



## The medical neighborhood expands the PCMH concept to include coordinated provision of specialty care.

The primary care medical home (PCMH) is designed to promote the delivery of high-value health care with its principles of patient-centered care, coordination across health care venues and the community, enhanced communication, and a systems-based approach to quality.<sup>1</sup> However, patients with multiple chronic conditions necessitate primary care physicians (PCPs) coordinating with large numbers of specialists<sup>2,3</sup> and can lead to discontinuity.<sup>4</sup> Patient discontinuity with primary care increases the likelihood of emergency department (ED) visits, hospitalizations, and greater costs.<sup>5</sup> Further, there is a risk of suboptimal communication and coordination between primary and specialty care,<sup>6</sup> which can lead to inefficient care and poor health outcomes.<sup>7</sup>

The medical neighborhood expands the PCMH concept to include coordinated provision of specialty care.<sup>8</sup> Integrated behavior health (IBH) is a common application of this paradigm and commonly colocates specialists within the PCMH.<sup>9</sup> IBH has demonstrated promise in improving outcomes and access and lowering costs.<sup>10-13</sup> However, it remains unclear if colocation of other specialties in a PCMH may yield similar benefits.

We previously described a 3.5-month pilot of colocated integrated community neurology (ICN) in a medical neighborhood care model. ICN demonstrated avoidance of diagnostic testing at a median of 6 months follow-up, reduced PCP referrals for face-to-face consultation to both ICN and non-colocated neurology, and safety.<sup>14</sup> However, the benefit of ICN over a longer period and its effect on other utilization patterns remains unknown.

We conducted a matched case-control design evaluating the effect of ICN on diagnostic testing, outpatient and ED visits, hospitalization, and access.

## METHODS

### Standard protocol approvals, registrations, and patient consents

We used deidentified patient information, for which written informed consent was not required. The Mayo Clinic institutional review board exempted this study.

### Setting and patients

This study was conducted with patients impaneled in Mayo Clinic's Employee and Community Health (ECH) practice. Mayo Clinic is a tertiary referral, vertically integrated, multi-specialty group practice that utilizes a shared electronic health record (EHR).<sup>15</sup> ECH is a PCMH including the divisions of primary care internal medicine, family medicine, and community pediatric and adolescent medicine. ECH encompasses a main practice site with 186 PCPs and 3 additional clinic sites with a total of 120 PCPs. ECH provides care to approximately 152,000 patients residing in and around Olmsted County, Minnesota. Mayo Clinic employees and dependents, primarily insured by Mayo Clinic, comprise approximately one-half of all ECH patients. ECH patients are assigned a physician, nurse practitioner, or physician assistant as their PCP.

### Integrated Community Neurology model

The ICN model has been described previously.<sup>14</sup> Prior to implementation of ICN, the Mayo Clinic non-colocated neurology referral practice provided neurology consultation and longitudinal care for ECH as well as regional, national, and international patients. Beginning October 1, 2014, a 0.6 full-time equivalent (FTE) neurologist was colocated within the main ECH practice site. Care management and scheduling support were also provided. ICN utilized a mix of scheduled appointments for face-to-face visits with new and return patients

and unscheduled time for curbside and electronic consultations (e-consults), as well as follow-up on EHR-generated patient messages and test results. Diagnostic tests were orderable at the discretion of the PCP without need for prior approval. There was no limitation on ordering of subsequent visits and testing by non-colocated neurologists for patients actively followed in the non-colocated referral practice during the study period. All controls were sampled before implementation of the ICN model to avoid risk of referral bias. ECH PCPs and neurologists in ICN and the non-colocated referral practice are salaried and not compensated on productivity.

### Data collection

Mayo Clinic billing data allowed for identification of patients and utilization tracking from October 1, 2013, to September 30, 2015. ICN cases were defined as patients billed for an evaluation and management (E&M) consultation code for ICN and with a disease-relevant ICD-9 neurologic diagnosis code under 5 indication-grouped categories: migraine/headache, epilepsy/seizure, dementia/behavioral neurology disorder, neuritis/neuropathy, and pain/myalgia. Controls were defined as patients with a neurologic diagnosis in the same 5 categories and billed for an E&M code with non-colocated neurology and no ICN billed code during the same period. Propensity scores were generated from a logistic regression model using the following baseline patient characteristics: age, sex, race, indication presence of Charlson comorbidities (myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, ulcer, liver disease, diabetes, hemiplegia, renal disease, metastatic solid tumor, rheumatologic disease, other cancer),<sup>16</sup> education level, employment status, payer, marital status, and living situation. Controls were sampled based on similarity of propensity score to gain balance within the covariates and remove the effect of baseline differences between cases and controls. Due to the number of covariates for matching and limited sample size, controls were sampled in a 1:1 ratio.

### Visit utilization

The primary care visit most closely preceding the first ICN visit (cases) or non-colocated neurology outpatient visit (controls) constituted the anchor visit. The mean, median, and interquartile range (IQR) of total outpatient, PCP, non-colocated neurology outpatient, and specialty outpatient visits as well as ED visits and hospital discharges were assessed over 1 year following the anchor visit. Visits were counted independently and summed over the 12-month period following the anchor visit. As each patient required an ICN or non-colocated neurology visit to be included as a case or control, respectively, the first visit for each patient was excluded prior to calculating utilization. Visits were classified using Current Procedural Terminology (CPT) and provider service location codes based on institutional administrative billing data.

### Diagnostic test utilization

The first ICN or non-colocated neurology outpatient visit was used as the anchor for diagnostic test utilization. We counted the number of EMG, EEG, CT head, MRI of the brain or spine, and magnetic resonance angiography (MRA) of the head and neck completed as defined by a billed CPT in institutional administrative billing data. Diagnostic test utilization was ascribed to ICN or non-colocated neurology if occurring in a window of 14 days prior to or 60 days following an outpatient visit for cases and controls, respectively.

### Access

The time to neurology face-to-face visit was calculated as the number of individual days between the dates of either the ICN or non-colocated neurology outpatient visit and the most recent PCP visit prior to it based on E&M codes.

### Statistical analyses

Demographic characteristics of the ICN and non-colocated neurology outpatient cohorts were compared using bivariate analyses, as appropriate, including  $\chi^2$  and Student *t* tests. Patients

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without an anchoring PCP visit prior to a visit in ICN or tertiary neurology were excluded from analyses. Mean and median visit and diagnostic test utilization were calculated with associated standard deviations and IQRs. Due to dispersion of the outcome data, negative binomial regression was used to ascertain differences in visit utilization and diagnostic test utilization, while controlling for the propensity score. Odds ratios (OR) were calculated with associated 95% confidence intervals (95% CI) and differences were considered significant if OR confidence intervals did not include 1.0 and the associated  $p$  values were less than 0.05. All data management and statistical analyses were performed using Statistical Analysis Software (SAS) version 9.4 (SAS Institute, Cary, NC).

### RESULTS

We identified 459 patients who had a face-to-face visit with ICN and 459 matched controls with a face-to-face visit in non-colocated neurology during the study period (table 1). The majority of patients were Caucasian and female. There were 70 cases and 212 controls who did not have a preceding PCP anchor visit and were excluded from analysis.

Compared to patients referred to non-colocated neurology for a face-to-face visit, ICN was associated with fewer subsequent neurology outpatient visits (adjusted OR 0.62; 95% CI 0.47–0.83;  $p = 0.001$ ) (table 2). There was no difference in total subsequent outpatient visits. In addition, there was no difference in other specialty outpatient visits (adjusted OR 0.94; 95% CI 0.81–1.10;  $p = 0.47$ ), emergency department visits (adjusted OR 0.83; 95% CI 0.63–1.10;  $p = 0.20$ ), or hospitalizations (adjusted OR 0.96; 95% CI 0.64–1.43;  $p = 0.83$ ).

Table 3 shows the number of diagnostic tests ordered in patients referred to ICN and non-colocated neurology. Patients seen in ICN were less likely to have an EMG (adjusted OR 0.64; 95% CI 0.46–0.89;  $p = 0.009$ ) or MRI brain (adjusted OR 0.60; 95% CI 0.45–0.79;  $p = 0.0004$ ). No differences were observed in the odds of having an EEG, CT head, MRI spine, or MRA head and neck imaging.

No differences in time to appointment were observed between patients referred to ICN vs those referred to tertiary neurology for a face-to-face visit (adjusted OR 1.08; 95% CI 0.89–1.32;  $p = 0.83$ ).

### DISCUSSION

We observed that the ICN care model was associated with fewer subsequent referrals for face-to-face visits with outpatient neurology and lower odds of having an EMG or MRI brain compared with referral to a non-colocated neurology practice. ICN was not associated with an increase in ED visits, hospitalizations, or appointment wait time. These findings extend the results of an earlier pilot and support the potential benefit of ICN on reducing possibly unnecessary testing and improving efficient utilization of neurologic care.<sup>14</sup>

Colocation and integration of specialty care in a PCMH addresses gaps in primary specialty health care delivery through the facilitation of curbside and e-consults.<sup>7,17,18</sup> We have previously demonstrated that ICN was associated with a reduction in need for new face-to-face visits to both ICN and the non-colocated neurology practice.<sup>14</sup> Curbside and e-consults mediate this effect as neurology expertise is leveraged without need or delay of a face-to-face visit while maintaining continuity with PCPs.<sup>18,19</sup> In this study, ICN was associated with

**Table 1** Baseline demographics of patients by care model

	Controls, non-ICN (n = 459)	Cases, ICN (n = 459)
Age, y, mean $\pm$ SD	55.6 $\pm$ 20.8	55.7 $\pm$ 18.9
Female, n (%)	285 (62.1)	283 (61.7)
Race, n (%)		
Caucasian	421 (91.7)	429 (93.4)
Black	13 (2.8)	10 (2.2)
Other	13 (2.8)	11 (2.4)
Asian	8 (1.8)	5 (1.1)
Unknown	4 (0.9)	4 (0.9)
CCS, mean $\pm$ SD		
Weighted	1.26 $\pm$ 1.93	1.24 $\pm$ 1.96
Age-weighted	2.80 $\pm$ 2.86	2.72 $\pm$ 2.87
Neurologic conditions, n (%)		
Pain/myalgia	315 (68.6)	326 (71.0)
Migraine/headache	199 (43.4)	185 (40.3)
Neuritis/neuropathy	217 (47.3)	230 (50.1)
Dementia/behavioral neurology	81 (17.7)	73 (15.9)
Epilepsy/seizure	57 (12.4)	51 (11.1)
Other diagnosed Charlson comorbidities, n (%)		
Myocardial infarction	15 (3.3)	17 (3.7)
Congestive heart failure	21 (4.6)	23 (5.0)
Peripheral vascular disease	88 (19.2)	82 (17.9)
Cerebrovascular disease	72 (15.7)	66 (14.4)
Dementia	46 (10.0)	45 (9.8)
Chronic pulmonary disease	59 (12.9)	63 (13.7)
Ulcer	12 (2.6)	9 (2.0)
Mild liver disease	22 (4.8)	24 (5.2)
Diabetes	73 (15.9)	78 (17.0)
Hemiplegia	11 (2.4)	10 (2.2)
Moderate/severe renal disease	15 (3.3)	13 (2.8)
Metastatic solid tumor	8 (1.7)	7 (1.5)
Other cancer	34 (7.4)	36 (7.8)
Education level, n (%)		
Some high school, but did not graduate	11 (2.4)	12 (2.6)
4-year college graduate	65 (14.1)	60 (13.1)
8th grade or less	11 (2.4)	7 (1.5)
High school graduate or GED	77 (16.8)	80 (17.4)
Postgraduate studies	84 (18.3)	62 (13.5)
Some college or 2-year degree	118 (25.7)	120 (26.1)
Not provided	93 (20.2)	118 (25.7)

Continued

**Table 1** Continued

	Controls, non-ICN (n = 459)	Cases, ICN (n = 459)
<b>Employment status, n (%)</b>		
Employed	153 (33.3)	150 (32.7)
Full-time homemaker	2 (0.4)	2 (0.4)
Other	7 (1.5)	7 (1.5)
Retired	141 (30.7)	125 (27.2)
Self-employed	21 (4.6)	19 (4.2)
Student	8 (1.8)	8 (1.8)
Unemployed	22 (4.8)	19 (4.1)
Work disabled	20 (4.4)	18 (3.9)
Not provided	85 (18.5)	111 (24.2)
<b>Payer, n (%)</b>		
Contract	89 (19.4)	76 (16.6)
Mayo insured	130 (28.3)	160 (34.8)
Medicare	187 (40.7)	174 (37.9)
Noncontract	5 (1.1)	4 (0.9)
Other government	48 (10.5)	45 (9.8)
<b>Marital status, n (%)</b>		
Married	287 (62.5)	293 (63.8)
Divorced	44 (9.6)	43 (9.4)
Single	100 (21.8)	97 (21.2)
Unknown	0 (0.0)	1 (0.2)
Widowed	27 (5.9)	24 (5.2)
Separated	1 (0.2)	1 (0.2)
Abbreviations: CCS = Charlson Comorbidity Score; GED = general educational development; ICN = integrated community neurology.		

decreased subsequent face-to-face visits to outpatient neurology. These results are consistent with other models that employ a component of preconsult screening similar to ICN to reduce unnecessary referrals.<sup>20,21</sup> Curbside and e-consult volume was not captured in our study; however, such exchanges between PCPs and ICN allow for ongoing coordinated care management and reassurance, lessening the need for subsequent face-to-face visits.<sup>14,22</sup> We observed that ICN patients had lower odds of EMGs and MRI brain tests ordered. These findings are consistent with other studies demonstrating the value of neurologists in prescreening diagnostic test ordering.<sup>23,24</sup> In our model, ICN did not employ neurologist prescreening of diagnostic test ordering. Our findings may be attributable to ICN allowing for a more collaborative, efficient approach to test ordering between PCPs and neurologists that involves leveraging close relationships and facilitating curbside and electronic consultations as well as shared care plan development and knowledge exchange.<sup>14</sup> The lack of observed reductions in CT head, MRI spine, and MRA head and neck test ordering still suggests opportunities for improvement based on high rates of inappropriate testing for such neuroimaging modalities.<sup>25</sup>

Neurologic disease accounts for a considerable subset of ED visits and hospitalizations<sup>26,27</sup> and lack of access to primary care and outpatient specialty care are known contributors to increased ED use and hospitalizations.<sup>28,29</sup> Moreover, US patients with headaches and

**Table 2** Outpatient visits, emergency department visits, and hospitalizations by care model

	Controls, non-ICN (n = 247)				Cases, ICN (n = 389)				Adjusted <sup>a</sup> (negative binomial)	
	Mean	SD	Median	IQR	Mean	SD	Median	IQR	OR (95% CI)	p Value
<b>All outpatient</b>	7.70	6.23	7.0	3.0-10.0	7.27	6.26	6.0	3.0-10.0	0.92 (0.81-1.05)	0.21
<b>Primary care outpatient</b>	1.77	2.35	1.0	0.0-3.0	1.48	2.07	1.0	0.0-2.0	0.82 (0.66-1.02)	0.07
<b>Outpatient neurology</b>	0.77	1.21	0.0	0.0-1.0	0.47	0.90	0.0	0.0-1.0	0.62 (0.47-0.83)	0.001
<b>Other outpatient specialty</b>	5.84	5.74	5.0	2.0-8.0	5.66	5.75	4.0	2.0-8.0	0.94 (0.81-1.10)	0.47
<b>Emergency department</b>	0.86	1.60	0.0	0.0-1.0	0.72	1.30	0.0	0.0-1.0	0.83 (0.63-1.10)	0.20
<b>Inpatient</b>	0.32	0.82	0.0	0.0-0.0	0.31	0.77	0.0	0.0-0.0	0.96 (0.64-1.43)	0.83

Abbreviations: CI = confidence interval; ICN = integrated community neurology; IQR = interquartile range; OR = odds ratio.

<sup>a</sup>Adjusted for age, sex, race, indication of presence of Charlson comorbidities, education level, employment status, payer, marital status, and living situation.

migraines seen in the ED account for substantial costs.<sup>30</sup> We previously observed that headache disorders accounted for one third of referrals to ICN.<sup>14</sup> One potential concern for ICN is that patients would not receive appropriate care and would seek emergent care as a result. In our study, despite decreased subsequent referrals to outpatient neurology, and decreased EMGs and MRI brain, ICN was not associated with increased ED use and hospitalizations, suggesting no major adverse effect on utilization from reduced ambulatory care utilization and testing.

We did not observe reduced time to appointment for patients seen for a face-to-face visit with ICN compared to non-colocated neurology. In contrast, IBH and collaborative care models employing curbsides and e-consults have demonstrated improved access and reduced appointment wait time.<sup>10,22</sup> In addition, this result contrasts with our previous findings of approximately 25% overall reduction in PCP referrals to both ICN and traditional neurology after model implementation.<sup>14</sup> Two factors may explain this discordance. First, the ICN model with 0.6 FTE compared to non-colocated neurology is likely understaffed for the volume referred. Second, curbsides and e-consults were not captured in this study and likely would have reflected reduced time to first contact with ICN.

**Table 3** Ordered diagnostic tests by care model

	Controls, non-ICN (n = 459)				Cases, ICN (n = 459)				Adjusted <sup>a</sup> (negative binomial)	
	Mean	SD	Median	IQR	Mean	SD	Median	IQR	OR (95% CI)	p Value
<b>EMG</b>	0.16	0.39	0.0	0.0-0.0	0.11	0.31	0.0	0.0-0.0	0.64 (0.46-0.89)	0.009
<b>EEG</b>	0.07	0.26	0.0	0.0-0.0	0.03	0.2	0.0	0.0-0.0	0.55 (0.30-1.02)	0.06
<b>CT head</b>	0.05	0.24	0.0	0.0-0.0	0.05	0.24	0.0	0.0-0.0	1.19 (0.64-2.21)	0.58
<b>MRI brain</b>	0.27	0.46	0.0	0.0-1.0	0.16	0.39	0.0	0.0-0.0	0.60 (0.45-0.79)	0.0004
<b>MRI spine</b>	0.12	0.33	0.0	0.0-0.0	0.11	0.36	0.0	0.0-0.0	0.93 (0.63-1.38)	0.73
<b>MRA head and neck</b>	0.05	0.23	0.0	0.0-0.0	0.04	0.2	0.0	0.0-0.0	0.79 (0.44-1.42)	0.43

Abbreviations: CI = confidence interval; ICN = integrated community neurology; IQR = interquartile range; MRA = magnetic resonance angiography; OR = odds ratio.

<sup>a</sup>Adjusted for age, sex, race, indication of presence of Charlson comorbidities, education level, employment status, payer, marital status, and living situation.

Strengths of this study include investigation of a novel application of the medical neighborhood paradigm in the setting of a well-developed PCMH serving a large patient population with comparable demographics and neurologic disease burden.<sup>31</sup> Coupled with use of a shared EHR and 1-year follow-up, this study allowed for adequate capture of diagnostic testing, outpatient, ED, and inpatient utilization.

This study has several limitations including those inherent to retrospective case-control study design and risk of selection bias. Propensity score matching offsets some of the limitations of a retrospective design. Although our propensity score matching utilized several patient characteristics, some potential confounding variables may be missed. Curbside consultations account for the majority of nonvisit exchanges with ICN<sup>14</sup> but were not electronically available for analysis. Similarly, the institutional administrative data did not allow for determining a reliable date of referral from the PCP, which limits a more accurate assessment of the effect of ICN on time to appointment accessibility. Clinical outcomes, as well as physician and patient satisfaction, were also not evaluated in this study and represent directions for future study in order to assess the ability of ICN to deliver on the quadruple aims of high-value care.<sup>32</sup> Given the small number of diagnostic tests, this study was also underpowered. In addition, expansion of ICN with enhanced focus on a higher volume of selected patients with specific conditions may also reveal benefit not seen at an aggregate level. Another potential limitation is that these findings may be attributable to the practice style of ICN participating neurologists. Nevertheless, it is unclear to what extent the ICN model with its paradigm of collaborative community-based care may influence a participating neurologist's practice style vs self-selection of neurologists with practice styles that align with the aims of ICN. Finally, although ICN has potential generalizability to other PCMHs operating within large, integrated delivery systems, this model with use of salaried physicians may not be generalizable to smaller practice settings or to settings in which physician compensation is productivity dependent. Similarly, ICN may be more feasible in settings where institutions have payer contract incentives to reduce potentially unnecessary testing such as through value-based payment or capitation models.

Neurologic conditions are prevalent among patients who seek health care and among the most commonly diagnosed in ambulatory visits.<sup>33,34</sup> PCPs routinely diagnose and manage many common neurologic diseases.<sup>35</sup> However, practice variation exists among PCPs in deciding when to refer to specialties, including neurology.<sup>36</sup> PCPs and neurologists may also disagree regarding appropriateness of referrals,<sup>35</sup> resulting in inefficiencies in the referral process.<sup>7</sup> National and regional shortages for PCPs<sup>37</sup> and neurologists result in long wait times and limited access,<sup>38</sup> necessitating development and dissemination of novel practice models. In the paradigm of the medical neighborhood, an effective neurology neighbor model complementing the PCMH with patient continuity may address these challenges<sup>19</sup> by affecting referral demand, referral quality, and access.<sup>8</sup> This becomes all the more imperative as insurers shift toward value-based payment and away from traditional fee-for-service.<sup>39</sup> The ICN model would support PCPs serving as collaborative care providers rather than competitive gatekeepers to specialty care.<sup>40</sup>

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Received January 25, 2017. Accepted in final form April 10, 2017.

## AUTHOR CONTRIBUTIONS

M.Y. Elrashidi participated in the design and conceptualization of the study, analysis and interpretation of the data, and drafting and revising of the manuscript for intellectual content. L.M. Philpot participated in the design and conceptualization of the study, analysis and interpretation of the data, and drafting and revising of the manuscript for intellectual content. N.P. Young participated in the design and conceptualization of the study, analysis and interpretation of the data, and drafting and revising of the manuscript for intellectual content. P. Ramar participated in the design and conceptualization of the study, analysis and interpretation of the data, and drafting and revising of the manuscript for intellectual content. K.M. Swanson participated in the design and conceptualization of the study, analysis and interpretation of the data, and drafting and revising of the manuscript for intellectual content. P.M. McKie participated in revising of the manuscript for intellectual content. S.J. Crane participated in revising of the manuscript for intellectual content. J.O. Ebbert participated in the design and conceptualization of the study, analysis and interpretation of the data, and drafting and revising of the manuscript for intellectual content.

## STUDY FUNDING

Supported by the Robert D. and Patricia E. Kern Center for the Science of Health Care Delivery.

## DISCLOSURES

M.Y. Elrashidi, L.M. Philpot, N.P. Young, and P. Ramar report no disclosures. K.M. Swanson receives research support from an AHRQ NRSA Training Grant (T32). P.M. McKie and S.J. Crane report no disclosures. J.O. Ebbert receives research support from Takeda, Pfizer, the US Department of Defense, and NIH. Full disclosure form information provided by the authors is available with the **full text of this article at [Neurology.org/cp](http://Neurology.org/cp)**.

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