CURRICULUM VITAE
The Johns Hopkins University School of Medicine

Mary Beth Nebel

13 March 2019

Mary Beth Nebel

DEMOGRAPHIC AND PERSONAL INFORMATION

Current Appointments
2015-present   Research Scientist, Center for Neurodevelopmental and Imaging Research, Kennedy Krieger Institute
2016-present   Affiliated Faculty, Wendy Klag Center for Autism & Developmental Disabilities, Johns Hopkins Bloomberg School of Public Health
2017-present   Assistant Professor, Department of Neurology, Johns Hopkins University School of Medicine

Personal Data
Kennedy Krieger Institute
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Education and Training
1998-2002   B.S.E., Biomedical Engineering, Duke University, Durham, NC
Research Advisor: Roger Nightingale
2005-2010   Ph.D., Joint Department of Biomedical Engineering, University of North Carolina & North Carolina State University, Chapel Hill, NC
Dissertation: Functional imaging of central mechanisms underlying human pain perception
Advisors: Gregory Essick & Mark Tommerdahl
2010-2015   Postdoctoral Research Fellowship, Neurology, Johns Hopkins School of Medicine, Baltimore, MD
Focus: Neuorimaging and behavioral methods for investigating sensorimotor deficits in autism
Advisor: Stewart Mostofsky

Professional Experience
2002-2003   Data Technician, Department of Psychiatry, Washington University School of Medicine
2003-2005   Associate in Research, Duke-UNC Brain Imaging and Analysis Center, Duke University
2010-2013   Junior Contract Editor, American Journal Experts
2015-2016   Instructor, Department of Neurology, Johns Hopkins University School of Medicine

PUBLICATIONS:

Original Research [OR]

[1]   Rathnanther J, Wang L, **Nebel MB**, Hosakere M, Han X, Csernansky J, Miller M. Validation of semiautomated methods for quantifying cingulate cortical metrics in schizophrenia. Psychiatry Research. 2004; 132(1): 53-68.

[2]   Selemon L, Wang L, **Nebel MB**, Csernansky J, Goldman-Rakic P, Rakic P. Direct and indirect effects of fetal irradiation on cortical gray and white matter volume in the macaque. Biological Psychiatry. 2005; 57(1): 83-90.

[3]   **Nebel MB**, Sims E, Keefe F, Kraus V, Guilak F, Caldwell D, Pells J, Queen R, Schmitt D. Relationship of self-reported pain and functional impairment to gait mechanics in overweight and obese persons with knee osteoarthritis. Arch Phys Med Rehabil. 2009; 90:1874-79.

[4]   **Nebel MB**, Folger S, Tommerdahl M, Hollins M, McGlone F, Essick G. Temporomandibular disorder modifies cortical response to tactile stimulation. J Pain. 2010; 11:1083-94.

[5] Cascio C, Moana-Filho E, Guest S, **Nebel MB**, Weisner J, Baranek G, Essick G. Perceptual and neural response to affective tactile texture stimulation in adults with Autism Spectrum Disorders. Autism Research. 2012; 5.4:231-244.

[6] Eloyan A, Muschelli J, **Nebel MB**, Liu H, Han F, Zhao T, Barber A, Joel S, Pekar J, Mostofsky S, Caffo B. Automated diagnoses of attention deficit hyperactive disorder using magnetic resonance imaging. Frontiers in Systems Neuroscience. 2012; 6: 61.

[7] Shou H, Eloyan A, Lee S, Zipunnikov V, Crainiceanu AN, **Nebel MB**, Caffo B, Lindquist M, Crainiceanu C. Quantifying the reliability of image replication studies: The image intraclass correlation coefficient (I2C2). Cognitive, Affective, Behavioral Neuroscience. 2013; 13(4): 714-724.

[8] Di Martino A, Yan C, Li Q, Denio E, Castellanos F, Alaerts K, Anderson J, Assaf M, Bookheimer S, Dapretto M, Deen B, Delmonte S, Dinstein I, Ertl-Wagner B, Fair D, Gallagher L, Kennedy D, Keown C, Keysers C, Lainhart J, Lord C, Luna B, Menon V, Minshew N, Monk C, Mueller S, Muller R, **Nebel MB**, Nigg J, O'Hearn K, Pelphrey K, Peltier S, Rudie S, Sunaert S, Thioux M, Tyszka J, Uddin L, Verhoeven J, Wenderoth N, Wiggins J, Mostofsky S, Milham M. The autism brain imaging data exchange: towards a large-scale evaluation of the intrinsic brain architecture in autism. Molecular Psychiatry. 2014; 19(6): 659-667.
Role: Prepared Kennedy Krieger's contribution to the data exchange and contributed to the critical revision of the manuscript

[9] **Nebel MB**, Joel SE, Muschelli J, Barber A, Caffo B, Pekar JJ, Mostofsky S. Disruption of functional organization within the primary motor cortex in children with autism. Human Brain Mapping. 2014; 35:567-580.

[10] *Muschelli J, *+**Nebel, MB**, Caffo B, Barber A, Pekar JJ, Mostofsky S. Reduction of motion-related artifacts in resting state fMRI using aCompCor. NeuroImage. 2014; 96:22-35, 2014.
Role: *contributed equally to all aspects of the manuscript; +corresponding author

[11] Lindquist M, Xu Y, **Nebel MB**, Caffo B. Evaluating dynamic bivariate correlations in resting-state fMRI: A comparison study and a new approach. NeuroImage. 2014; 101:531-46.

[12] Eloyan A, Shou H, Shinohara R, Sweeney E, **Nebel MB**, Cuzzocreo J, Calabresi P, Reich D, Lindquist M, Crainiceanu C. Health Effects of Lesion Localization in Multiple Sclerosis: Spatial Registration and Confounding Adjustment. PloS One. 2014; 9(9): e107263. Role: performed data analysis and wrote parts of the manuscript

[13] **Nebel MB**, Eloyan A, Barber A, Mostofsky S. Precentral gyrus functional connectivity signatures of autism. Frontiers in Systems Neuroscience. 2014; 8:80. doi: 10.3389/fnsys.2014.00080.

[14] Shou H, Eloyan A, **Nebel MB**, Mejia A, Pekar JJ, Mostofsky S, Caffo B, Lindquist M, Crainiceanu C. Shrinkage prediction of seed-voxel brain connectivity using resting state fMRI. NeuroImage. 2014; 102(2): 938-44.

[15] Barber A, Jacobson L, Wexler J, **Nebel MB**, Caffo B, Pekar JJ, Mostofsky S. Connectivity supporting attention in children with Attention Deficit Hyperactive Disorder. NeuroImage Clinical. 2015; 7: 68-81.

[16] Mejia AF, **Nebel MB**, Shou H, Crainiceanu C, Pekar JJ, Mostofsky S, Caffo B, Lindquist M. Improving reliability of subject-level resting-state fMRI parcellation with shrinkage estimators. NeuroImage. 2015; 112: 14-29.

[17] Sharer E, Crocetti D, Muschelli J, Barber AD, **Nebel MB**, Caffo BS, Pekar JJ, Mostofsky SH. Neural correlates of visuomotor learning in autism. Journal of Child Neurology. 2015; 30(14): 1877-1886.

[18] **Nebel MB**, Eloyan A, Nettles CA, Sweeney KL, Ament K, Ward RE, Choe AS, Barber AD, Pekar JJ, Mostofsky SH. Intrinsic Visual-Motor Synchrony Correlates With Social Deficits in Autism. Biological Psychiatry. 2016; 79(8): 633-41.

[19] Floris DL, Barber AD, **Nebel MB**, Martinelli MC, Lai M, Crocetti D, Baron-Cohen S, Suckling J, Pekar JJ, Mostofsky SH. Atypical lateralization of motor circuit functional connectivity in children with autism is associated with motor deficits. Molecular Autism. 2016; 7(1): 35.

[20] Landa RJ, Haworth JL, **Nebel MB**. Ready, set, go! Low anticipatory response during a dyadic task in infants at high familial risk for autism. Frontiers in Psychology. 2016; 7: 721.

[21] Dajani DR, Llabre MM, **Nebel MB**, Mostofsky SH, Uddin LQ. Heterogeneity of executive functions among comorbid neurodevelopmental disorders. Scientific Reports. 2016; 6: 36566. doi: 10.1038/srep36566.

[22] Mejia AF, **Nebel MB**, Eloyan A, Caffo B, Lindquist MA. PCA leverage: Outlier detection for high-dimensional functional magnetic resonance imaging data. Biostatistics. 2017; 18(3): 521-36.

[23]   Di Martino A, O'Connor D, Chen B, Alaerts K, Anderson J, Assaf M, Balsters J, Baxter L, Beggiato A, Bernaerts S, Blanken L, Bookheimer S, Braden BB, Byrge L, Castellanos F, Dapretto M, Delorme R, Fair D, Fishman I, Fitzgerald J, Gallagher L, Jao Keehn RJ, Kennedy D, Lainhart J, Luna B, Mostofsky S, Müller RA, **Nebel MB**, Nigg J, O'Hearn K, Solomon M, Toro R, Vaidya C, Wenderoth N, White T, Craddock C, Lord C, Leventhal B, Milham M. Enhancing studies of the connectome in autism using the Autism Brain Imaging Data Exchange II. Scientific Data. 2017; 4: 170010. doi: 10.1038/sdata.2017.10.
         Role: Prepared Kennedy Krieger's contribution to the data exchange and contributed to the critical revision of the manuscript

[24]   Chen S, Huang L, Qiu H, **Nebel MB**, Mostofsky SH, Pekar JJ, Lindquist MA, Eloyan A, Caffo BS. Parallel group independent component analysis for massive fMRI data sets. PloS One. 2017; 12(3): e0173496.

[25]   Dirlikov B, Younes L, **Nebel MB**, Martinelli MK, Tiedemann AN, Koch CA, Fiorilli D, Bastian A, Denckla MB, Miller MI, Mostofsky SH. Novel Automated Morphometric and Kinematic Handwriting Assessment: A validity study in children with ASD and ADHD. Journal of Occupational Therapy, Schools, Early Intervention. 2017; 10(2): 185-201.

[26]   Choe AS, **Nebel MB**, Barber AD, Cohen JR, Xu Y, Pekar JJ, Caffo BS, Lindquist MA. Comparing test-retest reliability of dynamic functional connectivity methods. NeuroImage. 2017; 158: 155-75.

[27]   Calhoun VD, Wager TD, Krishnan A, Rosch KS, Seymour KE, **Nebel MB**, Mostofsky SH, Nyalakanai P, Kiehl K. The impact of T1 vs EPI spatial normalization templates for fMRI data analyses. Human Brain Mapping. 2017; 38(11): 5331-42.

[28]   Stephens JA, Salorio CF, Gomes JP, **Nebel MB**, Mostofsky SH, Suskauer SJ. Response Inhibition Deficits and Altered Motor Network Connectivity in the Chronic Phase of Pediatric TBI. Journal of Neurotrama. 2017; 34(22): 3117-23.

[29]   Stoodley CJ, D'Mello AM, Ellegood J, Jakkamsetti V, Liu P, **Nebel MB**, Gibson JM, Kelly E, Meng F, Cano C, Pascual JM, Mostofsky SH, Lerch JP, Tsai PT. Altered cerebellar connectivity in autism spectrum disorders and rescue of autism-related behaviors in mice. Nature Neuroscience. 2017; 20(12): 1744-51.

[30]   Mejia AF, **Nebel MB**, Barber AD, Choe AS, Pekar JJ, Caffo BS & Lindquist MA. Improved estimation of subject-level functional connectivity using full and partial correlation with empirical Bayes shrinkage. NeuroImage. 2018; 172: 478-91.

[31]   Rosch KS, Mostofsky SH & **Nebel MB**. ADHD-related sex differences in fronto-subcortical intrinsic functional connectivity and associations with delay discounting. Journal of Neurodevelopmental Disorders. 2018; 10(1): 34.

[32]   Dajani DR, Burrows CA, Odriozola P, Baez A, **Nebel MB**, Mostofsky SH & Uddin LQ. Investigating functional brain network integrity using a traditional and novel categorical scheme for neurodevelopmental disorders. NeuroImage Clinical. 2019; 21, 101678.

Review Articles [RA]

[1]   **Nebel MB**, Gracely R. Neuroimaging of fibromyalgia. Rheum Dis Clin North America. 2009; 35(2): 313-27.

Proceedings Reports [PR]

[1]   Venkataraman A, Wymbs N, **Nebel M**, Mostofsky S. A Unified Bayesian Approach to Extract Network-Based Functional Differences from a Heterogeneous Patient Cohort. In Proc: CNI: International Workshop on Connectomics in NeuroImaging. 2017; 1-8.

[2]   D'Souza NS, **Nebel MB**, Wymbs N, Mostofsky S, Venkataraman A. A Generative-Discriminative Basis Learning Framework to Predict Clinical Severity from Resting State Functional MRI Data. In *International Conference on Medical Image Computing and Computer-Assisted Intervention*, pp. 163-171. Springer, Cham, 2018.

[3]   D'Souza NS, **Nebel MB**, Wymbs N, Mostofsky S, Venkataraman A. Integrating Neural Networks and Dictionary Learning for Multidimensional Clinical Characterizations from Functional Connectomics Data. In *International Conference on Medical Image Computing and Computer-Assisted Intervention*, 2019.

FUNDING

EXTRAMURAL Funding

<u>Current</u>:

5/13/16-4/30/21   Visual Motor Development in Infants at High Risk for Autism
K01 MH109766-01
National Institute of Mental Health
Role: P.I. 100% (12.00 calendar)
This study will investigate developmental patterns of behavior and brain function hypothesized to contribute to impaired acquisition of skills necessary for normal motor and social-communicative development in autism. This work is expected to contribute to a more nuanced understanding of the neurodevelopmental pathways that lead to a diagnosis of autism.

07/1/18-6/30/21   CRCNS Research Proposal: Collaborative Research: Discovering Network Structure in the Space of Group-Level Functional Differences
#1822581
National Science Foundation
P.I. Venkataraman
Role: Co-Investigator; 4.16% (0.50 calendar)
The goal of this project is to discover and characterize brain network architectures in the space of group-level functional differences. This strategy mimics our growing perception of complex neurological disorders as system-level dysfunctions, rather than a collection of isolated effects. We will strategically leverage patient heterogeneity to guide network estimation in three clinical test beds: autism, ADHD, and schizophrenia. *Please note, in years 1-2, and approximately 10 months of the 3rd year, Dr. Nebel's effort and funding support for this project will be subsumed under her K01.*

02/1/19-11/30/22   Bayesian Methods for Cortical Surface Neuroimaging Data
R01 EB027119
National Institute of Biomedical Imaging and Bioengineering
P.I. Mejia
Role: Co-Investigator; 15% (1.8 calendar)
This project will develop advanced statistical methods for cortical surface functional magnetic resonance imaging (fMRI) data, with a focus on computationally efficient Bayesian techniques. Compared with traditional volumetric fMRI, cortical surface fMRI offers superior alignment of subjects' cortical areas and more meaningful spatial modeling through neurologically relevant geodesic distances along the cortical surface. We will apply the proposed methods to study brain-behavior relationships in autism and amyotrophic lateral sclerosis. *Please note, for the first 2 years and approximately 3 months of the 3rd year, Dr. Nebel's effort and funding support for this project will be subsumed under her K01.*

<u>Completed</u>:

7/1/15-6/30/16   Statistical Methods for Large N and P Problems
R01 EB012547
National Institute of Biomedical Imaging and Bioengineering
P.I.: Caffo
Role: Co-Investigator; 25% (3.00 calendar)
The goal of this project is to tailor model-based independent component blind source separation methods to investigate brain-behavior relationships in large, multi-site fMRI data sets from various patient populations, including autism.

7/1/15-4/30/16   Statistical Methods for Mapping Human Brain Development
R01 MH095836
National Institute of Mental Health
P.I.: Reiss
Role: Co-Investigator; 25% (3.00 calendar)

The goal of this project is to develop new statistical methods to compare trajectories of the functional organization of the brain in typically developing children and children with neurodevelopmental disorders, namely autism and attention deficit hyperactivity disorder.

07/1/15-04/30/16   Adolescent Changes in Brain and Behavior in Boys and Girls with ADHD
2 R01 MH085328-10A1
National Institute of Mental Health
P.I.: Mostofsky
Role: Research Scientist; 32% (3.84 calendar)
The goal of this project is to examine developmental changes in brain structure and behavior in girls and boys with ADHD and to examine the impact of these changes on adolescent mental health and other functional outcomes. The findings will help identify risk factors in children with ADHD and could thereby lead to prevention efforts and improved outcomes for children with ADHD.

11/1/12-10/31/14   Understanding the Brain Basis of Impaired Imitation Learning in Autism
7961
Autism Speaks
Role: P.I.; 100% (12 calendar)
The goal of this project is to compare the influence of visual and proprioceptive input on imitation learning in school-age children with autism and to identify patterns of brain connectivity that are related to autism-associated impairments in imitation.

EDUCATIONAL ACTIVITIES

Teaching

Classroom instruction
2007 (Fall)   Co-Instructor, Ethics for Biomedical Graduate Students, UNC Chapel Hill
2011 (Spring)   Writing Mentor, Undergraduate, The Science of Staying in Shape, Duke University
2013 (Spring)   Writing Mentor, Undergraduate, Current Research in Neuroscience, Duke University
2014 (Fall)   Writing Mentor, Undergraduate, Engineering Innovation, Duke University
2015 (Spring)   Writing Mentor, Undergraduate, Visual Perception and the Brain, Duke University
2017 (Fall)   Guest Lecturer, Undergraduate, Applied Linear Regression, Indiana University
2018 (Fall)   Guest Lecturer, Undergraduate, Applied Linear Regression, Indiana University

CME instruction
JHMI/Regional
2016 (Fall)   Guest Lecturer for Pediatric Radiology Housestaff, Multidisciplinary Updates in Pediatric Radiology, "Investigating the brain-basis of motor deficits in autism using functional magnetic resonance imaging", Johns Hopkins University

Workshops /seminars
JHMI/Regional
2014 (Fall)   Guest Lecturer, Clinical Neurosciences Conference Series, "Visuomotor functional connectivity in autism", Johns Hopkins University
2015 (Winter)   Guest Lecturer for Child and Adolescent Psychiatry Fellows, "Neurobiology of Autism", Johns Hopkins University

RESEARCH ACTIVITIES

Research Focus
I am a biomedical engineer with specific training and expertise in imaging science and sensory-motor neuroscience. My research is focused on using large neuroimaging and video-based data sets to study how children learn to dynamically interpret sensory information to produce appropriate actions and how this process is disrupted in children with neurodevelopmental disorders, including Autism Spectrum Disorder (ASD). I have 14 years of experience collecting, processing and analyzing structural and functional Magnetic Resonance Imaging (MRI) data from healthy young adults,

typically developing children and various adult and pediatric patient populations. I am also experienced in the development and implementation of task-based functional MRI measures of multisensory integration and visuomotor learning. In recent years, I have focused on developing innovative and reliable functional connectivity-based parcellation methods to study brain organization. Using these methods, we have demonstrated that abnormalities in the functional segregation of limb control within the motor system and in the intrinsic synchronization between motor and visual systems are related to the severity of social deficits in school-age children with ASD. As part of my NIMH funded Career Development Award (K01 MH109766-01), I am extending these findings to study the longitudinal development of visual-motor synchronization and hand-eye coordination in infants at high risk for ASD to determine whether the abnormalities observed in school-age children come online before or after symptom onset. I am also collaborating with others in the department to develop movement-based intervention methods for enhancing visual-motor connectivity necessary for imitating and learning from the actions of others.

Research Program Building / Leadership
2000-2002   Research Assistant, Orthopaedic and Injury Biomechanics Lab, Duke University
2002-2003   Data Technician, Department of Psychiatry, Washington University School of Medicine
2003-2005   Associate in Research, Duke-UNC Brain Imaging and Analysis Center, Duke University
2005-2008   Graduate Research Assistant, Michael W. Krzyzewski Human Performance Lab, Duke University

Technology Transfer Activities
2009-2010   Graduate Student Intern, Office of Technology Development, University of North Carolina, Chapel Hill
                Performed prior art searches and assessed commercialization potential of medical device/diagnostic technology developed at UNC.

SYSTEM INNOVATION AND QUALITY IMPROVEMENT ACTIVITIES Not Applicable

ORGANIZATIONAL ACTIVITIES

Institutional Administrative Appointments
2016   Reviewer, K-to-R Transition Program Specific Aims Speed Critique Session

Journal peer review activities
2010-present   Biological Psychiatry, Ad-hoc Reviewer
2010-present   Cerebral Cortex, Ad-hoc Reviewer
2010-present   Journal of Neuroscience, Ad-hoc Reviewer
2013-present   NeuroImage, Ad-hoc Reviewer
2015-present   Frontiers in Computational Neuroscience, Review Editor

Professional Societies
2013-present   Society for Neuroscience, Member
2013-present   International Society for Autism Research, Member
2014-present   Organization for Human Brain Mapping, Member

RECOGNITION *(in chronological order, earliest first by start date under each subcategory)*

Awards, Honors
2002   Mary Beth Nebel Award, Duke University Division I Rowing Team
                Given annually to the varsity rower who best personifies persistence, leadership & resolve
2008   UNC School of Dentistry Table Clinics Basic Science Research Award
2012   ADHD-200 Global Prediction Competition Winning Team
                Contributed to the development of the Johns Hopkins Team's winning algorithm for classifying children as typically developing or having ADHD using demographic and neuroimaging information
2013   International Society for Autism Research Travel Award to San Sebastian, Spain
2017   Emerging Women's Leadership Program, Johns Hopkins School of Medicine

Invited Talks
JHMI/Regional

11/2014	Speaker, JHU Department of Biostatistics and The Wendy Klag Center for Autism and Developmental Disabilities Joint Grand Rounds, "Investigating the Brain Basis of Motor Deficits in Autism: SMART-KKI Collaborations," Baltimore, MD
6/2019	Speaker, 20th Anniversary Symposium of the F.M. Kirby Research Center for Functional Brain Imaging at Kennedy Krieger Institute, "Investigating the Brain Basis of Motor Deficits in Autism", Baltimore, MD

National
5/2015	Speaker, NYU Department of Child and Adolescent Psychiatry Lectures on Analysis of Neuroimaging Data, "Investigating the Brain Basis of Motor Deficits in Autism," New York, NY
6/2017	Speaker, Statistical Methods in Imaging Conference, "Making Motor Connectivity Great Again," Pittsburg, PA
6/2017	Speaker, Infant Brain Imaging Study Annual Meeting, "Examining the emergence of visually guided reaching/grasping in infants at high risk for autism," New York, NY
7/2018	Speaker, Emory University Center for Biomedical Imaging Statistics, "Communication is hard or why I study motor coordination in autism," Atlanta, GA
11/2018	Speaker, University of Virginia Department of Psychology, "Communication is hard or why I study motor coordination in autism," Charlottesville, VA

OTHER PROFESSIONAL ACCOMPLISHMENTS

Oral/Podium Presentations

Nebel MB, Folger S, Tommerdahl M, Hollins M, McGlone F, Essick G. *Modulation of tactile responsiveness in somatosensory cortex by noxious heat: Implications for TMD*. 5th Scientific Meeting of the TMJ Association, Bethesda, MD, June 2008.

Nebel MB, Joel SE, Muschelli J, Barber A, Caffo B, Pekar JJ, Mostofsky S. *Disruption of functional organization within the primary motor cortex in children with autism*. 21st Scientific Meeting and Exhibition, International Society for Magnetic Resonance in Medicine (ISMRM), Melbourne, Australia, May 2012.

Nebel MB, Eloyan A, Nettles C, Sweeney K, Ament K, Ward R, Choe AS, Barber AD, Caffo BS, Pekar JJ, Mostofsky SH. *Visual-Motor Connectivity Relates to Autism Trait Severity*. 23rd Scientific Meeting and Exhibition, ISMRM, Milan, Italy, May 2014.

Barber A, Choe AS, Cohen J, **Nebel MB**, Xu Y, Lindquist MA. *Evaluating the Reproducibility of Dynamic Connectivity in fMRI*. IEEE International Symposium on Biomedical Imaging, Brooklyn, NY, April 2015 [Dr. Lindquist gave the talk].

Floris DL, Barber AD, **Nebel MB,** Mostofsky SH. *Atypical Lateralization of Motor Circuit Connectivity in Children with High-Functioning Autism Is Associated with Motor Deficits*. IMFAR, Salt Lake City, UT, May 2015 [Dr. Floris gave the talk].

Community Services
2011-2013	High School Student Mentor & Teacher Liaison Committee Member, Thread (formerly the Incentive Mentoring Program)
2016-present	Back on My Feet Baltimore, an organization that combats homelessness through the power of running, community support, and essential employment and housing resources, Core Volunteer
2017	Baltimore Point-In-Time Homeless Street Count Volunteer