Rochester MN; Jacksonville FL   U Louisville, U Pittsburgh

Or visit http://www.surveymonkey.com/s/QIBA_fMRI_Workflow_Poll