APPENDIX A. SEARCH STRATEGIES

DATABASE SEARCHED & TIME PERIOD COVERED:
PubMed - From inception to 3/8/2019

LANGUAGE:
English

SEARCH STRATEGY:
"panel size"

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DATABASE SEARCHED & TIME PERIOD COVERED:
WEB OF SCIENCE Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC – From inception to 3/10/2019

LANGUAGE:
English

SEARCH STRATEGY #1:
"panel size"

Refined by: WEB OF SCIENCE CATEGORIES: (MEDICINE GENERAL INTERNAL OR HEALTH CARE SCIENCES SERVICES OR PRIMARY HEALTH CARE OR HEALTH POLICY SERVICES OR MEDICAL INFORMATICS OR PEDIATRICS OR ENGINEERING BIOMEDICAL OR GERIATRICS GERONTOLOGY OR GERONTOLOGY OR INFECTIOUS DISEASES OR MEDICINE RESEARCH EXPERIMENTAL)

SEARCH STRATEGY #2:
Cited searches on the following articles:

1. 2017. Hausmann, L. R. M., A. Canamucio, S. Gao, A. L. Jones, S. Keddem, J. A. Long and R. Werner. "Racial and Ethnic Minority Concentration in Veterans Affairs Facilities and Delivery of Patient-Centered Primary Care." Popul Health Manag **20**(3): 189-198.

2. 2016. Rajkomar, A., J. W. Yim, K. Grumbach and A. Parekh. "Weighting Primary Care Patient Panel Size: A Novel Electronic Health Record-Derived Measure Using Machine Learning." JMIR Med Inform **4**(4): e29.

3. 2016. Hirozawa, A. M., M. E. Montez-Rath, E. C. Johnson, S. A. Solnit, M. J. Drennan, M. H. Katz and R. Marx. "Multivariate Risk Adjustment of Primary Care Patient Panels in a Public Health Setting: A Comparison of Statistical Models." J Ambul Care Manage **39**(4): 333-42.

4. 2016. Dahrouge, S., W. Hogg, J. Younger, E. Muggah, G. Russell and R. H. Glazier. "Primary Care Physician Panel Size and Quality of Care: A Population-Based Study in Ontario, Canada." Ann Fam Med **14**(1): 26-33.

5. 2016. Angstman, K. B., J. L. Horn, M. E. Bernard, M. M. Kresin, E. W. Klavetter, J. Maxson, F. B. Willis, M. L. Grover, M. J. Bryan and T. D. Thacher. "Family Medicine Panel Size with Care Teams: Impact on Quality." J Am Board Fam Med **29**(4): 444-51.

6. 2013. Weiss, J. M., M. A. Smith, P. J. Pickhardt, S. A. Kraft, G. E. Flood, D. H. Kim, E. Strutz and P. R. Pfau. "Predictors of colorectal cancer screening variation among primary-care providers and clinics." Am J Gastroenterol **108**(7): 1159-67.

7. 2013. Ozen, A. and H. Balasubramanian. "The impact of case mix on timely access to appointments in a primary care group practice." Health Care Manag Sci **16**(2): 101-18.

8. 2012. Mohr, D. C. and G. J. Young. "Slack resources and quality of primary care." Med Care **50**(3): 203-9.

9. 2012. Dahrouge, S., W. E. Hogg, G. Russell, M. Tuna, R. Geneau, L. K. Muldoon, E. Kristjansson and J. Fletcher. "Impact of remuneration and organizational factors on completing preventive manoeuvres in primary care practices." Cmaj **184**(2): E135-43.

10. 2011. Stefos, T., J. F. Burgess, Jr., M. F. Mayo-Smith, K. L. Frisbee, H. B. Harvey, L. Lehner, S. Lo and E. Moran. "The effect of physician panel size on health care outcomes." Health Serv Manage Res **24**(2): 96-105.

11. 2010. Balasubramanian, H., R. Banerjee, B. Denton, J. Naessens and J. Stahl. "Improving clinical access and continuity through physician panel redesign." J Gen Intern Med **25**(10): 1109-15.

12. 2009. Hogg, W., S. Dahrouge, G. Russell, M. Tuna, R. Geneau, L. Muldoon, E. Kristjansson and S. Johnston. "Health promotion activity in primary care: performance of models and associated factors." Open Med **3**(3): e165-73.

13. 2009. Francis, M. D., W. E. Zahnd, A. Varney, S. L. Scaife and M. L. Francis. "Effect of number of clinics and panel size on patient continuity for medical residents." J Grad Med Educ **1**(2): 310-5.

14. 2008. Dobscha, S. K., K. Corson, J. A. Flores, E. C. Tansill and M. S. Gerrity. "Veterans affairs primary care clinicians' attitudes toward chronic pain and correlates of opioid prescribing rates." Pain Med **9**(5): 564-71.

15. 2007. Green, L. V., S. Savin and M. Murray. "Providing timely access to care: what is the right patient panel size?" Jt Comm J Qual Patient Saf **33**(4): 211-8.

DATABASE SEARCHED & TIME PERIOD COVERED:
Scopus – inception-3/8/2019

LANGUAGE:
English

SEARCH STRATEGY #1:
TITLE-ABS-KEY ("panel size")
AND
LIMIT-TO (SUBJAREA , "MEDI") OR LIMIT-TO (SUBJAREA , "SOCI")
AND
EXCLUDE (SUBJAREA , "BIOC") OR EXCLUDE (SUBJAREA , "ENGI") OR EXCLUDE (SUBJAREA , "AGRI") OR EXCLUDE (SUBJAREA , "COMP") OR EXCLUDE (SUBJAREA , "ARTS")

STRATEGY #2:

Scopus – inception-3/10/2019

Cited searches on the above-listed 15 articles

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DATABASE SEARCHED & TIME PERIOD COVERED:
Embase – inception-3/8/2019

LANGUAGE:
English

SEARCH STRATEGY:
'panel size'
AND
‘primary care’

APPENDIX B. PEER REVIEW COMMENTS/AUTHOR RESPONSES

Question	Reviewer comment	Authors' response
Are there any published or unpublished studies that we may have overlooked?	Yes - Helfrich CD, Simonetti J, Clinton WL, Wood GB, Taylor L, Schectman G, Stark R, Fihn SD, Nelson KM*. The Association of Team-Specific Workload and Staffing with Odds of Burnout Among VA Primary Care Team Members. 2017; J Gen Intern Med. 32 (7): 760–766. Has information on staffing, panel size overcapacity and burnout.	Thank you for this! We have now included this study in our analysis.
	Yes - Hannah Neprash did her dissertation on a related area. See http://scholar.harvard.edu/files/hannahneprash/files/neprash_jmp_november2016.pdf Hannah is now an assistant professor at UMN. https://directory.sph.umn.edu/bio/sph-a-z/hannah-neprash	This is an interesting dissertation, but it does not relate directly to panel size. We therefore did not add it to our review. However, Dr. Neprash is an expert in this area, and we will bring to the Coordinating Center the suggestion to contact her.
Additional suggestions or comments can be provided below. If applicable, please indicate the page and line numbers from the draft report.	See comments and corrections inserted in document attached.	Thank you for these comments and corrections. They are now addressed in-text.
	Page 8 "The emergence of the 1,200 patient panel is somewhat of a mystery" could be changed to "The emergence of the 1,200 patient panel size was based on historical means at the time" Page 17 "this study is of marginal relevance to VA non-teaching clinic care" could include the point that it would be relevant to teaching clinics panel sizes.	Thank you for these comments! We have now made these changes to the text.
	This is fairly comprehensive review of the primary care panel size question across clinical, health services and operations research literature. It is well written; it is not a mere summary, but advances empirically grounded judgments on the existing literature and what is missing. I am not aware of any important studies that have been omitted. The conclusions are sound and correctly point out that causal relationships between panel size and key outcomes such as clinical quality, patient experience, access and continuity have not yet been measured. In fact, this is a massive gap in the literature and it exists because techniques such as randomized control trials and longitudinal studies are are probably difficult to implement in the primary care setting. The authors correctly state that risk adjustment is key while considering panel size, as is the increasingly dominant role of non face to face work. The section on future research offers promise that the gaps in the literature could be addressed through research at VA.	Thank you for your comments!

	The goal of this report is to review the scientific evidence behind primary care providers panel metrics. These metrics are used for a variety of functions from deciding when to hire more providers to creating bonuses (penalties) for high (low) performing providers. The reviewers combed through the literature finding 462 potential articles. Most articles were excluded upon further review and the final sample included 29, as shown in figure 1. Typically most syntheses grade the quality of the evidence or weight the meta-analytic results with the sample size. The authors acknowledge that this was not done here as all of the articles were observational or modeling exercises. I offer some comments and below: 1. The authors do a nice job explaining the rationale for panel size and the adoption of panel metrics in VA. The authors might want to explain that panel metrics in commercial health care plans may be measuring a different denominator than VA panels. In commercial plans, a patient can only have 1 primary insurer. That is not the case in the VA. Because VA coverage is an entitlement, not a benefit, a Veteran can be in a commercial plan and also have a primary care provider in VA. In fact, most older Veterans are enrolled in Medicare with a substantial number in Medicare Advantage. When dually covered, the Veterans can choose to use the VA or non-VA providers. This has implications for panel management in VA that is rarely discussed. But it is worth noting that the underlying denominator may be different. 2. On page 15, the authors review some existing papers and generally note that higher panel sizes were associated with worse outcomes (effectiveness). If possible, I would encourage the authors to report marginal effects. The odd ratios are not that informative. In addition, readers need to understand if there are thresholds as well as the levels of uncertainty. They do a little of this on the study from Ottawa, but greater details here would be very helpful. Possibly a table of these outcomes would be helpful. 3. Page 17, the authors review 1 study that measured efficiency. It should be noted that charges is not a good measure of costs or efficiency. There is good reason to argue that this study should be ignored and that this area hasn't been studied well at all. 4. I would encourage the authors to connect with Hannah Neprash, if they haven't done so yet. She did her dissertation on this issue and has evaluated a natural experiment that might provide causal estimates. She is now an assistant professor	1. Great point. We now address dual eligibility in the Applicability to the VA section in the Discussion on pg. 31. 2. Thank you for this comment. We have now added the marginal effects in text for the Stefos and Dahrouge (Ottawa) papers. Angstman and colleauges did not provide enough data to calculate marginal effects. 3. We now note that charges are not a good measure of costs or efficiency in the Results. 4. We will bring to the Coordinating Center the suggestion to contact Dr. Neprash for her expertise on the subject. Thank you for your comments!

	at Minnesota. In summary, the authors do a very good job reviewing the literature. The lack of evidence on this topic is rather shocking given how these metrics are used for management.	

APPENDIX C. CITATIONS FOR EXCLUDED STUDIES

Background (n=15)

1. Panel size expansion in the medical home. 2010.
2. Patient Centered Management Module (PCMM) for Primary Care. 2017.
3. Facilitating Panel Management. 2018.
4. Bavafa H, Hitt LM, Terwiesch C. The Impact of E-Visits on Visit Frequencies and Patient Health: Evidence from Primary Care. *Manage Sci.* 2018;64(12):5461-5480.
5. Chamblee J, S R. Using patient panel as a principle element in primary care physician compensation. 2018.
6. Chien AT, Kyle MA, Peters AS, et al. The degree to which practice configuration, size, and composition change while practices establish Teams. *Journal of general internal medicine.* 2017;32(2):S335.
7. Chung S, Eaton LJ, Luft HS. Standardizing primary care physician panels: is age and sex good enough? . *The American journal of managed care.* 2012;18(7):e262-268.
8. Edwards ST, Marino M, Balasubramanian BA, et al. Burnout Among Physicians, Advanced Practice Clinicians and Staff in Smaller Primary Care Practices. *Journal of general internal medicine.* 2018;33(12):2138-2146.
9. Huang PY, Yano EM, Lee ML, Chang BL, Rubenstein LV. Variations in nurse practitioner use in Veterans Affairs primary care practices. *Health services research.* 2004;39(4 Pt 1):887-904.
10. Hulshof P, Vanberkel, PT , Boucherie, RJ , Hans, EW, van Houdenhoven, M , van Ommeren, JKC Analytical models to determine room requirements in outpatient clinics. *OR Spectrum.* 2012;34(2):391-405.
11. Improvement IoH. Manage Panel Size and Scope of Practice.
12. Kivlahan C, C S. Identifying the Optimal Panel Sizes for Primary Care Physicians. 2018.
13. Kivlahan C, Pellegrino K, Grumbach K, et al. Calculating primary care panel size. 2017.
14. S S. How many patients can a primary care physician care for? 2014.
15. Virani SS, Akeroyd JM, Ramsey DJ, et al. Health Care Resource Utilization for Outpatient Cardiovascular Disease and Diabetes Care Delivery Among Advanced Practice Providers and Physician Providers in Primary Care. *Popul Health Manag.* 2018;21(3):209-216.

Duplicate (n=2)

1. Balasubramanian H, Denton B, M L. Managing physician panels in primary care. In. *Handbook of healthcare delivery systems*2011.

2. Mayo-Smith MF, Frisbee K, Harvey C, Stefos T, Burgess J, Miller M. Relationship of primary care panel size and healthcare outcomes in the VA. *Journal of general internal medicine.* 2006;21:123-123.

Non-Systematic Review (n=1)

1. Ahmadi-Javid A, Jalali Z, Klassen KJ. Outpatient appointment systems in healthcare: A review of optimization studies. *Eur J Oper Res.* 2017;258(1):3-34.

Not about Panel Size (n=9)

1. Cheung A, Stukel TA, Alter DA, et al. Primary Care Physician Volume and Quality of Diabetes Care A Population-Based Cohort Study. *Ann Intern Med.* 2017;166(4):240-+.

2. Devlin RA, Hogg W, Zhong JW, Shortt M, Dahrouge S, Russell G. Practice size, financial sharing and quality of care. *BMC Health Serv Res.* 2013;13.

3. Ellis R, Ash A, J F. "Good-Enough" Risk Adjustment Models for Physician Payment and Performance Assessment. In:2015.

4. Huntley A, Lasserson D, Wye L, et al. Which features of primary care affect unscheduled secondary care use? A systematic review. *BMJ Open.* 2014;4(5):e004746.

5. Liu N, S Z. Panel size and overbooking decisions for appointment-based services under patient no-shows. *Prod Oper Manag.* 2014;23(12):2209-2223.

6. Marx R, Drennan MJ, Johnson EC, Hirozawa AM, Tse WM, Katz MH. Assessing and increasing patient panel size in the public sector. *Journal of public health management and practice : JPHMP.* 2011;17(6):506-512.

7. Stempniewicz R, J C. Primary care panel size: Exploratory Analysis. 2015.

8. Wang JS, Lin SY, Sheu WH, Lee IT, Tseng LN, Song YM. Effects of patient volume on quality of outpatient diabetes care. *Diabetes Res Clin Pract.* 2009;84(2):e27-29.

9. Zantingea EM VP, de Bakkera DH. The workload of general practitioners does not affect their awareness of patients' psychological problems. *Pat Educ Counsel.* 2007;67:93-99.

Unavailable (n=1)

1. Danforth KN, Slezak JM, Chen LH, et al. Risk factors for care-gaps in abnormal lab results follow-up within a large integrated health system. *Diagnosis.* 2017;4(4):eA118-eA119.

Commentary (n=1)

1. Keller AO. Does team-based task delegation affect patient panel size for primary care providers? *JAAPA-J Am Acad Physician Assist.* 2015;28(6).

Not a Predictor (n=1)

1. Chien AT, Kyle MA, Peters AS, et al. Establishing Teams How Does It Change Practice Configuration, Size, and Composition? *J Ambul Care Manag.* 2018;41(2):146-155.

APPENDIX D. EVIDENCE TABLE

Author, year	Practitioner type	Study design	Sample size (# of practices)	Panel size range	Other factors	Outcome (access, quality, patient experience, cost, continuity)	Outcomes of study
Angstman 2016[15]	Department of Family Medicine at Mayo Clinic (MN)	Observational; Cross-sectional; Retrospective	36 physicians; 3 sites; 9 care teams	Range adjusted for FTE: 1,876-4,828; Mean adjusted for FTE: 2,959 (SD 629);	CMS-HCC complexity score	Access Quality	Access: Days until third next available appt (+) Quality: Cost of care ranking (/) Patient satisfaction (/) Percentage daily appointment fill rate (/) Physician quality ranking for diabetes (-)
Baker 2011 [23]	Primary care trusts in Leicester City and Leicestershire, UK	Cross-sectional	145 general practices; providers NR; patients NR	Median: 5,903, IQR: 3,122-9,682, years 2006/2007; 6,317, IQR: 3,344, 9,685, years 2007/2008	Deprivation; Practice size; Patient age; Patient race; Patient sex; Distance of the practice from the hospital; Patient satisfaction with telephone access to primary care	Access	Emergency department attendance (-)
Dahrouge 2016[12]	Primary care practices in Ontario, Canada	Observational; Cross-sectional; Retrospective	4,195 physicians	Range: 1,200-3,900	Number of physicians; Physician age; Physician sex; Foreign-trained physician indicator; Time since physician graduation; Practice	Continuity Quality	Continuity: Physician continuity of care (+) Quality:

Author, year	Practitioner type	Study design	Sample size (# of practices)	Panel size range	Other factors	Outcome (access, quality, patient experience, cost, continuity)	Outcomes of study
					group size; Practice rurality; Number of patients; Proportion of patients virtually rostered; Patient age; Patient sex; Proportion of recent immigrant patients; Patient rurality; Patient income quintile; Resource Utilization Band case mix measure		Asthma spirometry (/) Admissions for ambulatory-care sensitive conditions (+) Breast cancer screening (-) Cervical cancer screening (-) CHF ACEi/ARB prescription (/) CHF echocardiogram (+) Colorectal cancer screening (/) Diabetes ACEi/ARB prescription (/) Diabetes eye examination (/) Diabetes lipid test (/) Diabetes HbA1c test (/) Diabetes lipid-lowering agent prescription (/)

Author, year	Practitioner type	Study design	Sample size (# of practices)	Panel size range	Other factors	Outcome (access, quality, patient experience, cost, continuity)	Outcomes of study
							Diabetes metformin prescription (/) Low triage ED visits (+) Physician comprehensiveness (/)
Dahrouge 2912[20]	Family medicine physicians in Ontario	Cross-sectional	Providers NR; 3,284 patients	NR	Practice funding model; Patient age; Patient sex; Physician sex; Panel size <1,600 patients/FTE physician; Presence of electronic reminder system	Quality	Breast cancer screening (/) Cervical cancer screening (+) Colorectal cancer screening (/) Eye examination (/) Hearing examination (+) Influenza vaccination (+) Preventative care composite score (+)
Edwards 2017[18]	Small-to-medium-sized primary care practices in 7 regions of the US	Cross-sectional	1,685 practices; 5,953 practice members; patients NR	NR	Clustering by practice	Provider experience	Burnout (/)
Francis 2009[16]	Internal medicine residency	Cross-sectional	40 residents; patients NR	Mean: 54.7 (SD 4.1)	Number of clinics attended by a resident;	Access	Patient continuity (-)

Author, year	Practitioner type	Study design	Sample size (# of practices)	Panel size range	Other factors	Outcome (access, quality, patient experience, cost, continuity)	Outcomes of study
	program at Southern Illinois University				Attending physician fixed effects		
Helfrich 2017[11]	Primary care providers (primary care physicians; nurse practitioners; physician assistants), nurse care managers, clinical associates, and administrative clerks from a national VA sample	Cross-sectional	4,610: 1,517 PCPs; 1,276 nurses care managers; 1,164 clinical associates; 653 administrative clerks	NR; 31.6% of panels >1,200 (overcapacity)	Team staffed to the 3:1 ratio indicator; Working on multiple teams indicator; Last 12-month team turnover indicator; Average panel comorbidity; Working extended hours indicator; Respondent occupation; Duration of VA tenure; VA medical center (vs community-based outpatient clinic [CBOC]) indicator; Team random intercept; Clinic random intercept; Occupation-panel overcapacity interaction	Provider experience	Burnout (+)
Kamnetz 2018[7]	Primary care physicians in the University of Wisconsin (UW) School of Medicine and Public Health, the UW Hospital and Clinics, and the UW Medical Foundation	Observational; Pre-post; Retrospective	112 physicians in 27 clinics	Range: 1,244-2,315(preweighting); 949-2,705 (postweighting)	Patient age; Patient sex; Patient insurance type	Access	Panel weighting: Active patients (+) Appointment available when needed in family or general internal medicine (+)

Author, year	Practitioner type	Study design	Sample size (# of practices)	Panel size range	Other factors	Outcome (access, quality, patient experience, cost, continuity)	Outcomes of study
Katz 2013[10]	VA primary care providers; unspecified specialty	Cross-sectional	Providers NR; 180,808 patients	Median: 1,178; IQR: 982–1,295	Demographics; Disability status; Chronic medical and psychiatric conditions; Number of primary care clinic visits; Primary care FTE; PCP participation in a PACT Learning Collaborative; Usual site of care	Continuity	Modified Continuity Index (/) Physician/patient communication (+) Physician/patient shared decision-making (/) Usual Provider Continuity Index (/)
Margolius 2018[14]	Primary care providers in MetroHealth system (NE Ohio; 76% MDs)	Observational; Cross-sectional; Retrospective	114 providers; practices NR	Mean: 1,146 (SD 618)	FTE; clinicians/site	Access	Days until third next available appt (+)
Margolius 2018[19]	Nineteen practice sites in the MetroHealth System in Northeastern Ohio	Cross-sectional	86 primary care physicians; patients NR	NR	PCP full time equivalents; Estimated average income of PCP's panel	Provider experience	Inbox volume (+)
Mittelstaedt 2013[13]	Primary care providers in OHSU Department of Family Medicine outpatient clinics (71% MDs)	Observational; Cross-sectional; Retrospective	63 providers; 4 clinics	Range: 65-1,377; Mean: 577.4 (SD 315.8)	Clinic frequency (half-day clinic sessions per month); Patient load (ratio of panel size to clinic frequency); Years in practice; Provider type; Provider type*patient load interaction	Continuity	Usual Provider Continuity Index (/)

Author, year	Practitioner type	Study design	Sample size (# of practices)	Panel size range	Other factors	Outcome (access, quality, patient experience, cost, continuity)	Outcomes of study
Mohr 2013[9]	Primary care providers in VA (% physician NR)	Observational; Cross-sectional; Retrospective	Providers NR; 222 clinics	NR; Workload defined/reported as the ratio between actual panel size and optimal panel size	Patient age; Patient sex; Patient race; Patient ethnicity; Patient SF-12 score; Patient SHEP responses; Clinic rurality; Clinic hospital/community-based setting; Clinic geographic region; Clinic teaching hospital affiliation; Clinic years in operation; Clinic full-time equivalent employees; Clinic RNs per support staff	Access Patient experience Quality	Access: Workload: Patient-provider interaction time (-) Patient experience: Workload: Patient complaints (+) Quality: Workload: Overall visit quality (-) Workload relationship with complaints and interaction time only significant in low-relational working climates (vs. high-relational)
Stefos 2011[8]	Primary care providers in VA (71-74% MDs)		All VA not otherwise specified	Mean panel size 1,168-1,206	Patient age; Patient gender; Patient insurance status; Patient VA priority status; Patient clinical risk; Clinical support staff; Adjusted exam rooms; Per primary care provider clinical FTE; Available support staff; Capital resources; Patient satisfaction;	Access Patient experience Quality	Access: Waiting time (+) Patient experience: Patient satisfaction (-) Quality: Alcohol Misuse Screen (-)

Author, year	Practitioner type	Study design	Sample size (# of practices)	Panel size range	Other factors	Outcome (access, quality, patient experience, cost, continuity)	Outcomes of study
					Distance in miles from VA facility; CBOC or not		AMI/Ischemic Heart Disease Full Lipid Profile (/) Colorectal Cancer Screen (/) Diabetes Mellitus, HbA1c <= 9 (/) Diabetes Mellitus Retinal Eye Exam (/) Hyper-lipidaemia Screen (-) Hyper-tension Diagnosis Blood Pressure <= 140/90 (/) Pneumococcal Immunizations (-)
Ward 2012[21]	Physicians in primary care practices the Massachusetts General Hospital network; unspecified specialty	Cross-sectional	156 provider; 14,857 patients	NR	Patient age; Patient sex; Patient insurance status; Patient race; Patient language; Patient education; Patient Charlson score	Access Patient experience	Access: Access composite score (/) Patient experience: Patient communication composite sore (+)

Author, year	Practitioner type	Study design	Sample size (# of practices)	Panel size range	Other factors	Outcome (access, quality, patient experience, cost, continuity)	Outcomes of study
							Time spent with patient (/)

Note: (+) indicates a significant positive association between outcome and increasing panel size, (-) indicates a significant negative association with increasing panel size, and (/) indicates no association. Predictors other than panel size are specified when appropriate.

APPENDIX E. MODELING STUDIES EVIDENCE TABLE

Article	Predictors of Patient Demand	Demand Primary Estimates/ Source	Demand Stochastic?	Decision Variables	Outcomes	Value	Optimization/ Technique	Other Notes
UCSF: **Altschuler 2012**[24]	Chronic conditions for chronic services time; unconditional averages for preventive and acute services	Based on Duke studies (Yarnall 2009; Yarnall 2003; Ostbye 2005)	No	Panel Size; Team Organization	Supply = Demand	No explicit calculation	Accounting: The authors computed the maximum panel size that could be handled by an FTE PCP within a non-team or various team organizations, given the following: average appointment time demand by chronic condition type; prevalence of chronic condition; average acute appointment time; average time to provide preventive services; and average percentage of time for these services that could be offloaded from the PCP under various team models	Assumes an average US patient case mix; Discussion mentions VA and perhaps needing lower panel sizes given the older patient population with more prevalent chronic conditions
UCSF: **Rajkomar 2016**[28]	Age, sex, prior year demand patterns, *etc*	UCSF 2013-5 patients receiving care from	N/A	None	None	None	Prediction only: They develop a relatively complex statistical model to	They split their data to have training data (70%) and test data (30%)

Article	Predictors of Patient Demand	Demand Primary Estimates/ Source	Demand Stochastic?	Decision Variables	Outcomes	Value	Optimization/ Technique	Other Notes
		PCPs within academic health system					predict patient demand for visits and other non-face-to-face services, which they use to reweight current panel sizes based on this predicted patient heterogeneity	
Mayo: **Balasubramanian 2007**[29]	Age, sex	Mayo Clinic Primary care practice data 2004-2006 (39 PCP panels)	Yes	Panel size and case mix	Appointment wait times; Redirection to another PCP; Daily appointment overage	Outcomes (all negative) are valued as costs, with total cost being minimized	Panel Design Genetic Algorithm	Authors claim that they likely do better than Green for situations where variance around predicted demand for patient categories is relatively high (*ie*, when demand is hard to predict). Essentially, the authors state that stochastic surges in demand will occur and will not be absorbed well in panel sizes/ appointment slots as suggested by Green. This happens because the surges will happen more frequently than

Article	Predictors of Patient Demand	Demand Primary Estimates/ Source	Demand Stochastic?	Decision Variables	Outcomes	Value	Optimization/ Technique	Other Notes
								there is excess capacity to quickly absorb of the backlog of demand. The backlog will then propagate and grow. Supply is also not very flexible, because unused appointments from 1 day cannot be moved forward to another day's capacity.
Mayo: **Balasubramanian 2010**[25]	Age, sex, chronic conditions	Mayo Clinic Primary Care practice data 2004-2006 (39 PCP panels)	Yes	Panel size and case mix	Appointment wait times; Redirection to another PCP	Not stated but appears to be a similar cost minimization for (negative) outcomes like 2007 paper	Stochastic Linear Programming	Also considers increased panel sizes; Their limitations section notes many of the behavioral responses around demand and supply, and the potential importance of patient/PCP matching
Mayo: **Ozen 2013**[27]	Chronic conditions	Mayo Clinic Primary Care practice data 2004-2006 (39 PCP panels)	Yes	Panel size and case mix	Overflow Frequency		Integer Non-Linear Programming	Instead of specifying a trade-off between PCP/patient continuity and total panel size, they

Article	Predictors of Patient Demand	Demand Primary Estimates/ Source	Demand Stochastic?	Decision Variables	Outcomes	Value	Optimization/ Technique	Other Notes
								optimize without allowing redirection and show how many fewer patients can be empaneled if continuity is required; they also consider at what clinical capacity physicians are working and expected overflow
Mayo: **Rossi 2018**[31]	None explicitly, statistical sampling based on empirical distribution of actual data	MEPS 2011	N/A	None	None	None	Prediction only: They use a set of statistical sampling techniques on patient-level longitudinal data that predicts weekly demand for a variety of PCP office and non-office services that require PCP coordination and then suggest that normal PCPs with panels of 2,000 will struggle to meet demand	The main extension from the prior work, aside from considering more broadly representative distributions of patient demand, is to jointly model expected demands on PCP time from both appointments as well as other types of encounters that demand PCP time for coordination
Columbia: **Green 2007**[32]	Unconditional average	Based on prior studies by practice type (adult	No	Panel Size; Daily Appointment Slots	Supply = Demand; Low frequency of overflow	No explicit calculation	Based on assumptions about distribution of demanded	They are looking at an advanced access model (patients should be able to

Article	Predictors of Patient Demand	Demand Primary Estimates/ Source	Demand Stochastic?	Decision Variables	Outcomes	Value	Optimization/ Technique	Other Notes
		PCP; pediatrician)					appointments (binomial), number available daily slots, and a suitably low targeted overflow fraction, they compute a panel size for which demand is satisfied and the overflow fraction does not exceed the target	get same-day appointments)
Florida: **Zacharias 2017**[30]	None (could in principle but study is entirely mathematical/simulation)	None	Yes	Panel size; Daily appointment slots	Appointments delivered, cost of delayed appointments, cost of patient waiting, overtime costs	Outcomes are combined and reward is maximized	Diffusion approximations and other techniques used to provide analytical solutions that are then illustrated in simulation	Allow for more patient behaviors like deciding not to use care when the appointment backlog is too long; they show that in their model advanced access (same-day appointment offering) will be optimal generally; They have a small example applied to an MRI clinic to determine a panel size that the clinic could handle under assumption about the relative

Article	Predictors of Patient Demand	Demand Primary Estimates/ Source	Demand Stochastic?	Decision Variables	Outcomes	Value	Optimization/ Technique	Other Notes
								costs/benefits of their outcomes
South Florida: **Zeng 2013**[22]	None explicitly stated; parameters derived from actual data	Public mental health clinic at the Johns Hopkins Bayview Medical Center in Baltimore, MD	No	Panel size; overbooking status	Appointment delay; office delay; Daily clinic profit; Patient show-up probability	Not stated	Prediction only	