Critical gaps in knowledge and implementation of recommendations by the US Preventive Services Task Force

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ABSTRACT

Introduction: The United States Preventive Services Task Force (USPSTF) has issued 31 recommendations applicable to non-pregnant adults. We hypothesized variability in knowledge and implementation of these recommendations among US family medicine resident physicians.

Methods: We performed two electronic surveys: a local survey, and then a nationally-representative, multicenter, survey. We evaluated self-reported knowledge and implementation of USPSTF recommendations related to non-pregnant adults.

Results: 84 family medicine residents from 40 residency programs across 25 states participated. Knowledge and implementation of recommendations varied widely. Most residents lacked knowledge relating to breast cancer chemoprophylaxis (9.9 % "known in detail" or "mostly know"), BRCA-related genetic counseling (BRCA-GC) referral (30 %), tuberculosis (TB) screening (41 %), and sexually transmitted infection (STI) counseling (45 %). There is virtually no implementation of recommendations for breast cancer chemoprophylaxis (90 % never/rarely implement). Many residents never/rarely implement recommendations for BRCA-GC referral (75 %), TB screening (62 %), and HIV pre-exposure prophylaxis (61 %). This remained true even for residents in their final year of training. Relative to their male counterparts, female physicians more frequently implemented recommendations for BRCA-GC referral (11 % vs 0 % always/often implement, p = 0.019), cervical cancer screening (100 % vs 83 %, p = 0.019), and folic acid supplementation (60 % vs 29 %, p = 0.007). Knowledge and implementation of recommendations were strongly related (β = 0.75, 95 % CI 0.50–1.00, p < 0.001, Spearman R^2 = 0.56).

Conclusion: Critical gaps exist in resident knowledge and implementation of USPSTF recommendations. We discuss urgent implications for cancer prevention, public health, and health equity.

1. Introduction

The United States Preventive Services Task Force (USPSTF) issues evidence-based preventive care guidelines. Grade A and B recommendations have net benefits and USPSTF suggests practitioners "offer or provide" these services. 31 Grade A or B recommendations apply to non-pregnant adults. Implementation of USPSTF recommendations among physicians has been studied for individual recommendations, *viz.*: screening mammography (Brooks, 2009; Corbelli et al., 2014; Alvarez et al., 2019; Fung et al., 2015), breast cancer chemoprophylaxis (Armstrong et al., 2006), lung cancer (Henderson et al., 2017), cervical cancer screening (Fung et al., 2015), diabetes screening (Fung et al., 2015), cardiovascular disease/lipid disorders (Fung et al., 2015), colon cancer screening (Fung et al., 2015), alcohol use disorder (Le, 2015), breast

self-exam (Loh, 2015), and osteoporosis (Alvarez et al., 2019; Powell et al., 2012). Much older work – *e.g.,* Walsh and Papadakis in 1994 (Walsh and Papadakis, 1994) – performed a then-comprehensive analysis, but we are aware of no recent comparative analysis of all 31 adult recommendations.

We hypothesized that family medicine resident physicians lacked uniform knowledge and frequency of implementation of these recommendations. We therefore comprehensively evaluated – first at our local institution and, subsequently, using a multicenter representative survey – self-reported knowledge and frequency of implementation of all adult USPSTF Grade A or B recommendations. We discuss urgent implications of our data for cancer prevention, public health, and health equity.

Table 1

Respondent characteristics.

Variable	No. (%)	
	Multicenter sample	Local sample
All respondents	71 (100)	13 (100)
Age, years		
25–29	33 (48.5)	7 (54)
30–34	30 (44.1)	6 (46)
35–40	5 (7.4)	–
Not reported	3	–
Sex		
Male	24 (34.8)	5 (38)
Female	45 (65.2)	8 (62)
Not reported	2	–
Gender		
Man	25 (35.7)	5 (38)
Woman	45 (64.3)	8 (62)
Not reported	1	–
Race		
Asian	12 (17.1)	2 (15)
Black	3 (4.3)	1 (8)
White	51 (72.9)	9 (69)
Other/Multiple	4 (5.7)	1 (8)
Not reported	1	–
Ethnicity		
Not Hispanic	67 (98.5)	12 (92)
Hispanic	1 (1.5)	1 (8)
Not reported	3	
Resident level		
1st Year/PGY-1/R1	25 (35.2)	7 (54)
2nd Year/PGY-2/R2	22 (31.0)	3 (23)
3rd Year/PGY-3/R3	24 (33.8)	3 (23)
Medical degree		
MD	47 (66.2)	–[a]
DO	23 (32.4)	–[a]
MBBS	1 (1.4)	–[a]
Academic medical center		
Yes	34 (47.9)	13 (100)
No	37 (52.1)	–
Rurality		
Rural or Frontier	10 (14.1)	–
Suburban	24 (33.8)	–
Urban	37 (52.1)	13 (100)
Census region		
Northeast	12 (16.9)	–
Midwest	16 (22.5)	13 (100)
South	26 (36.6)	–
West	17 (24.0)	–

[a] Not measured.

2. Methods

2.1. Measures

Resident physicians self-reported how well they knew, and how frequently they implemented, all 31 USPSTF grade A or B recommendations promulgated by USPSTF as of 2020 relating to non-pregnant adults. Knowledge was rated on a four-level scale (know in detail, mostly know, know a little, or do not know). Implementation was rated on a five-level scale (always, often, sometimes, rarely, never).

For knowledge, the survey asked "how much did you know about each of these recommendations immediately prior to starting this survey?" and gave a short summary of the recommendation, adapted from the USPSTF description (United States Preventive Services Task Force, 2020). For implementation, the survey asked "Think about office visits over the last six months with adults that have been primarily about preventive care. How frequently have you applied the following USPSTF recommendations?" and stated the title of the recommendation.

Demographic and professional characteristics were also collected, viz.: age, sex, gender, race, ethnicity, year in residency, academic vs community practice setting, rurality, location, and academic degree.

2.2. Population and survey implementation

The survey was distributed electronically using REDCap (Harris, 2019; Harris, 2009). We first distributed the survey locally, as a pilot, to the 27 family medicine resident physicians at the University of Kansas Medical Center in January and February 2020. Resident physicians were also given in-person reminders to consider completing the survey during an afternoon lecture series.

We then distributed the survey at multiple centers. Invitations to participate were posted to the Association of Family Medicine Residency Directors listserv, with a request that Program Directors (faculty responsible for a residency) forward a survey link to their resident physicians. The initial invitation was sent March 1, 2021, with reminders April 8, 2021, and May 19, 2021. Data collection remained open until June 30, 2021 (upon which most resident physicians "graduate" or are promoted to the next "year" of residency). Survey results for the local and multicenter sample were analyzed separately.

The local survey response rate could be directly calculated because all 27 resident physicians can be assumed to have been aware of the survey due to numerous announcements. For the multicenter survey, the distribution method prevented direct enumeration of individuals exposed to the survey invitation, but this can nevertheless be estimated. The number of individuals exposed to the survey invitation depends on how many program directors elected to forward the survey invitation to their resident physicians and how often the residents actually opened the invitation e-mail (the "open rate"). We assumed that for every program with at least one respondent, the director forwarded the survey to all resident physicians in the program. Program size was estimated using the total number of filled positions in the American Academy of Family Physicians Residency Directory (American Academy of Family Physicians, 2021). Four programs had missing data in this directory and their residency size was estimated from their websites. We finally estimated a lower bound on the multicenter survey response rate by assuming a 100 % open rate and an upper bound on the response rate by assuming a 20 % open rate. (A 20 % "open rate" is common in mass e-mail and marketing campaigns) (Intuit Mailchimp, 2022; Campaign Monitor, 2022).

2.3. Statistical analysis

Descriptive statistics were calculated using R v. 3.6.1. Diverging bar graphs were created using custom software written in C#. Comparisons between groups used the Kruskal-Wallis rank sum test. The false discovery rate of multiple comparisons was controlled by adjusting the p-values using the Benjamini-Hochberg procedure. We restricted comparisons to the multicenter sample, and to hypotheses with the strongest scientific rationale, to limit the total number of hypotheses tested to further limit detection of spurious correlations associated with multiple hypothesis testing. Moreover, we stratified outcomes only by provider sex and practice setting. Respondents from the same residency might have correlated responses ("cluster") and we performed a *post hoc* control analysis to evaluate the impact of clustering on our results using the Rosner-Glynn-Lee correction to the Wilcoxon rank sum test (Jiang et al., 2020; Rosner et al., 2003). Because we considered the possibility of a monotonic – though not necessarily linear – relationship between knowledge and implementation of recommendations, we analyzed rank orders. Implementation and knowledge were rank-ordered by (1) the sum of 'always' and 'often' implemented and the sum of 'know in detail' and 'mostly know', and, to break ties, by (2) 'always' implemented and 'know in detail'. Linear regression on knowledge and implementation rank orders was performed.

2.4. Human subjects protection

The University of Kansas Medical Center Institutional Review Board approved this study.
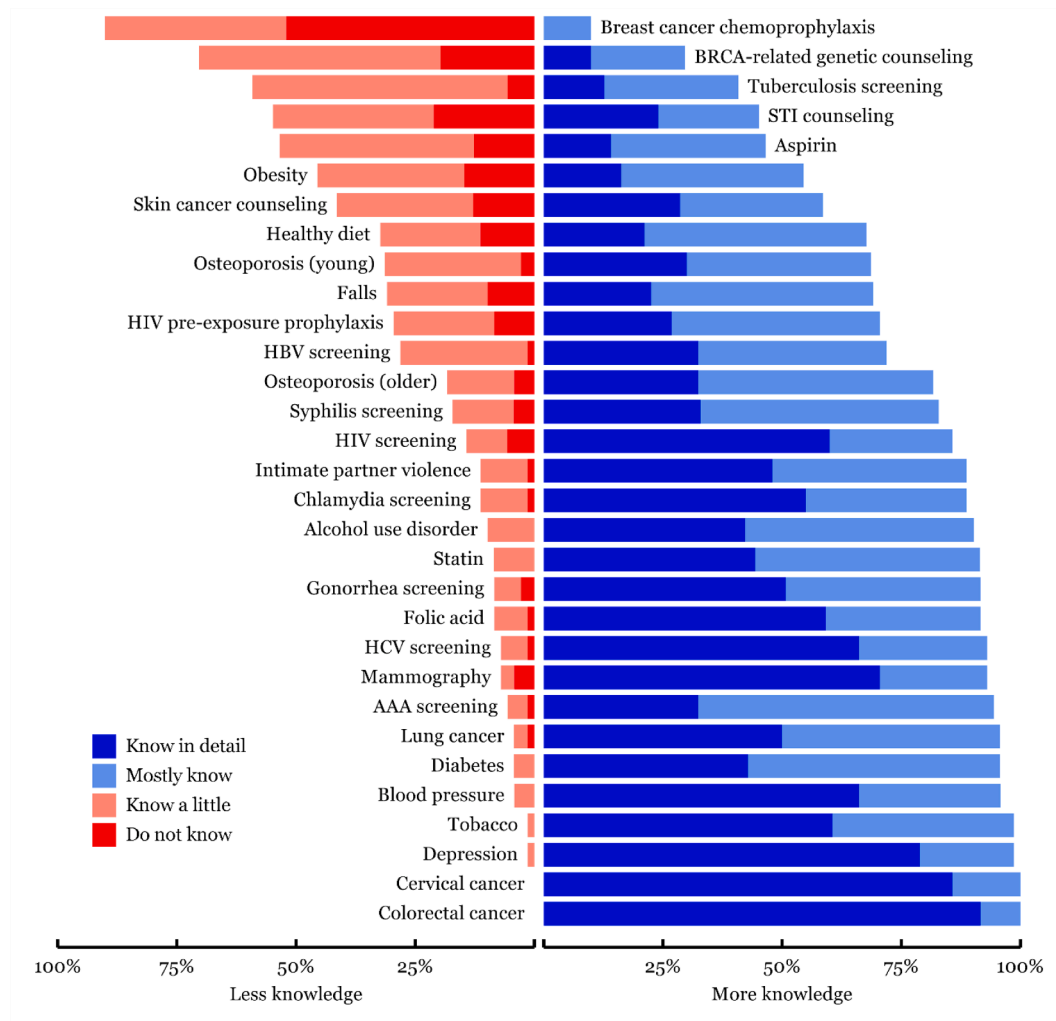
Fig. 1. Knowledge of USPSTF recommendations among US family medicine resident physicians. Residents (N = 71) were asked to self-report the extent to which they know USPSTF recommendations applying to non-pregnant adults. Stronger responses (know in detail, do not know) are clustered on the midline with weaker responses towards the periphery. Residents have low knowledge of breast cancer recommendations other than mammography, tuberculosis screening, counseling for sexually transmitted infections and aspirin prophylaxis. AAA, abdominal aorta aneurysm; BRCA, Breast cancer gene; HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus; STI, sexually transmitted infection.

3. Results

3.1. Respondent characteristics and response rate

Thirteen resident physicians responded to the local survey and 71 resident physicians responded to the multicenter survey (characteristics summarized in Table 1). Respondents to the multicenter survey were drawn from 39 residency programs in 24 states; all US census regions are well-represented. No individual residency dominated the sample; the largest cluster of respondents from a single residency program comprised 8 individuals. First-, second-, and third-year residents were included in approximately equal proportion in the multicenter sample. About half of the multicenter sample practiced in an academic environment (48 %), as did all residents in the local sample. Residents were well-distributed across urban, suburban, and rural/frontier settings in the multicenter sample. The response rate for the local survey was 48 % (13 of 27). For the multicenter survey, we estimated between 168 and 843 individuals were exposed to the survey invitation (see Methods) and we received 71 responses, with a response rate between 8.4 % (lower bound) and 42 % (upper bound). (Note that our analysis of response rate takes as the denominator the total number of resident physicians exposed to the survey invitation, but this is still <1 % of all U.S. family

medicine residents).

3.2. Knowledge of preventive care recommendations

Knowledge of preventive care guidelines varied widely by topic in the multicenter sample (Fig. 1 and Appendix Table A1). Virtually all resident physicians reported they "know in detail" or "mostly know" recommendations for colorectal cancer screening (100 %), cervical cancer screening (100 %), depression screening (99 %), tobacco use counseling (99 %), blood pressure screening (96 %) and diabetes (96 %). By contrast, only 9.9 % of residents "mostly know" recommendations related to breast cancer chemoprophylaxis and no resident reported knowing that recommendation in detail. Indeed, more than half (52 %) of residents reported that they simply "do not know" that recommendation at all. Similarly, most residents lacked knowledge of recommendations for BRCA-related genetic counseling (BRCA-GC) referral (30 % "know in detail" or "mostly know"), tuberculosis screening (41 %), sexually transmitted infection (STI) counseling (45 %), and aspirin prophylaxis (46 %). Even among residents in their final year of residency, knowledge of these recommendations remained poor (**Appendix Table A2**): 21 % for breast cancer chemoprophylaxis, 25 % for BRCA-GC, 42 % for tuberculosis screening, 42 % for STI counseling, and 63 % for
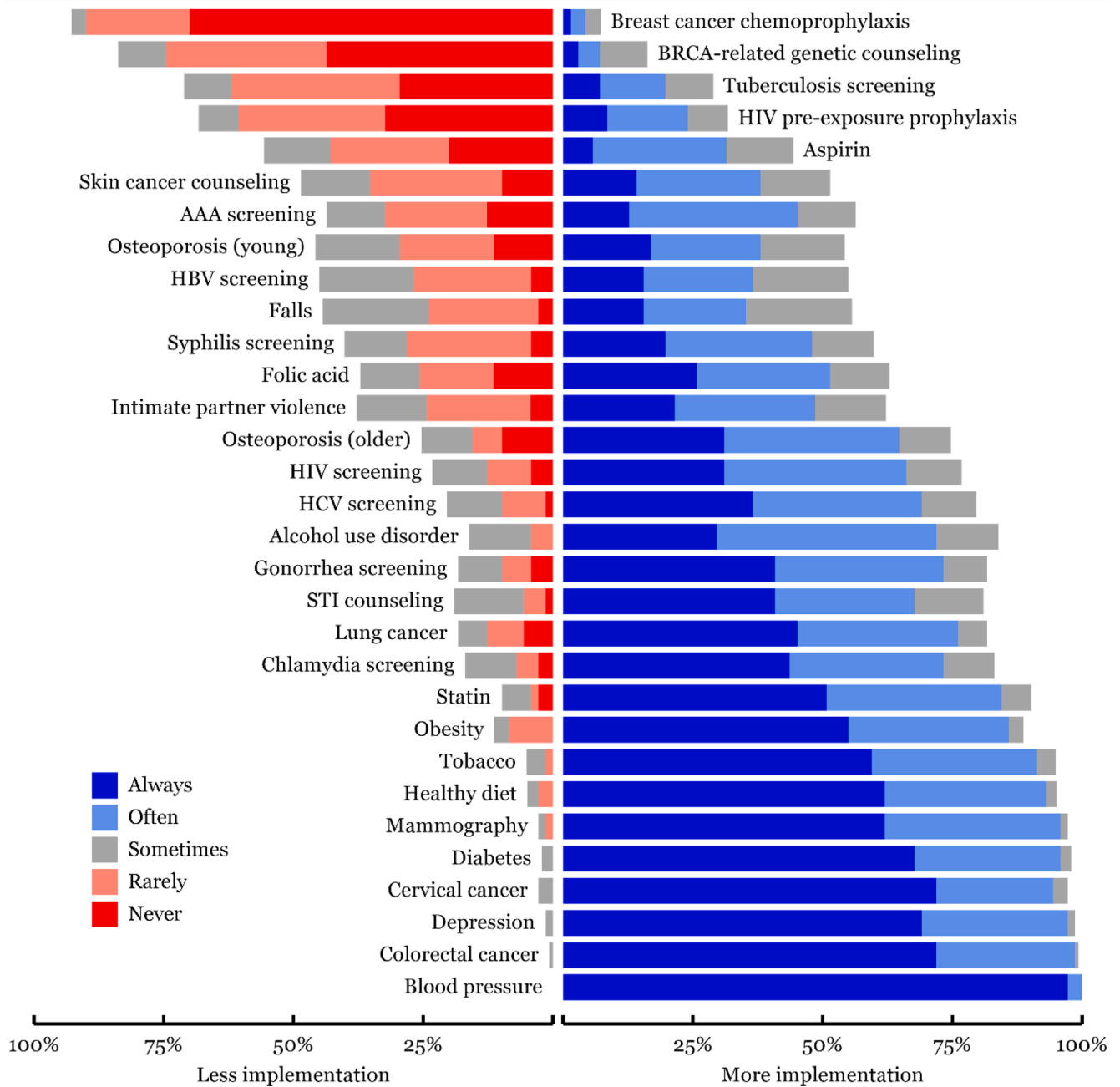
Fig. 2. Implementation of USPSTF recommendations among US family medicine resident physicians. Residents (N = 71) were asked to self-report the extent to which they implemented USPSTF recommendations applying to non-pregnant adults. Results are summarized in the figure below. Stronger responses (always, never) are clustered on the midline with weaker responses towards the periphery. "Sometimes" is split in half and appears partially on both left and right sides of the figure. Residents report that they do not consistently implement breast cancer recommendations other than mammography, tuberculosis screening, HIV pre-exposure prophylaxis or aspirin use. AAA, abdominal aorta aneurysm; BRCA, Breast cancer gene; HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus; STI, sexually transmitted infection.

aspirin prophylaxis. A strikingly similar pattern of results was found in the local sample (compare Fig. 1 with **Appendix** Fig. A1 and see **Appendix** Table A3). There was a strong correlation between local and multicenter results (Spearman R^2 = 0.59; **Appendix** Fig. A2).

3.3. Implementation of preventive care recommendations

Similarly, there was marked variation in the implementation of preventive care recommendations in the multicenter sample (Fig. 2 and **Appendix** Table A4). Screening for hypertension was almost universally implemented (100 % "always" or "often" implementing this

recommendation, with 97 % "always" implementing this recommendation). Colorectal cancer screening (99 %), depression screening (99 %), diabetes (96 %), cervical cancer screening (94 %), mammography (96 %), healthy diet (93 %) and tobacco use (91 %) were also highly implemented. In contrast, there is virtually no implementation of breast cancer chemoprophylaxis (90 % "never" or "rarely" implement). Similarly, many residents "never" or "rarely" implement recommendations for BRCA-GC referral (75 %), tuberculosis screening (62 %), HIV pre-exposure prophylaxis (61 %), and aspirin prophylaxis (42 %). This is again true even among 3rd year residents: 96 % never/rarely implement breast cancer chemoprophylaxis, 79 % for BRCA-GC referral, 67 % for
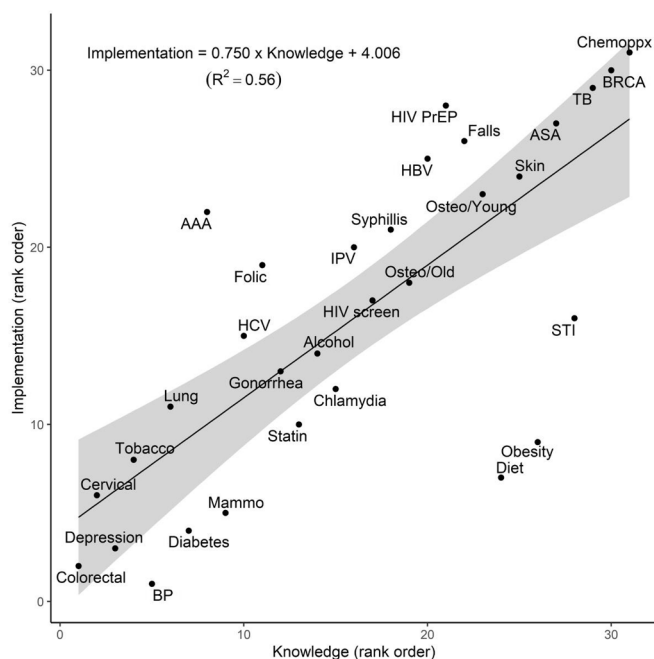
Fig. 3. Relationship between rank order of knowledge and implementation of USPSTF recommendations. Recommendations were ranked between 1 (most) and 31 (least) for knowledge and implementation by (1) the sum of 'always' and 'often' implemented and the sum of 'know in detail' and 'mostly know', and then by (2) 'always' implemented and 'know in detail'. There is a strong correlation between knowledge and implementation of USPSTF recommendations (Spearman $R^2 = 0.56$). The linear model (dark line) and 95 % confidence interval for the model (gray region) are shown. AAA, abdominal aortic aneurysm; ASA, aspirin; BP, blood pressure, BRCA, BRCA-related genetic counseling referral; Chemoppx, Breast cancer chemoprophylaxis; HBV, hepatitis B virus screening; HCV, hepatitis C virus screening; HIV, human immunodeficiency virus screening; HIV PrEP, human deficiency virus pre-exposure prophylaxis; IPV, intimate partner violence; Mammo, mammography; Osteo, osteoporosis; STI, sexually transmitted infection counseling; TB, tuberculosis.

tuberculosis screening, 67 % for HIV pre-exposure prophylaxis, and 38 % for aspirin prophylaxis (**Appendix Table A5**). A similar pattern of results was again found in the local sample (compare Fig. 2 with **Appendix Fig. A3** and see **Appendix Table A6**). There was a strong correlation between local and multicenter results (Spearman $R^2 = 0.77$; **Appendix Fig. A4**).

We wondered if implementation of referral to BRCA-GC depended on availability of genetic counselors. We did not collect data on availability of genetic counseling (self-report of referral service availability is likely to be inaccurate, especially since most participants report poor knowledge and implementation of this referral recommendation). We reasoned, however, genetic counseling is likely more available at academic centers. Interestingly, our data do not support a difference in BRCA-GC referral implementation at academic centers as compared to community environments (Benjamini-Hochberg adjusted Kruskal-Wallis p = 0.66, **Appendix Tables A7 and A8**).

3.4. Association between physician sex and implementation of recommendations

We also investigated whether physician sex impacts implementation of sex-specific recommendations (**Appendix Tables A8 and A9**). We hypothesized that recommendations pertaining to the physicians own sex would be more salient. We found significant differences in the implementation of BRCA-GC referral ("always" or "often" implement in 11 % female vs 0 % male physicians; adjusted Kruskal-Wallis p = 0.019), cervical cancer screening (100 % female vs 83 % male, adjusted p =

0.019), and folic acid supplementation (66 % female vs 29 % male, adjusted p = 0.007). Of these, male and female physicians differed only in their knowledge (**Appendix Tables A8 and A10**) of cervical cancer screening recommendations (96 % female physicians "know in detail" vs 71 % male, adjusted p = 0.019), not folic acid knowledge (adjusted p = 0.42) or BRCA-GC referral knowledge (adjusted p = 0.19). Factors other than physician knowledge thus likely mediate differences in implementation. We did not find an association between physician sex and implementation of screening mammography, intimate partner violence screening or AAA screening (adjusted p > 0.05, **Appendix Tables A8 and A9**). Control analyses using the Rosner-Glynn-Lee correction for clustering effects (Jiang et al., 2020; Rosner et al., 2003) attenuated the strength of some of these relationships (**Appendix Table A8**).

3.5. Association between knowledge and implementation of recommendations

Lastly, we evaluated whether there was a relationship between knowledge and implementation of recommendations (Fig. 3). As expected, we found a strong relationship between knowledge and implementation rank order (β = 0.75; 95 % CI 0.50–1.00; p < 0.001; Spearman $R^2 = 0.56$). Notable outliers from this trend include (1) AAA screening, which is implemented less frequently than knowledge would predict, and (2) STI screening, healthful diet promotion, and obesity interventions, which are all implemented more frequently than knowledge would predict.

3.6. Control analyses to evaluate for non-response bias

Due to the multicenter survey distribution method, we could not directly measure, but could estimate upper- and lower-bounds on the multicenter survey response rate: 8.4 % to 42 %. We further evaluated for evidence of non-response bias in the multicenter sample using three common methods (Lewis et al., 2013): (1) applying continuum of resistance theory to check for differences in earlier and later respondents, (2) comparing respondent demographics to family medicine residents generally, and (3) comparing local results (with known higher response rate, and thus less susceptible to nonresponse bias) to the multicenter data. These analyses failed to find evidence of non-response bias and are described in detail in **Appendix Results,** supported by **Appendix Figs. A1-A8** and **Appendix Tables A11** (Accreditation Council for Graduate Medical Education, 2021).

4. Discussion

We evaluated self-reported knowledge and implementation of USPSTF recommendations among family medicine resident physicians. First, we evaluated this at our local institution and received responses from about half of our resident physicians. These data are sufficient to draw the conclusion that, although some USPSTF recommendations are broadly understood and implemented, there are many important gaps in knowledge and practice. From this a question of generalizability emerged: Are we merely an outlier program, or is our experience reflective of a broader multicenter problem? To evaluate this, we conducted a multicenter survey that, likewise, revealed many important gaps in knowledge and practice that mirrored the trends in our local data (**Appendix Fig. A2** and **Appendix Fig. A4**). This is suggestive – although, owing to some methodological limitations as discussed below, not definitive – that the trends seen in our local data are present at multiple centers.

In our data, the most severe deficits are related to breast cancer chemoprophylaxis, BRCA-GC referral, tuberculosis screening, HIV pre-exposure prophylaxis, and aspirin prophylaxis. Alarmingly, deficits persist even among residents approaching the end of their postgraduate training. Nevertheless, there are some causes for hope: For 19 of the 31 recommendations, >75 % of residents reported they "know in detail" or
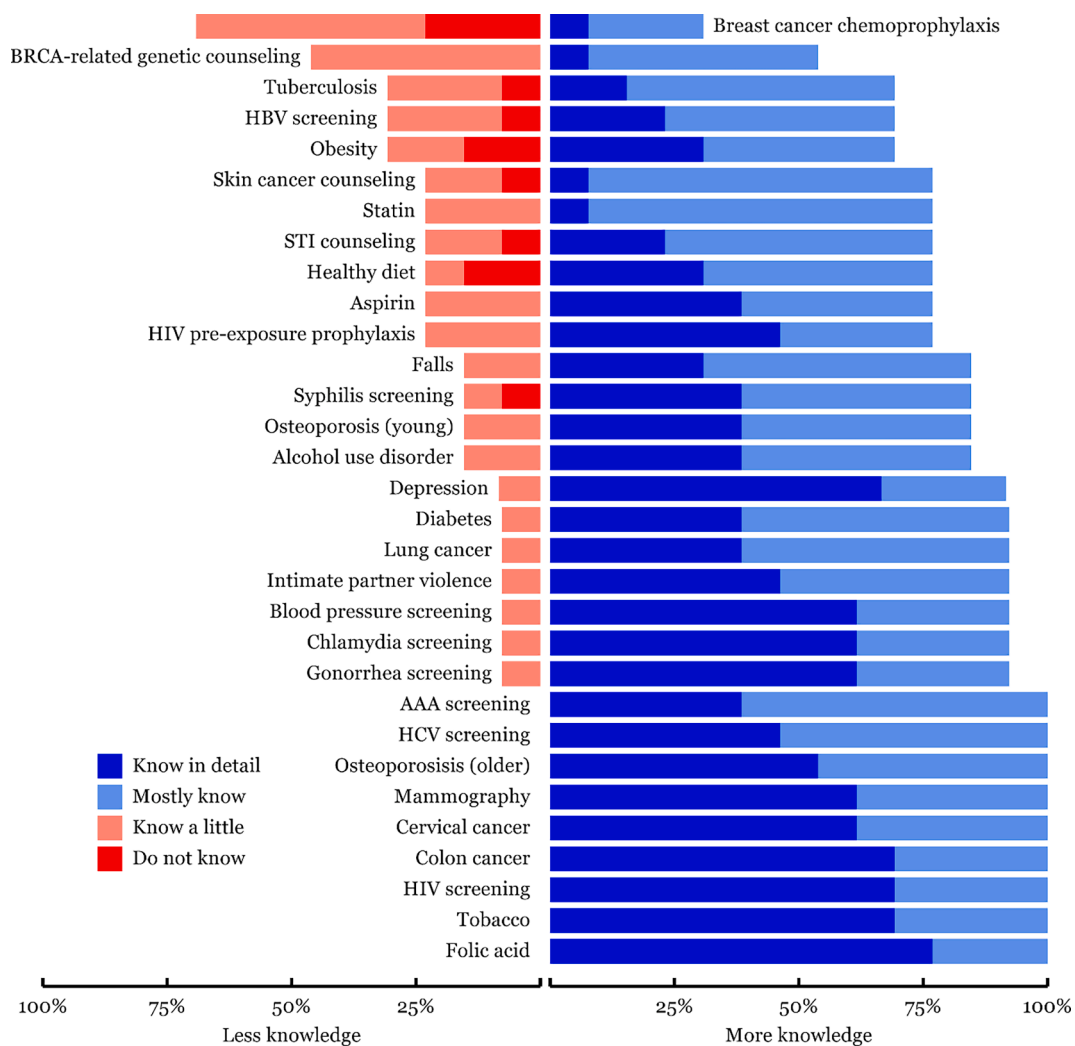
Fig. A1. Knowledge of USPSTF recommendations among local (University of Kansas Family Medicine) resident physicians. Residents (N = 13 of 27; 48 %) were asked to self-report the extent to which they know USPSTF recommendations applying to non-pregnant adults. Stronger responses (know in detail, do not know) are clustered on the midline with weaker responses towards the periphery. AAA, abdominal aorta aneurysm; BRCA, Breast cancer gene; HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus; STI, sexually transmitted infection.

"mostly know" the guideline.

Breast cancer chemoprophylaxis is infrequently implemented even among practicing (attending) physicians (Corbelli et al., 2014; Armstrong et al., 2006; Owens, 2019; Kaplan et al., 2005). Implementation of this recommendation requires knowledge that (1) a recommendation for chemoprophylaxis exists, (2) familiarity with breast cancer risk stratification, and (3) willingness to prescribe tamoxifen or raloxifene. Resident implementation of this recommendation further depends on attending physician comfort with these factors. Inadequate experience with this recommendation during residency likely creates attending physicians who are uncomfortable with breast cancer chemoprophylaxis. Likewise, attending physicians uncomfortable with breast cancer chemoprophylaxis are unlikely to feel comfortable supervising resident physicians who want to provision chemoprophylaxis in appropriate settings. Intentional efforts to disrupt this feedback loop during residency may be required.

Similarly, implementation of BRCA-GC referral relies on (1) knowledge that the recommendation exists, (2) accessibility of genetic counseling services, and (3) familiarity with BRCA-GC referral risk stratification. We recently reported that about 1 in 4 women meet referral criteria for BRCA-GC services, but that almost all this need is unmet (Parente, 2020). Consistent with this, we found that resident physicians poorly know and infrequently implement this

recommendation. We did not find support for correlation between practice environment (academic vs community) and implementation of this recommendation. Meanwhile, the recommendation's instructions for performing genetic counseling referral risk stratification are remarkably muddled. USPSTF recommends seven different possible risk stratification systems and leaves physicians to choose between them, simply stating "each risk assessment tool has advantages and limitations and [USPSTF] found insufficient evidence to recommend one over another." In our clinical practice we have anecdotally observed that resident physicians frequently do not know which of these instruments to use, and we speculate that an abundance of possible risk stratification choices results in residents making no choice at all. Adverse outcomes in the setting of too-many-choices has been referred to in the behavioral economics literature as the "Paradox of Choice" (Schwartz, 2004). Future analyses should investigate this possibility. Greater specificity by USPSTF regarding which instrument to use under common clinical scenarios may help alleviate this barrier.

Inadequate implementation of preventive care recommendations may also have deleterious consequences for public health, not merely individual patients. Resident physicians do not know (41 %) or implement (20 %) recommendations for tuberculosis screening and fail to implement recommendations for HIV pre-exposure prophylaxis (24 %). Implementation of recommendations for syphilis (48 %), gonorrhea (73

Fig. A2. Comparison between the rank order of recommendation knowledge in the local (University of Kansas Family Medicine) sample as compared to the multicenter sample.

%), and chlamydia (73 %) is inconsistent despite generally high levels knowledge of these recommendations (83 %, 82 % and 89 %, respectively). Failure to implement these recommendations represents a missed opportunity to stop the spread of these pathogens within communities.

Finally, inadequate implementation of HIV pre-exposure prophylaxis recommendations is likely to exacerbate structural inequality in healthcare. Black-identifying adults and adolescents have an HIV incidence 8.4-fold higher than their White counterparts (47.5 versus 5.6 per 100,000 per year) (Kaiser Family Foundation, 2020). Moreover, among Black gay and bisexual men, the prevalence of HIV approaches 39 % (Kaiser Family Foundation, 2020; Centers for Disease Control and Prevention, 2017). Failure to implement recommendations for HIV pre-exposure prophylaxis will therefore disproportionally affect minority communities that are already experiencing structural disadvantages in healthcare.

Knowledge and implementation of recommendations is strongly related ($R^2 = 0.56$), but the causality of this relationship is not determined by our data. Possibly greater knowledge of a recommendation results in greater implementation. If so, then knowledge-enhancing strategies (*e.g.*, formal didactic education) may increase implementation. Alternatively, resident physicians may preferentially implement recommendations that they perceive to be "important" and, through repeated clinical exposure, become knowledgeable about these topics. If this is the case, then strategies that emphasize the importance of less-implemented recommendations – rather than mere education about the recommendations – may lead to greater knowledge and
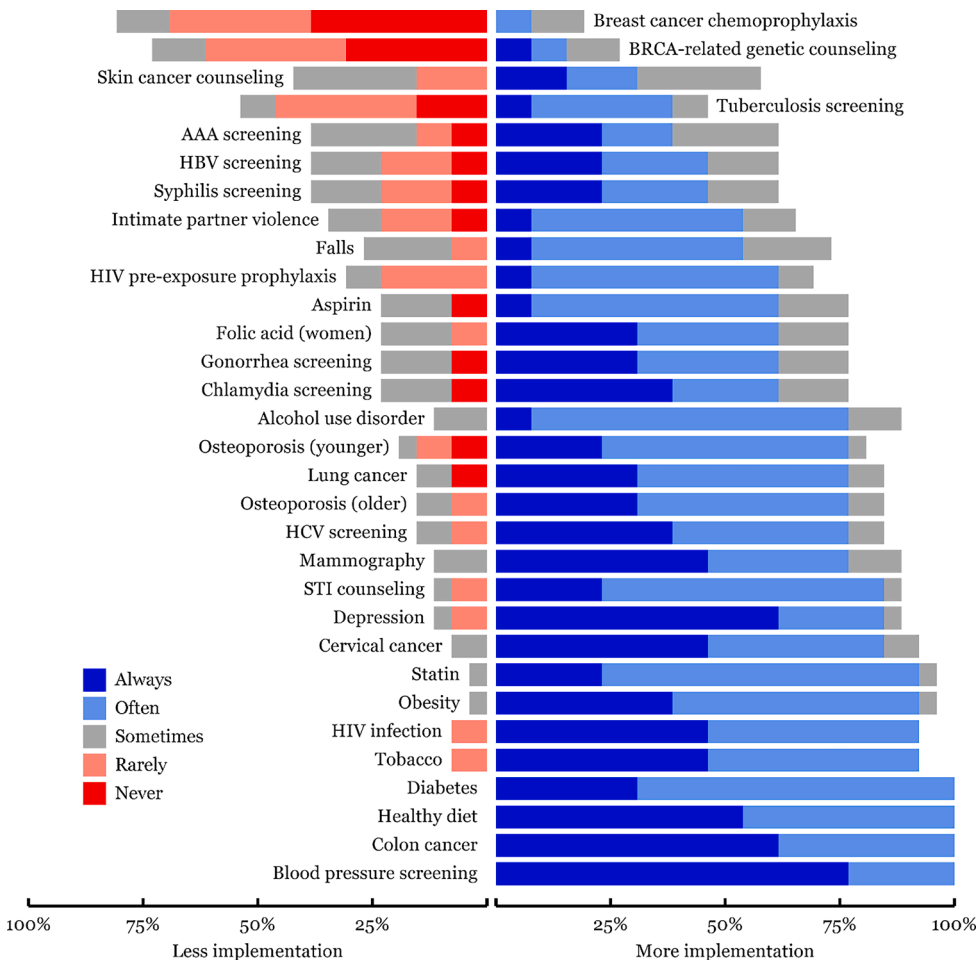
Fig. A3. Implementation of USPSTF recommendations among local (University of Kansas Family Medicine) resident physicians. Residents (N = 13 of 27; 48 %) were asked to self-report the extent to which they implemented USPSTF recommendations applying to non-pregnant adults. Stronger responses (always, never) are clustered on the midline with weaker responses towards the periphery. AAA, abdominal aorta aneurysm; BRCA, Breast cancer gene; HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus; STI, sexually transmitted infection.

Implementation (Multicenter) = 0.875 × Implementation (Local) + 1.994
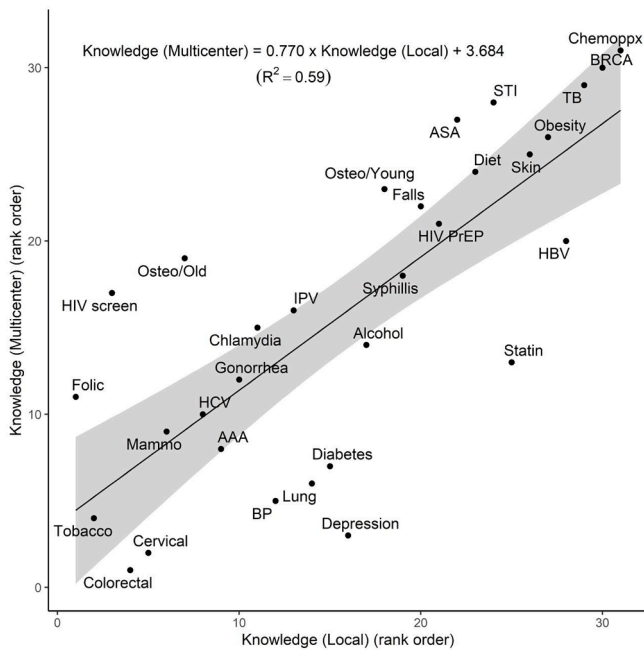
$(R^2 = 0.77)$
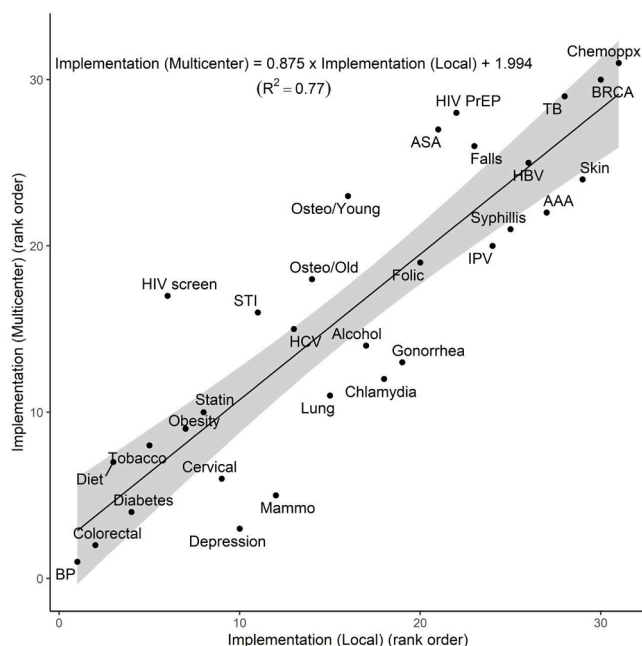
Fig. A4. Comparison between the rank order of recommendation frequency of implementation in the local (University of Kansas Family Medicine) sample as compared to the multicenter sample.

implementation of these recommendations. Indeed, merely providing education about recommendations that resident physician do not perceive to be important is likely to be ineffective, or even unwelcome. Interventions may also need to be targeted at multiple levels: at both resident physicians and the attending physicians who supervise them. Moreover, because the resident physicians of today are the attending physicians of tomorrow, efforts to improve resident physician competency in preventive care are likely to pay dividends in improved training for years to come. Contrastingly, neglecting to robustly address these training gaps is likely to result in inadequate resident training for many more years.

This study has limitations. Knowledge and implementation frequency are self-reported estimates and the scales used to measure them (*e.g.*, "Always," "Often," etc.) have not been validated for these specific

questions. The sample size of both the multicenter and local samples are modest. The local survey had a relatively high response rate (48 %) which reduces the risk of non-response bias. For the multicenter survey, we could not directly measure the response rate, but were able to estimate upper- and lower-bounds: 8.4 % to 42 % of residents who received the survey. We estimate that between 167 and 843 residents were exposed to the survey invitation. Note that this is only a small fraction of the ∼ 13000 family medicine residents training nationwide (characteristics of which are described in **Appendix** Table A11). National electronic surveys commonly have low response rates (*e.g.*, Pew Research polls commonly achieve response rates between 5 and 15 %) (Pew Research Center, 2020). Even if the response rate of the multicenter sample were closer to the lower bound, this worst-case lower bound actually exceeds the response rate for one of the "gold standard" surveys of Family Medicine resident physicians: the Council of Academic Family Medicine (CAFM) Educational Research Alliance (CERA) survey. In 2020, the CERA survey of resident physicians received responses from only 283 of 5000 respondents (response rate 5.7 %). Lower response rates are not – in and of themselves – bad except insofar as they increase the likelihood of non-response bias. We nevertheless evaluated for non-response bias using three separate methods and did not find evidence of non-response bias. This suggests – but does not definitively establish – that even if the multicenter response rate were closer to the lower-bound we estimated that non-response bias is not seriously impacting our key results and conclusions. Our initial statistical analysis also did not account for clustering of responses within residencies. Although no residency dominated the responses (the largest cluster contained eight respondents), control analyses accounting for clustering attenuated the relationships between physician sex and knowledge/implementation of sex-specific recommendations. Future analyses should be designed *a priori* to account for clustering among respondents.

Our analyses here focused on family medicine resident physicians and on recommendations that apply to nonpregnant adults. Recommendations applying to children and to pregnant persons are, ostensibly, within the scope of family medicine residents, but we chose not to interrogate them here to avoid making our 75-item survey even longer than it already was. Other providers – *e.g.*, internal medicine physicians, obstetricians/gynecologists (OB/Gyn) – also routinely implement USPSTF recommendations. Similar analyses should be conducted among internal medicine and OB/Gyn resident physicians. We speculate that similar results would be obtained among internal medicine resident physicians – due to the similarity of patient panel and scope of practice –
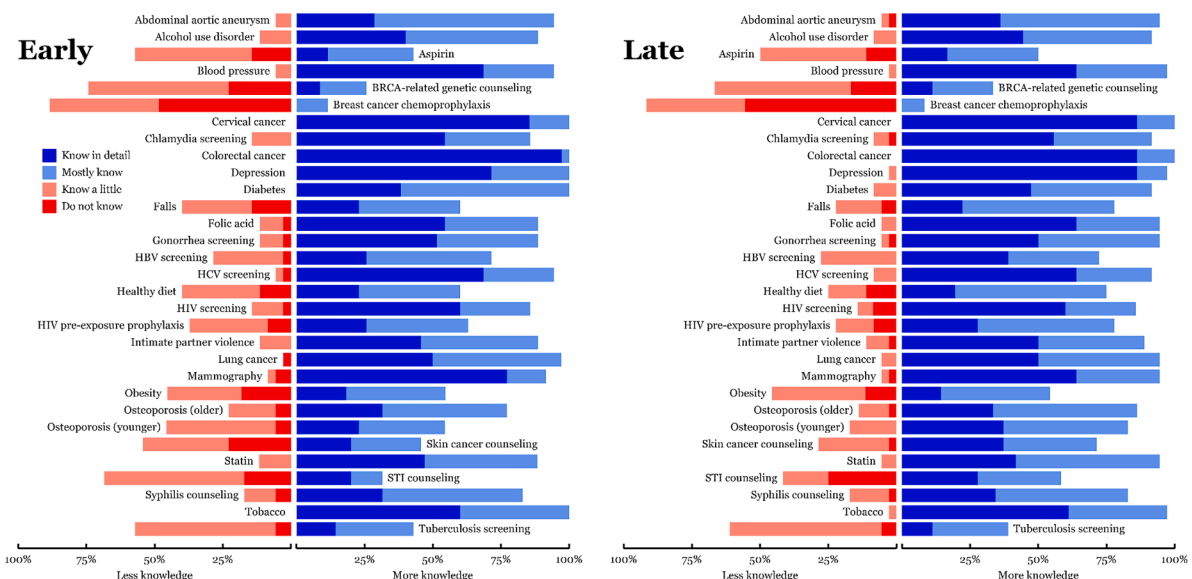
Fig. A5. Comparison between self-reported knowledge among early and late respondents (multicenter).
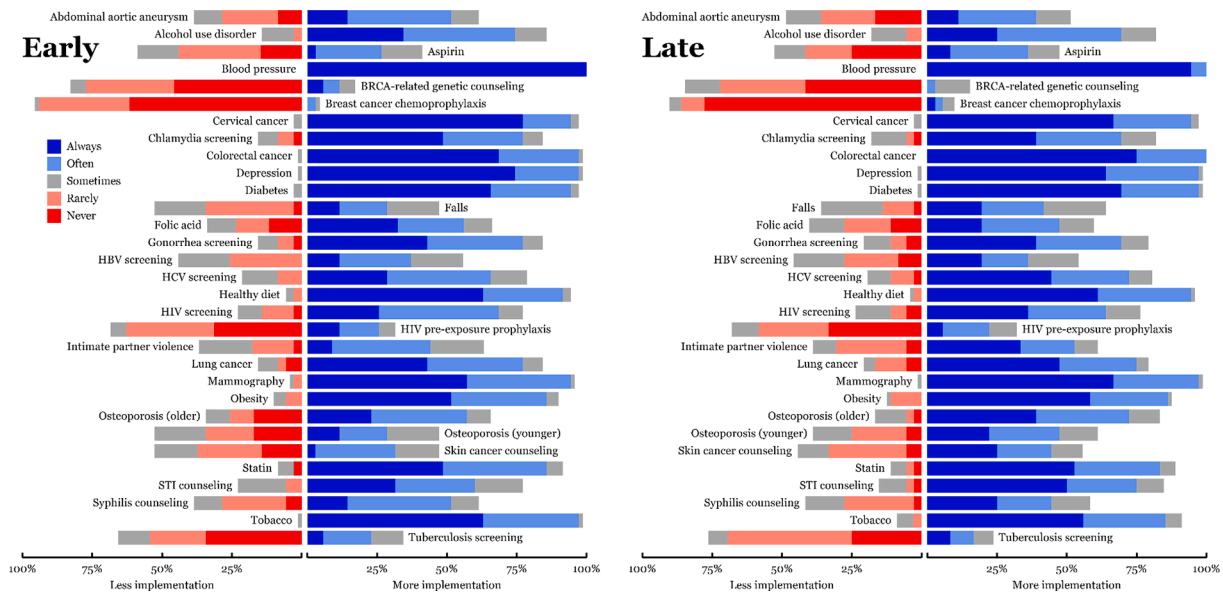
Fig. A6. Comparison between self-reported implementation frequency among early and late respondents (multicenter).
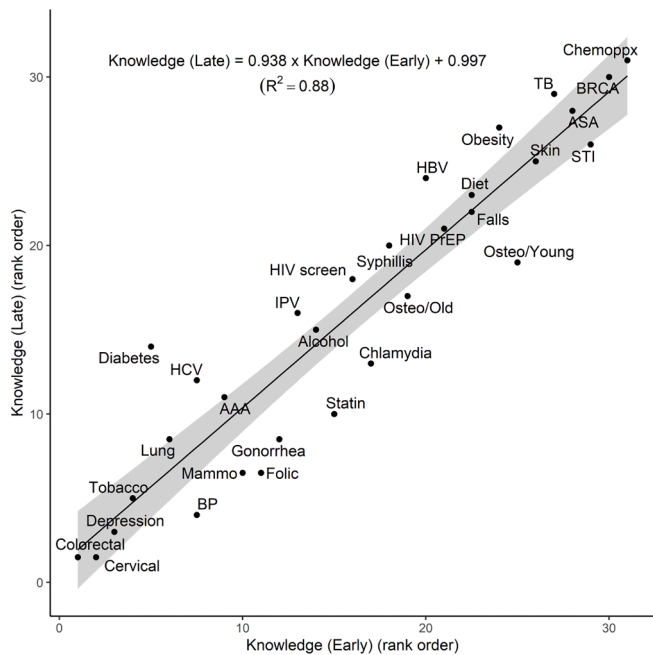
Fig. A7. Relationship between rank order of knowledge among early and late respondents (multicenter). Recommendations were ranked between 1 (most) and 31 (least) for knowledge by the sum of 'know in detail' and 'mostly know', and then by (2) 'know in detail'. There is a strong correlation between knowledge of recommendations reported by early and late respondents (Spearman $R^2 = 0.88$). The linear model (dark line) and 95 % confidence interval for the model (gray region) are shown. AAA, abdominal aortic aneurysm; ASA, aspirin; BP, blood pressure, BRCA, BRCA-related genetic counseling referral; Chemoppx, Breast cancer chemoprophylaxis; HBV, hepatitis B virus screening; HCV, hepatitis C virus screening; HIV, human immunodeficiency virus screening; HIV PrEP, human deficiency virus pre-exposure prophylaxis; IPV, intimate partner violence; Mammo, mammography; Osteo, osteoporosis; STI, sexually transmitted infection counseling; TB, tuberculosis.
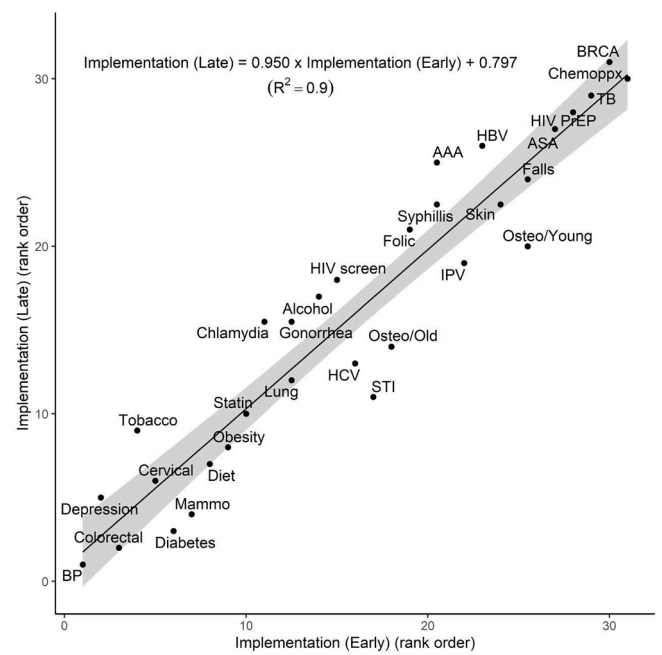
Fig. A8. Relationship between rank order of implementation among early and late respondents (multicenter). Recommendations were ranked between 1 (most) and 31 (least) for implementation by the sum of ''always' and 'often', and then by (2) 'always'. There is a strong correlation between implementation of recommendations reported by early and late respondents (Spearman $R^2 = 0.90$). The linear model (dark line) and 95 % confidence interval for the model (gray region) are shown. AAA, abdominal aortic aneurysm; ASA, aspirin; BP, blood pressure, BRCA, BRCA-related genetic counseling referral; Chemoppx, Breast cancer chemoprophylaxis; HBV, hepatitis B virus screening; HCV, hepatitis C virus screening; HIV, human immunodeficiency virus screening; HIV PrEP, human deficiency virus pre-exposure prophylaxis; IPV, intimate partner violence; Mammo, mammography; Osteo, osteoporosis; STI, sexually transmitted infection counseling; TB, tuberculosis.

Table A1
Self-reported knowledge among multicenter respondents.

	No. (%)				
Recommendation	Know in detail	Mostly know	Know a little	Do not know	No answer
Abdominal aortic aneurysm	23 (32.4)	44 (62.0)	3 (4.2)	1 (1.4)	–
Alcohol use disorder	30 (42.3)	34 (47.9)	7 (9.9)	–	–
Aspirin	10 (14.1)	23 (32.4)	29 (40.8)	9 (12.7)	–
Blood pressure	47 (66.2)	21 (29.6)	3 (4.2)	–	–
BRCA-related GC	7 (9.9)	14 (19.7)	36 (50.7)	14 (19.7)	–
Breast cancer chemoppx	–	7 (9.9)	27 (38.0)	37 (52.1)	–
Cervical cancer	60 (85.7)	10 (14.3)	–	–	1
Chlamydia screening	39 (54.9)	24 (33.8)	7 (9.9)	1 (1.4)	–
Colorectal cancer	65 (91.5)	6 (8.5)	–	–	–
Depression	56 (78.9)	14 (19.7)	1 (1.4)	–	–
Diabetes	30 (42.9)	37 (52.9)	3 (4.3)	–	1
Falls	16 (22.5)	33 (46.5)	15 (21.1)	7 (9.9)	–
Folic acid	42 (59.2)	23 (32.4)	5 (7.0)	1 (1.4)	–
Gonorrhea screening	36 (50.7)	29 (40.8)	4 (5.6)	2 (2.8)	–
HBV screening	23 (32.4)	28 (39.4)	19 (26.8)	1 (1.4)	–
HCV screening	47 (66.2)	19 (26.8)	4 (5.6)	1 (1.4)	–
Healthy diet	15 (21.1)	33 (46.5)	15 (21.1)	8 (11.3)	–
HIV screening	42 (60.0)	18 (25.7)	6 (8.6)	4 (5.7)	1
HIV PrEP	19 (26.8)	31 (43.7)	15 (21.1)	6 (8.5)	–
Intimate partner violence	34 (47.9)	29 (40.8)	7 (9.9)	1 (1.4)	–
Lung cancer	35 (50.0)	32 (45.7)	2 (2.9)	1 (1.4)	1
Mammography	50 (70.4)	16 (22.5)	2 (2.8)	3 (4.2)	–
Obesity	11 (16.2)	26 (38.2)	21 (30.9)	10 (14.7)	3
Osteoporosis (older)	23 (32.4)	35 (49.3)	10 (14.1)	3 (4.2)	–
Osteoporosis (younger)	21 (30.0)	27 (38.6)	20 (28.6)	2 (2.9)	1
Skin cancer counseling	20 (28.6)	21 (30.0)	20 (28.6)	9 (12.9)	1
Statin	31 (44.3)	33 (47.1)	6 (8.6)	–	1
STI counseling	17 (23.9)	15 (21.1)	24 (33.8)	15 (21.1)	–
Syphilis counseling	23 (32.9)	35 (50.0)	9 (12.9)	3 (4.3)	1
Tobacco	43 (60.6)	27 (38.0)	1 (1.4)	–	–
Tuberculosis screening	9 (12.7)	20 (28.2)	38 (53.5)	4 (5.6)	–

Table A2
Self-reported knowledge stratified by years of residency training (multicenter).

	No. (%)				
Recommendation/Level	Know in detail	Mostly know	Know a little	Do not know	No answer
Abdominal aortic aneurysm					
1st Year/PGY-1/R1	7 (28.0)	16 (64.0)	2 (8.0)	–	–
2nd Year/PGY-2/R2	7 (31.8)	14 (63.6)	1 (4.5)	–	–
3rd Year/PGY-3/R3	9 (37.5)	14 (58.3)	–	1 (4.2)	–
Alcohol use disorder					
1st Year/PGY-1/R1	14 (56.0)	9 (36.0)	2 (8.0)	–	–
2nd Year/PGY-2/R2	8 (36.4)	12 (54.5)	2 (9.1)	–	–
3rd Year/PGY-3/R3	8 (33.3)	13 (54.2)	3 (12.5)	–	–
Aspirin					
1st Year/PGY-1/R1	2 (8.0)	12 (48.0)	8 (32.0)	3 (12.0)	–
2nd Year/PGY-2/R2	1 (4.5)	3 (13.6)	13 (59.1)	5 (22.7)	–
3rd Year/PGY-3/R3	7 (29.2)	8 (33.3)	8 (33.3)	1 (4.2)	–
Blood pressure					
1st Year/PGY-1/R1	16 (64.0)	7 (28.0)	2 (8.0)	–	–
2nd Year/PGY-2/R2	14 (63.6)	7 (31.8)	1 (4.5)	–	–
3rd Year/PGY-3/R3	17 (70.8)	7 (29.2)	–	–	–
BRCA-related genetic counseling					
1st Year/PGY-1/R1	1 (4.0)	6 (24.0)	15 (60.0)	3 (12.0)	–
2nd Year/PGY-2/R2	3 (13.6)	5 (22.7)	8 (36.4)	6 (27.3)	–
3rd Year/PGY-3/R3	3 (12.5)	3 (12.5)	13 (54.2)	5 (20.8)	–
Breast cancer chemoprophylaxis					
1st Year/PGY-1/R1	–	2 (8.0)	8 (32.0)	15 (60.0)	–
2nd Year/PGY-2/R2	–	–	8 (36.4)	14 (63.6)	–
3rd Year/PGY-3/R3	–	5 (20.8)	11 (45.8)	8 (33.3)	–
Cervical cancer					
1st Year/PGY-1/R1	21 (87.5)	3 (12.5)	–	–	1
2nd Year/PGY-2/R2	19 (86.4)	3 (13.6)	–	–	–
3rd Year/PGY-3/R3	20 (83.3)	4 (16.7)	–	–	–
Chlamydia screening					
1st Year/PGY-1/R1	13 (52.0)	9 (36.0)	2 (8.0)	1 (4.0)	–
2nd Year/PGY-2/R2	12 (54.5)	6 (27.3)	4 (18.2)	–	–
3rd Year/PGY-3/R3	14 (58.3)	9 (37.5)	1 (4.2)	–	–
Colorectal cancer					
1st Year/PGY-1/R1	23 (92.0)	2 (8.0)	–	–	–
2nd Year/PGY-2/R2	19 (86.4)	3 (13.6)	–	–	–

Table A2 (*continued*)

Recommendation/Level	No. (%)				
	Know in detail	Mostly know	Know a little	Do not know	No answer
3rd Year/PGY-3/R3	23 (95.8)	1 (4.2)	–	–	–
Depression					
1st Year/PGY-1/R1	20 (80.0)	4 (16.0)	1 (4.0)	–	–
2nd Year/PGY-2/R2	16 (72.7)	6 (27.3)	–	–	–
3rd Year/PGY-3/R3	20 (83.3)	4 (16.7)	–	–	–
Diabetes					
1st Year/PGY-1/R1	9 (37.5)	14 (58.3)	1 (4.2)	–	1
2nd Year/PGY-2/R2	9 (40.9)	11 (50.0)	2 (9.1)	–	–
3rd Year/PGY-3/R3	12 (50.0)	12 (50.0)	–	–	–
Falls					
1st Year/PGY-1/R1	6 (24.0)	13 (52.0)	5 (20.0)	1 (4.0)	–
2nd Year/PGY-2/R2	6 (27.3)	7 (31.8)	4 (18.2)	5 (22.7)	–
3rd Year/PGY-3/R3	4 (16.7)	13 (54.2)	6 (25.0)	1 (4.2)	–
Folic acid					
1st Year/PGY-1/R1	15 (60.0)	7 (28.0)	2 (8.0)	1 (4.0)	–
2nd Year/PGY-2/R2	10 (45.5)	10 (45.5)	2 (9.1)	–	–
3rd Year/PGY-3/R3	17 (70.8)	6 (25.0)	1 (4.2)	–	–
Gonorrhea screening					
1st Year/PGY-1/R1	13 (52.0)	10 (40.0)	1 (4.0)	1 (4.0)	–
2nd Year/PGY-2/R2	12 (54.5)	6 (27.3)	3 (13.6)	1 (4.5)	–
3rd Year/PGY-3/R3	11 (45.8)	13 (54.2)	–	–	–
HBV screening					
1st Year/PGY-1/R1	11 (44.0)	7 (28.0)	7 (28.0)	–	–
2nd Year/PGY-2/R2	6 (27.3)	9 (40.9)	6 (27.3)	1 (4.5)	–
3rd Year/PGY-3/R3	6 (25.0)	12 (50.0)	6 (25.0)	–	–
HCV screening					
1st Year/PGY-1/R1	16 (64.0)	7 (28.0)	2 (8.0)	–	–
2nd Year/PGY-2/R2	17 (77.3)	3 (13.6)	1 (4.5)	1 (4.5)	–
3rd Year/PGY-3/R3	14 (58.3)	9 (37.5)	1 (4.2)	–	–
Healthy diet					
1st Year/PGY-1/R1	8 (32.0)	8 (32.0)	7 (28.0)	2 (8.0)	–
2nd Year/PGY-2/R2	5 (22.7)	9 (40.9)	6 (27.3)	2 (9.1)	–
3rd Year/PGY-3/R3	2 (8.3)	16 (66.7)	2 (8.3)	4 (16.7)	–
HIV screening					
1st Year/PGY-1/R1	17 (70.8)	5 (20.8)	1 (4.2)	1 (4.2)	1
2nd Year/PGY-2/R2	16 (72.7)	1 (4.5)	4 (18.2)	1 (4.5)	–
3rd Year/PGY-3/R3	9 (37.5)	12 (50.0)	1 (4.2)	2 (8.3)	–
HIV pre-exposure prophylaxis					
1st Year/PGY-1/R1	9 (36.0)	9 (36.0)	5 (20.0)	2 (8.0)	–
2nd Year/PGY-2/R2	6 (27.3)	10 (45.5)	4 (18.2)	2 (9.1)	–
3rd Year/PGY-3/R3	4 (16.7)	12 (50.0)	6 (25.0)	2 (8.3)	–
Intimate partner violence					
1st Year/PGY-1/R1	13 (52.0)	11 (44.0)	1 (4.0)	–	–
2nd Year/PGY-2/R2	12 (54.5)	5 (22.7)	5 (22.7)	–	–
3rd Year/PGY-3/R3	9 (37.5)	13 (54.2)	1 (4.2)	1 (4.2)	–
Lung cancer					
1st Year/PGY-1/R1	7 (29.2)	16 (66.7)	–	1 (4.2)	1
2nd Year/PGY-2/R2	15 (68.2)	6 (27.3)	1 (4.5)	–	–
3rd Year/PGY-3/R3	13 (54.2)	10 (41.7)	1 (4.2)	–	–
Mammography					
1st Year/PGY-1/R1	19 (76.0)	4 (16.0)	1 (4.0)	1 (4.0)	–
2nd Year/PGY-2/R2	15 (68.2)	5 (22.7)	–	2 (9.1)	–
3rd Year/PGY-3/R3	16 (66.7)	7 (29.2)	1 (4.2)	–	–
Obesity					
1st Year/PGY-1/R1	6 (25.0)	5 (20.8)	10 (41.7)	3 (12.5)	1
2nd Year/PGY-2/R2	4 (20.0)	9 (45.0)	4 (20.0)	3 (15.0)	2
3rd Year/PGY-3/R3	1 (4.2)	12 (50.0)	7 (29.2)	4 (16.7)	–
Osteoporosis (older)					
1st Year/PGY-1/R1	8 (32.0)	14 (56.0)	1 (4.0)	2 (8.0)	–
2nd Year/PGY-2/R2	9 (40.9)	7 (31.8)	5 (22.7)	1 (4.5)	–
3rd Year/PGY-3/R3	6 (25.0)	14 (58.3)	4 (16.7)	–	–
Osteoporosis (younger)					
1st Year/PGY-1/R1	8 (32.0)	9 (36.0)	7 (28.0)	1 (4.0)	–
2nd Year/PGY-2/R2	7 (31.8)	5 (22.7)	9 (40.9)	1 (4.5)	–
3rd Year/PGY-3/R3	6 (26.1)	13 (56.5)	4 (17.4)	–	1
Skin cancer counseling					
1st Year/PGY-1/R1	8 (32.0)	7 (28.0)	10 (40.0)	–	–
2nd Year/PGY-2/R2	10 (45.5)	1 (4.5)	5 (22.7)	6 (27.3)	–
3rd Year/PGY-3/R3	2 (8.7)	13 (56.5)	5 (21.7)	3 (13.0)	1
Statin					
1st Year/PGY-1/R1	8 (32.0)	15 (60.0)	2 (8.0)	–	–
2nd Year/PGY-2/R2	12 (54.5)	7 (31.8)	3 (13.6)	–	–
3rd Year/PGY-3/R3	11 (47.8)	11 (47.8)	1 (4.3)	–	1

Table A2 (*continued*)

Recommendation/Level	No. (%)				
	Know in detail	Mostly know	Know a little	Do not know	No answer
STI counseling					
1st Year/PGY-1/R1	8 (32.0)	5 (20.0)	7 (28.0)	5 (20.0)	–
2nd Year/PGY-2/R2	5 (22.7)	4 (18.2)	10 (45.5)	3 (13.6)	–
3rd Year/PGY-3/R3	4 (16.7)	6 (25.0)	7 (29.2)	7 (29.2)	–
Syphilis counseling					
1st Year/PGY-1/R1	10 (41.7)	13 (54.2)	1 (4.2)	–	1
2nd Year/PGY-2/R2	8 (36.4)	10 (45.5)	2 (9.1)	2 (9.1)	–
3rd Year/PGY-3/R3	5 (20.8)	12 (50.0)	6 (25.0)	1 (4.2)	–
Tobacco					
1st Year/PGY-1/R1	17 (68.0)	8 (32.0)	–	–	–
2nd Year/PGY-2/R2	13 (59.1)	9 (40.9)	–	–	–
3rd Year/PGY-3/R3	13 (54.2)	10 (41.7)	1 (4.2)	–	–
Tuberculosis screening					
1st Year/PGY-1/R1	4 (16.0)	5 (20.0)	15 (60.0)	1 (4.0)	–
2nd Year/PGY-2/R2	2 (9.1)	8 (36.4)	11 (50.0)	1 (4.5)	–
3rd Year/PGY-3/R3	3 (12.5)	7 (29.2)	12 (50.0)	2 (8.3)	–

but that OB/Gyn physicians may have a markedly different pattern of knowledge and implementation of USPSTF recommendations (*e.g.*, it seems unlikely that OB/Gyns routinely consider tuberculosis screening, but we speculate might feel more comfortable offering breast cancer chemoprophylaxis). Likewise, our analyses do not evaluate implementation of these recommendations among board-certified (*i.e.*, non-resident) physicians. This group should also be systematically studied. Similarly, we did not inquire how respondents became aware of

recommendations, or whether they nevertheless managed to implement the recommendation despite unaware of the USPSTF as its source. Future analyses with qualitative or mixed-methods designs would be more appropriate to investigate these issues.

In summary, we demonstrate that there are critical gaps in knowledge and implementation of preventive care recommendations among family medicine resident physicians in our local sample and provide preliminary evidence that these gaps are reflective of broader multi-center trends. Inherent limitations in our methodology and small sample size preclude a definitive conclusion that these gaps are widespread among the >13000 family medicine residents nationally. Our results are, nevertheless, suggestive that such gaps may exist, and this would have grave implications for cancer prevention, public health, and health equity. We suggest residency program directors should urgently develop interventions to locally evaluate and improve knowledge and implementation of USPSTF recommendations. Furthermore, we recommend national organizations with the resources and authority to conduct a larger national survey – such as the American Board of Family Medicine, the American Board of Internal Medicine, and the ACGME – act quickly to *definitively* evaluate the scope of this problem, and then enforce standards that ensure that resident physicians will be adequately trained in preventive care so they may appropriately serve their patients.

Table A3
Self-reported knowledge among local residents.

Recommendation	No. (%)				
	Know in detail	Mostly know	Know a little	Do not know	No answer
Abdominal aortic aneurysm	5 (38.5)	8 (61.5)	–	–	–
Alcohol use disorder	5 (38.5)	6 (46.2)	2 (15.4)	–	–
Aspirin	5 (38.5)	5 (38.5)	3 (23.1)	–	–
Blood pressure	8 (61.5)	4 (30.8)	1 (7.7)	–	–
BRCA-related GC	1 (7.7)	6 (46.2)	6 (46.2)	–	–
Breast cancer chemoppx	1 (7.7)	3 (23.1)	6 (46.2)	3 (23.1)	–
Cervical cancer	8 (61.5)	5 (38.5)	–	–	–
Chlamydia screening	8 (61.5)	4 (30.8)	1 (7.7)	–	–
Colorectal cancer	9 (69.2)	4 (30.8)	–	–	–
Depression	8 (66.7)	3 (25.0)	1 (8.3)	–	1
Diabetes	5 (38.5)	7 (53.8)	1 (7.7)	–	–
Falls	4 (30.8)	7 (53.8)	2 (15.4)	–	–
Folic acid	10 (76.9)	3 (23.1)	–	–	–
Gonorrhea screening	8 (61.5)	4 (30.8)	1 (7.7)	–	–
HBV screening	3 (23.1)	6 (46.2)	3 (23.1)	1 (7.7)	–
HCV screening	6 (46.2)	7 (53.8)	–	–	–
Healthy diet	4 (30.8)	6 (46.2)	1 (7.7)	2 (15.4)	–
HIV screening	9 (69.2)	4 (30.8)	–	–	–
HIV PrEP	6 (46.2)	4 (30.8)	3 (23.1)	–	–
Intimate partner violence	6 (46.2)	6 (46.2)	1 (7.7)	–	–
Lung cancer	5 (38.5)	7 (53.8)	1 (7.7)	–	–
Mammography	8 (61.5)	5 (38.5)	–	–	–
Obesity	4 (30.8)	5 (38.5)	2 (15.4)	2 (15.4)	–
Osteoporosis (older)	7 (53.8)	6 (46.2)	–	–	–
Osteoporosis (younger)	5 (38.5)	6 (46.2)	2 (15.4)	–	–
Skin cancer counseling	1 (7.7)	9 (69.2)	2 (15.4)	1 (7.7)	–
Statin	1 (7.7)	9 (69.2)	3 (23.1)	–	–
STI counseling	3 (23.1)	7 (53.8)	2 (15.4)	1 (7.7)	–
Syphilis counseling	5 (38.5)	6 (46.2)	1 (7.7)	1 (7.7)	–
Tobacco	9 (69.2)	4 (30.8)	–	–	–
Tuberculosis screening	2 (15.4)	7 (53.8)	3 (23.1)	1 (7.7)	–

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CRediT authorship contribution statement

Kelsie Kelly: Conceptualization, Investigation, Writing – review & editing. **Daniel J. Parente:** Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Table A4

Self-reported implementation frequency among multicenter residents.

Recommendation	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
Abdominal aortic aneurysm	9 (12.7)	23 (32.4)	16 (22.5)	14 (19.7)	9 (12.7)	–
Alcohol use disorder	21 (29.6)	30 (42.3)	17 (23.9)	3 (4.2)	–	–
Aspirin	4 (5.7)	18 (25.7)	18 (25.7)	16 (22.9)	14 (20.0)	1
Blood pressure	69 (97.2)	2 (2.8)	–	–	–	–
BRCA-related GC	2 (2.8)	3 (4.2)	13 (18.3)	22 (31.0)	31 (43.7)	–
Breast cancer chemoppx	1 (1.4)	2 (2.9)	4 (5.7)	14 (20.0)	49 (70.0)	1
Cervical cancer	51 (71.8)	16 (22.5)	4 (5.6)	–	–	–
Chlamydia screening	31 (43.7)	21 (29.6)	14 (19.7)	3 (4.2)	2 (2.8)	–
Colorectal cancer	51 (71.8)	19 (26.8)	1 (1.4)	–	–	–
Depression	49 (69.0)	20 (28.2)	2 (2.8)	–	–	–
Diabetes	48 (67.6)	20 (28.2)	3 (4.2)	–	–	–
Falls	11 (15.5)	14 (19.7)	29 (40.8)	15 (21.1)	2 (2.8)	–
Folic acid	18 (25.7)	18 (25.7)	16 (22.9)	10 (14.3)	8 (11.4)	1
Gonorrhea screening	29 (40.8)	23 (32.4)	12 (16.9)	4 (5.6)	3 (4.2)	–
HBV screening	11 (15.5)	15 (21.1)	26 (36.6)	16 (22.5)	3 (4.2)	–
HCV screening	26 (36.6)	23 (32.4)	15 (21.1)	6 (8.5)	1 (1.4)	–
Healthy diet	44 (62.0)	22 (31.0)	3 (4.2)	2 (2.8)	–	–
HIV screening	22 (31.0)	25 (35.2)	15 (21.1)	6 (8.5)	3 (4.2)	–
HIV PrEP	6 (8.5)	11 (15.5)	11 (15.5)	20 (28.2)	23 (32.4)	–
Intimate partner violence	15 (21.4)	19 (27.1)	19 (27.1)	14 (20.0)	3 (4.3)	1
Lung cancer	32 (45.1)	22 (31.0)	8 (11.3)	5 (7.0)	4 (5.6)	–
Mammography	44 (62.0)	24 (33.8)	2 (2.8)	1 (1.4)	–	–
Obesity	39 (54.9)	22 (31.0)	4 (5.6)	6 (8.5)	–	–
Osteoporosis (older)	22 (31.0)	24 (33.8)	14 (19.7)	4 (5.6)	7 (9.9)	–
Osteoporosis (younger)	12 (16.9)	15 (21.1)	23 (32.4)	13 (18.3)	8 (11.3)	–
Skin cancer counseling	10 (14.1)	17 (23.9)	19 (26.8)	18 (25.4)	7 (9.9)	–
Statin	36 (50.7)	24 (33.8)	8 (11.3)	1 (1.4)	2 (2.8)	–
STI counseling	29 (40.8)	19 (26.8)	19 (26.8)	3 (4.2)	1 (1.4)	–
Syphilis counseling	14 (19.7)	20 (28.2)	17 (23.9)	17 (23.9)	3 (4.2)	–
Tobacco	41 (59.4)	22 (31.9)	5 (7.2)	1 (1.4)	–	2
Tuberculosis screening	5 (7.0)	9 (12.7)	13 (18.3)	23 (32.4)	21 (29.6)	–

Chemoppx, chemoprophylaxis; GC, genetic counseling; PrEP, pre-exposure prophylaxis.

Table A5

Self-reported implementation frequency stratified by years of residency training (multicenter).

Recommendation/Level	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
Abdominal aortic aneurysm						
1st Year/PGY-1/R1	1 (4.0)	6 (24.0)	6 (24.0)	8 (32.0)	4 (16.0)	–
2nd Year/PGY-2/R2	3 (13.6)	8 (36.4)	4 (18.2)	4 (18.2)	3 (13.6)	–
3rd Year/PGY-3/R3	5 (20.8)	9 (37.5)	6 (25.0)	2 (8.3)	2 (8.3)	–
Alcohol use disorder						
1st Year/PGY-1/R1	9 (36.0)	12 (48.0)	3 (12.0)	1 (4.0)	–	–
2nd Year/PGY-2/R2	7 (31.8)	9 (40.9)	6 (27.3)	–	–	–
3rd Year/PGY-3/R3	5 (20.8)	9 (37.5)	8 (33.3)	2 (8.3)	–	–
Aspirin						
1st Year/PGY-1/R1	–	12 (50.0)	7 (29.2)	1 (4.2)	4 (16.7)	1
2nd Year/PGY-2/R2	–	1 (4.5)	5 (22.7)	9 (40.9)	7 (31.8)	–
3rd Year/PGY-3/R3	4 (16.7)	5 (20.8)	6 (25.0)	6 (25.0)	3 (12.5)	–
Blood pressure						
1st Year/PGY-1/R1	24 (96.0)	1 (4.0)	–	–	–	–
2nd Year/PGY-2/R2	22 (100)	–	–	–	–	–
3rd Year/PGY-3/R3	23 (95.8)	1 (4.2)	–	–	–	–
BRCA-related genetic counseling						
1st Year/PGY-1/R1	–	2 (8.0)	5 (20.0)	4 (16.0)	14 (56.0)	–
2nd Year/PGY-2/R2	2 (9.1)	1 (4.5)	3 (13.6)	10 (45.5)	6 (27.3)	–
3rd Year/PGY-3/R3	–	–	5 (20.8)	8 (33.3)	11 (45.8)	–
Breast cancer chemoprophylaxis						
1st Year/PGY-1/R1	–	2 (8.3)	3 (12.5)	3 (12.5)	16 (66.7)	1
2nd Year/PGY-2/R2	1 (4.5)	–	–	7 (31.8)	14 (63.6)	–
3rd Year/PGY-3/R3	–	–	1 (4.2)	4 (16.7)	19 (79.2)	–
Cervical cancer						
1st Year/PGY-1/R1	19 (76.0)	6 (24.0)	–	–	–	–
2nd Year/PGY-2/R2	17 (77.3)	3 (13.6)	2 (9.1)	–	–	–
3rd Year/PGY-3/R3	15 (62.5)	7 (29.2)	2 (8.3)	–	–	–
Chlamydia screening						
1st Year/PGY-1/R1	12 (48.0)	8 (32.0)	3 (12.0)	2 (8.0)	–	–
2nd Year/PGY-2/R2	10 (45.5)	7 (31.8)	4 (18.2)	–	1 (4.5)	–
3rd Year/PGY-3/R3	9 (37.5)	6 (25.0)	7 (29.2)	1 (4.2)	1 (4.2)	–
Colorectal cancer						

Table A5 (*continued*)

Recommendation/Level	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
1st Year/PGY-1/R1	17 (68.0)	7 (28.0)	1 (4.0)	–	–	–
2nd Year/PGY-2/R2	17 (77.3)	5 (22.7)	–	–	–	–
3rd Year/PGY-3/R3	17 (70.8)	7 (29.2)	–	–	–	–
Depression						
1st Year/PGY-1/R1	16 (64.0)	8 (32.0)	1 (4.0)	–	–	–
2nd Year/PGY-2/R2	15 (68.2)	7 (31.8)	–	–	–	–
3rd Year/PGY-3/R3	18 (75.0)	5 (20.8)	1 (4.2)	–	–	–
Diabetes						
1st Year/PGY-1/R1	18 (72.0)	7 (28.0)	–	–	–	–
2nd Year/PGY-2/R2	16 (72.7)	5 (22.7)	1 (4.5)	–	–	–
3rd Year/PGY-3/R3	14 (58.3)	8 (33.3)	2 (8.3)	–	–	–
Falls						
1st Year/PGY-1/R1	5 (20.0)	6 (24.0)	9 (36.0)	4 (16.0)	1 (4.0)	–
2nd Year/PGY-2/R2	2 (9.1)	2 (9.1)	11 (50.0)	6 (27.3)	1 (4.5)	–
3rd Year/PGY-3/R3	4 (16.7)	6 (25.0)	9 (37.5)	5 (20.8)	–	–
Folic acid						
1st Year/PGY-1/R1	3 (12.5)	9 (37.5)	4 (16.7)	4 (16.7)	4 (16.7)	1
2nd Year/PGY-2/R2	9 (40.9)	2 (9.1)	6 (27.3)	4 (18.2)	1 (4.5)	–
3rd Year/PGY-3/R3	6 (25.0)	7 (29.2)	6 (25.0)	2 (8.3)	3 (12.5)	–
Gonorrhea screening						
1st Year/PGY-1/R1	10 (40.0)	11 (44.0)	2 (8.0)	1 (4.0)	1 (4.0)	–
2nd Year/PGY-2/R2	10 (45.5)	6 (27.3)	4 (18.2)	1 (4.5)	1 (4.5)	–
3rd Year/PGY-3/R3	9 (37.5)	6 (25.0)	6 (25.0)	2 (8.3)	1 (4.2)	–
HBV screening						
1st Year/PGY-1/R1	5 (20.0)	7 (28.0)	8 (32.0)	4 (16.0)	1 (4.0)	–
2nd Year/PGY-2/R2	2 (9.1)	7 (31.8)	8 (36.4)	5 (22.7)	–	–
3rd Year/PGY-3/R3	4 (16.7)	1 (4.2)	10 (41.7)	7 (29.2)	2 (8.3)	–
HCV screening						
1st Year/PGY-1/R1	10 (40.0)	10 (40.0)	2 (8.0)	3 (12.0)	–	–
2nd Year/PGY-2/R2	7 (31.8)	7 (31.8)	7 (31.8)	1 (4.5)	–	–
3rd Year/PGY-3/R3	9 (37.5)	6 (25.0)	6 (25.0)	2 (8.3)	1 (4.2)	–
Healthy diet						
1st Year/PGY-1/R1	16 (64.0)	8 (32.0)	–	1 (4.0)	–	–
2nd Year/PGY-2/R2	17 (77.3)	5 (22.7)	–	–	–	–
3rd Year/PGY-3/R3	11 (45.8)	9 (37.5)	3 (12.5)	1 (4.2)	–	–
HIV screening						
1st Year/PGY-1/R1	10 (40.0)	9 (36.0)	4 (16.0)	2 (8.0)	–	–
2nd Year/PGY-2/R2	6 (27.3)	10 (45.5)	4 (18.2)	1 (4.5)	1 (4.5)	–
3rd Year/PGY-3/R3	6 (25.0)	6 (25.0)	7 (29.2)	3 (12.5)	2 (8.3)	–
HIV pre-exposure prophylaxis						
1st Year/PGY-1/R1	2 (8.0)	2 (8.0)	4 (16.0)	7 (28.0)	10 (40.0)	–
2nd Year/PGY-2/R2	1 (4.5)	6 (27.3)	5 (22.7)	5 (22.7)	5 (22.7)	–
3rd Year/PGY-3/R3	3 (12.5)	3 (12.5)	2 (8.3)	8 (33.3)	8 (33.3)	–
Intimate partner violence						
1st Year/PGY-1/R1	7 (28.0)	6 (24.0)	4 (16.0)	8 (32.0)	–	–
2nd Year/PGY-2/R2	2 (9.5)	7 (33.3)	8 (38.1)	3 (14.3)	1 (4.8)	1
3rd Year/PGY-3/R3	6 (25.0)	6 (25.0)	7 (29.2)	3 (12.5)	2 (8.3)	–
Lung cancer						
1st Year/PGY-1/R1	11 (44.0)	5 (20.0)	4 (16.0)	2 (8.0)	3 (12.0)	–
2nd Year/PGY-2/R2	9 (40.9)	9 (40.9)	2 (9.1)	1 (4.5)	1 (4.5)	–
3rd Year/PGY-3/R3	12 (50.0)	8 (33.3)	2 (8.3)	2 (8.3)	–	–
Mammography						
1st Year/PGY-1/R1	14 (56.0)	9 (36.0)	1 (4.0)	1 (4.0)	–	–
2nd Year/PGY-2/R2	14 (63.6)	8 (36.4)	–	–	–	–
3rd Year/PGY-3/R3	16 (66.7)	7 (29.2)	1 (4.2)	–	–	–
Obesity						
1st Year/PGY-1/R1	14 (56.0)	7 (28.0)	3 (12.0)	1 (4.0)	–	–
2nd Year/PGY-2/R2	13 (59.1)	7 (31.8)	1 (4.5)	1 (4.5)	–	–
3rd Year/PGY-3/R3	12 (50.0)	8 (33.3)	–	4 (16.7)	–	–
Osteoporosis (older)						
1st Year/PGY-1/R1	6 (24.0)	9 (36.0)	4 (16.0)	2 (8.0)	4 (16.0)	–
2nd Year/PGY-2/R2	5 (22.7)	12 (54.5)	3 (13.6)	1 (4.5)	1 (4.5)	–
3rd Year/PGY-3/R3	11 (45.8)	3 (12.5)	7 (29.2)	1 (4.2)	2 (8.3)	–
Osteoporosis (younger)						
1st Year/PGY-1/R1	5 (20.0)	3 (12.0)	8 (32.0)	5 (20.0)	4 (16.0)	–
2nd Year/PGY-2/R2	3 (13.6)	7 (31.8)	8 (36.4)	4 (18.2)	–	–
3rd Year/PGY-3/R3	4 (16.7)	5 (20.8)	7 (29.2)	4 (16.7)	4 (16.7)	–
Skin cancer counseling						
1st Year/PGY-1/R1	4 (16.0)	4 (16.0)	4 (16.0)	8 (32.0)	5 (20.0)	–
2nd Year/PGY-2/R2	1 (4.5)	6 (27.3)	9 (40.9)	6 (27.3)	–	–
3rd Year/PGY-3/R3	5 (20.8)	7 (29.2)	6 (25.0)	4 (16.7)	2 (8.3)	–
Statin						
1st Year/PGY-1/R1	14 (56.0)	7 (28.0)	2 (8.0)	1 (4.0)	1 (4.0)	–
2nd Year/PGY-2/R2	11 (50.0)	9 (40.9)	2 (9.1)	–	–	–

Table A5 (*continued*)

Recommendation/Level	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
3rd Year/PGY-3/R3	11 (45.8)	8 (33.3)	4 (16.7)	–	1 (4.2)	–
STI counseling						
1st Year/PGY-1/R1	13 (52.0)	7 (28.0)	5 (20.0)	–	–	–
2nd Year/PGY-2/R2	8 (36.4)	4 (18.2)	8 (36.4)	2 (9.1)	–	–
3rd Year/PGY-3/R3	8 (33.3)	8 (33.3)	6 (25.0)	1 (4.2)	1 (4.2)	–
Syphilis counseling						
1st Year/PGY-1/R1	6 (24.0)	4 (16.0)	9 (36.0)	4 (16.0)	2 (8.0)	–
2nd Year/PGY-2/R2	3 (13.6)	11 (50.0)	4 (18.2)	4 (18.2)	–	–
3rd Year/PGY-3/R3	5 (20.8)	5 (20.8)	4 (16.7)	9 (37.5)	1 (4.2)	–
Tobacco						
1st Year/PGY-1/R1	14 (58.3)	8 (33.3)	1 (4.2)	1 (4.2)	–	1
2nd Year/PGY-2/R2	13 (59.1)	8 (36.4)	1 (4.5)	–	–	–
3rd Year/PGY-3/R3	14 (60.9)	6 (26.1)	3 (13.0)	–	–	1
Tuberculosis screening						
1st Year/PGY-1/R1	2 (8.0)	–	8 (32.0)	8 (32.0)	7 (28.0)	–
2nd Year/PGY-2/R2	1 (4.5)	6 (27.3)	2 (9.1)	8 (36.4)	5 (22.7)	–
3rd Year/PGY-3/R3	2 (8.3)	3 (12.5)	3 (12.5)	7 (29.2)	9 (37.5)	–

Data availability

Data will be made available on request.

Appendix

Appendix A. Results

Control analyses to evaluate for non-response bias

Due to the multicenter survey distribution method, we could not directly measure, but could estimate upper- and lower-bounds on the multicenter survey response rate: 8.4 % to 42 %. We further evaluated for evidence of non-response bias in the multicenter sample using three common methods (Lewis et al., 2013): (1) applying continuum of resistance theory to check for differences in earlier and later respondents, (2) comparing respondent demographics to family medicine residents generally, and (3) comparing local results (with known higher response rate, and thus less susceptible to nonresponse bias) to the multicenter data.

First, we applied continuum of resistance theory – which proposes that later respondents are "almost" non-respondents – to evaluate whether there are differences between early and later respondents (Lewis et al., 2013). Response profiles (**Appendix** Figs. A5 and A6) among early and late respondents are similar. Moreover, correlation in the rank order of responses between early and late respondents are

Table A6
Self-reported implementation frequency among local residents.

Recommendation	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
Abdominal aortic aneurysm	3 (23.1)	2 (15.4)	6 (46.2)	1 (7.7)	1 (7.7)	–
Alcohol use disorder	1 (7.7)	9 (69.2)	3 (23.1)	–	–	–
Aspirin	1 (7.7)	7 (53.8)	4 (30.8)	–	1 (7.7)	–
Blood pressure	10 (76.9)	3 (23.1)	–	–	–	–
BRCA-related GC	1 (7.7)	1 (7.7)	3 (23.1)	4 (30.8)	4 (30.8)	–
Breast cancer chemoppx	–	1 (7.7)	3 (23.1)	4 (30.8)	5 (38.5)	–
Cervical cancer	6 (46.2)	5 (38.5)	2 (15.4)	–	–	–
Chlamydia screening	5 (38.5)	3 (23.1)	4 (30.8)	–	1 (7.7)	–
Colorectal cancer	8 (61.5)	5 (38.5)	–	–	–	–
Depression	8 (61.5)	3 (23.1)	1 (7.7)	1 (7.7)	–	–
Diabetes	4 (30.8)	9 (69.2)	–	–	–	–
Falls	1 (7.7)	6 (46.2)	5 (38.5)	1 (7.7)	–	–
Folic acid	4 (30.8)	4 (30.8)	4 (30.8)	1 (7.7)	–	–
Gonorrhea screening	4 (30.8)	4 (30.8)	4 (30.8)	–	1 (7.7)	–
HBV screening	3 (23.1)	3 (23.1)	4 (30.8)	2 (15.4)	1 (7.7)	–
HCV screening	5 (38.5)	5 (38.5)	2 (15.4)	1 (7.7)	–	–
Healthy diet	7 (53.8)	6 (46.2)	–	–	–	–
HIV screening	6 (46.2)	6 (46.2)	–	1 (7.7)	–	–
HIV PrEP	1 (7.7)	7 (53.8)	2 (15.4)	3 (23.1)	–	–
Intimate partner violence	1 (7.7)	6 (46.2)	3 (23.1)	2 (15.4)	1 (7.7)	–
Lung cancer	4 (30.8)	6 (46.2)	2 (15.4)	–	1 (7.7)	–
Mammography	6 (46.2)	4 (30.8)	3 (23.1)	–	–	–
Obesity	5 (38.5)	7 (53.8)	1 (7.7)	–	–	–
Osteoporosis (older)	4 (30.8)	6 (46.2)	2 (15.4)	1 (7.7)	–	–
Osteoporosis (younger)	3 (23.1)	7 (53.8)	1 (7.7)	1 (7.7)	1 (7.7)	–
Skin cancer counseling	2 (15.4)	2 (15.4)	7 (53.8)	2 (15.4)	–	–
Statin	3 (23.1)	9 (69.2)	1 (7.7)	–	–	–
STI counseling	3 (23.1)	8 (61.5)	1 (7.7)	1 (7.7)	–	–
Syphilis counseling	3 (23.1)	3 (23.1)	4 (30.8)	2 (15.4)	1 (7.7)	–
Tobacco	6 (46.2)	6 (46.2)	–	1 (7.7)	–	–
Tuberculosis screening	1 (7.7)	4 (30.8)	2 (15.4)	4 (30.8)	2 (15.4)	–

Chemoppx, chemoprophylaxis; GC, genetic counseling; PrEP, pre-exposure prophylaxis.

Table A7
Self-reported implementation frequency stratified by practice setting (multicenter).

Recommendation/Setting	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
Abdominal aortic aneurysm						
Academic	–	13 (38.2)	7 (20.6)	8 (23.5)	6 (17.6)	–
Non-academic	9 (24.3)	10 (27.0)	9 (24.3)	6 (16.2)	3 (8.1)	–
Alcohol use disorder						
Academic	10 (29.4)	13 (38.2)	10 (29.4)	1 (2.9)	–	–
Non-academic	11 (29.7)	17 (45.9)	7 (18.9)	2 (5.4)	–	–
Aspirin						
Academic	1 (2.9)	9 (26.5)	6 (17.6)	10 (29.4)	8 (23.5)	–
Non-academic	3 (8.3)	9 (25.0)	12 (33.3)	6 (16.7)	6 (16.7)	1
Blood pressure						
Academic	34 (100)	–	–	–	–	–
Non-academic	35 (94.6)	2 (5.4)	–	–	–	–
BRCA-related genetic counseling						
Academic	1 (2.9)	2 (5.9)	5 (14.7)	13 (38.2)	13 (38.2)	–
Non-academic	1 (2.7)	1 (2.7)	8 (21.6)	9 (24.3)	18 (48.6)	–
Breast cancer chemoprophylaxis						
Academic	1 (2.9)	1 (2.9)	1 (2.9)	8 (23.5)	23 (67.6)	–
Non-academic	–	1 (2.8)	3 (8.3)	6 (16.7)	26 (72.2)	1
Cervical cancer						
Academic	26 (76.5)	8 (23.5)	–	–	–	–
Non-academic	25 (67.6)	8 (21.6)	4 (10.8)	–	–	–
Chlamydia screening						
Academic	15 (44.1)	13 (38.2)	6 (17.6)	–	–	–
Non-academic	16 (43.2)	8 (21.6)	8 (21.6)	3 (8.1)	2 (5.4)	–
Colorectal cancer						
Academic	25 (73.5)	9 (26.5)	–	–	–	–
Non-academic	26 (70.3)	10 (27.0)	1 (2.7)	–	–	–
Depression						
Academic	24 (70.6)	9 (26.5)	1 (2.9)	–	–	–
Non-academic	25 (67.6)	11 (29.7)	1 (2.7)	–	–	–
Diabetes						
Academic	25 (73.5)	9 (26.5)	–	–	–	–
Non-academic	23 (62.2)	11 (29.7)	3 (8.1)	–	–	–
Falls						
Academic	4 (11.8)	3 (8.8)	17 (50.0)	10 (29.4)	–	–
Non-academic	7 (18.9)	11 (29.7)	12 (32.4)	5 (13.5)	2 (5.4)	–
Folic acid						
Academic	8 (24.2)	11 (33.3)	8 (24.2)	4 (12.1)	2 (6.1)	1
Non-academic	10 (27.0)	7 (18.9)	8 (21.6)	6 (16.2)	6 (16.2)	–
Gonorrhea						
Academic	14 (41.2)	15 (44.1)	3 (8.8)	2 (5.9)	–	–
Non-academic	15 (40.5)	8 (21.6)	9 (24.3)	2 (5.4)	3 (8.1)	–
HBV screening						
Academic	4 (11.8)	10 (29.4)	9 (26.5)	10 (29.4)	1 (2.9)	–
Non-academic	7 (18.9)	5 (13.5)	17 (45.9)	6 (16.2)	2 (5.4)	–
HCV screening						
Academic	11 (32.4)	12 (35.3)	6 (17.6)	5 (14.7)	–	–
Non-academic	15 (40.5)	11 (29.7)	9 (24.3)	1 (2.7)	1 (2.7)	–
Healthy diet						
Academic	22 (64.7)	11 (32.4)	–	1 (2.9)	–	–
Non-academic	22 (59.5)	11 (29.7)	3 (8.1)	1 (2.7)	–	–
HIV screening						
Academic	10 (29.4)	15 (44.1)	6 (17.6)	2 (5.9)	1 (2.9)	–
Non-academic	12 (32.4)	10 (27.0)	9 (24.3)	4 (10.8)	2 (5.4)	–
HIV pre-exposure prophylaxis						
Academic	3 (8.8)	9 (26.5)	7 (20.6)	6 (17.6)	9 (26.5)	–
Non-academic	3 (8.1)	2 (5.4)	4 (10.8)	14 (37.8)	14 (37.8)	–
Intimate partner violence						
Academic	5 (14.7)	10 (29.4)	11 (32.4)	6 (17.6)	2 (5.9)	–
Non-academic	10 (27.8)	9 (25.0)	8 (22.2)	8 (22.2)	1 (2.8)	1
Lung cancer						
Academic	13 (38.2)	11 (32.4)	3 (8.8)	4 (11.8)	3 (8.8)	–
Non-academic	19 (51.4)	11 (29.7)	5 (13.5)	1 (2.7)	1 (2.7)	–
Mammography						
Academic	23 (67.6)	10 (29.4)	–	1 (2.9)	–	–
Non-academic	21 (56.8)	14 (37.8)	2 (5.4)	–	–	–
Obesity						
Academic	17 (50.0)	15 (44.1)	1 (2.9)	1 (2.9)	–	–
Non-academic	22 (59.5)	7 (18.9)	3 (8.1)	5 (13.5)	–	–
Osteoporosis (older)						
Academic	10 (29.4)	13 (38.2)	7 (20.6)	1 (2.9)	3 (8.8)	–
Non-academic	12 (32.4)	11 (29.7)	7 (18.9)	3 (8.1)	4 (10.8)	–
Osteoporosis (younger)						

Table A7 (*continued*)

Recommendation/Setting	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
Academic	3 (8.8)	8 (23.5)	14 (41.2)	4 (11.8)	5 (14.7)	–
Non-academic	9 (24.3)	7 (18.9)	9 (24.3)	9 (24.3)	3 (8.1)	–
Skin cancer counseling						
Academic	4 (11.8)	10 (29.4)	11 (32.4)	6 (17.6)	3 (8.8)	–
Non-academic	6 (16.2)	7 (18.9)	8 (21.6)	12 (32.4)	4 (10.8)	–
Statin						
Academic	18 (52.9)	10 (29.4)	4 (11.8)	1 (2.9)	1 (2.9)	–
Non-academic	18 (48.6)	14 (37.8)	4 (10.8)	–	1 (2.7)	–
STI counseling						
Academic	14 (41.2)	11 (32.4)	8 (23.5)	1 (2.9)	–	–
Non-academic	15 (40.5)	8 (21.6)	11 (29.7)	2 (5.4)	1 (2.7)	–
Syphilis counseling						
Academic	7 (20.6)	13 (38.2)	6 (17.6)	6 (17.6)	2 (5.9)	–
Non-academic	7 (18.9)	7 (18.9)	11 (29.7)	11 (29.7)	1 (2.7)	–
Tobacco						
Academic	18 (52.9)	12 (35.3)	3 (8.8)	1 (2.9)	–	–
Non-academic	23 (65.7)	10 (28.6)	2 (5.7)	–	–	2
Tuberculosis screening						
Academic	2 (5.9)	7 (20.6)	6 (17.6)	10 (29.4)	9 (26.5)	–
Non-academic	3 (8.1)	2 (5.4)	7 (18.9)	13 (35.1)	12 (32.4)	–

Table A8

Kruskal-Wallis test results for knowledge or implementation of various recommendations stratified by either provider sex or practice type (multicenter).
Raw and Benjamini-Hochberg p-values (adjusted for multiple comparisons) are reported. Some comparisons used most – but not all – of the sample (N = 71) due to missing data. Adj., adjusted; p, p-value; Sig; significance, $* p < 0.05$, $** p < 0.01$, $*** p < 0.001$.

Recommendation	Know/Imp	Stratified by	Kruskal-Wallis test					Clustered-corrected Wilcoxon test				
			No.	p	Sig.	Adj. p	Adj. Sig.	No.	p	Sig.	Adj. p.	Adj. Sig.
AAA	Implement	Sex	69	0.217		0.310		69	0.519		0.577	
BRCA GC	Implement	Sex	69	0.009	**	0.021	*	69	0.067		0.163	
BRCA GC	Know	Sex	69	0.696		0.696		69	0.149		0.213	
BRCA GC	Implement	Practice type	71	0.598		0.664		71	0.964		0.964	
Cervical cancer	Implement	Sex	69	0.007	**	0.021	*	69	0.017	*	0.057	
Cervical cancer	Know	Sex	68	0.004	**	0.021	*	68	0.006	**	0.032	*
Folic acid	Implement	Sex	68	<0.001	***	0.007	**	68	0.002	**	0.017	*
Folic acid	Know	Sex	69	0.37		0.462		69	0.360		0.449	
IPV	Implement	Sex	68	0.153		0.255		68	0.124		0.207	
Mammography	Implement	Sex	69	0.106		0.212		69	0.081		0.163	

Table A9

Self-reported implementation frequency stratified by physician biological sex (multicenter).

Recommendation/Sex	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
Abdominal aortic aneurysm						
Male	3 (12.5)	10 (41.7)	6 (25.0)	3 (12.5)	2 (8.3)	–
Female	5 (11.1)	13 (28.9)	10 (22.2)	11 (24.4)	6 (13.3)	–
Sex not reported	1 (50.0)	–	–	–	1 (50.0)	–
Alcohol use disorder						
Male	5 (20.8)	10 (41.7)	7 (29.2)	2 (8.3)	–	–
Female	15 (33.3)	20 (44.4)	9 (20.0)	1 (2.2)	–	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–	–
Aspirin						
Male	2 (8.3)	5 (20.8)	5 (20.8)	8 (33.3)	4 (16.7)	–
Female	2 (4.4)	13 (28.9)	12 (26.7)	8 (17.8)	10 (22.2)	–
Sex not reported	–	–	1 (100.0)	–	–	1
Blood pressure						
Male	22 (91.7)	2 (8.3)	–	–	–	–
Female	45 (100)	–	–	–	–	–
Sex not reported	2 (100)	–	–	–	–	–
BRCA-related genetic counseling						
Male	–	–	4 (16.7)	4 (16.7)	16 (66.7)	–
Female	2 (4.4)	3 (6.7)	9 (20.0)	17 (37.8)	14 (31.1)	–
Sex not reported	–	–	–	1 (50.0)	1 (50.0)	–
Breast cancer chemoprophylaxis						
Male	–	–	3 (13.0)	4 (17.4)	16 (69.6)	1
Female	1 (2.2)	2 (4.4)	1 (2.2)	10 (22.2)	31 (68.9)	–
Sex not reported	–	–	–	–	2 (100.0)	–

Table A9 (*continued*)

Recommendation/Sex	No. (%)					
	Always	Often	Sometimes	Rarely	Never	No answer
Cervical cancer						
Male	13 (54.2)	7 (29.2)	4 (16.7)	–	–	–
Female	37 (82.2)	8 (17.8)	–	–	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–	–
Chlamydia screening						
Male	7 (29.2)	6 (25.0)	6 (25.0)	3 (12.5)	2 (8.3)	–
Female	23 (51.1)	14 (31.1)	8 (17.8)	–	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–	–
Colorectal cancer						
Male	16 (66.7)	8 (33.3)	–	–	–	–
Female	34 (75.6)	11 (24.4)	–	–	–	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–	–
Depression						
Male	11 (45.8)	12 (50.0)	1 (4.2)	–	–	–
Female	37 (82.2)	7 (15.6)	1 (2.2)	–	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–	–
Diabetes						
Male	13 (54.2)	8 (33.3)	3 (12.5)	–	–	–
Female	34 (75.6)	11 (24.4)	–	–	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–	–
Falls						
Male	3 (12.5)	3 (12.5)	12 (50.0)	5 (20.8)	1 (4.2)	–
Female	8 (17.8)	10 (22.2)	17 (37.8)	9 (20.0)	1 (2.2)	–
Sex not reported	–	1 (50.0)	–	1 (50.0)	–	–
Folic acid						
Male	2 (8.3)	5 (20.8)	6 (25.0)	6 (25.0)	5 (20.8)	–
Female	16 (36.4)	13 (29.5)	9 (20.5)	4 (9.1)	2 (4.5)	1
Sex not reported	–	–	1 (50.0)	–	1 (50.0)	–
Gonorrhea screening						
Male	6 (25.0)	7 (29.2)	5 (20.8)	3 (12.5)	3 (12.5)	–
Female	22 (48.9)	15 (33.3)	7 (15.6)	1 (2.2)	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–	–
HBV screening						
Male	6 (25.0)	3 (12.5)	9 (37.5)	3 (12.5)	3 (12.5)	–
Female	5 (11.1)	12 (26.7)	15 (33.3)	13 (28.9)	–	–
Sex not reported	–	–	2 (100.0)	–	–	–
HCV screening						
Male	9 (37.5)	6 (25.0)	7 (29.2)	1 (4.2)	1 (4.2)	–
Female	16 (35.6)	17 (37.8)	7 (15.6)	5 (11.1)	–	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–	–
Healthy diet						
Male	13 (54.2)	8 (33.3)	3 (12.5)	–	–	–
Female	30 (66.7)	13 (28.9)	–	2 (4.4)	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–	–
HIV screening						
Male	7 (29.2)	6 (25.0)	6 (25.0)	3 (12.5)	2 (8.3)	–
Female	14 (31.1)	19 (42.2)	8 (17.8)	3 (6.7)	1 (2.2)	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–	–
HIV pre-exposure prophylaxis						
Male	3 (12.5)	1 (4.2)	2 (8.3)	7 (29.2)	11 (45.8)	–
Female	3 (6.7)	10 (22.2)	9 (20.0)	11 (24.4)	12 (26.7)	–
Sex not reported	–	–	–	2 (100.0)	–	–
Intimate partner violence						
Male	5 (21.7)	5 (21.7)	3 (13.0)	7 (30.4)	3 (13.0)	1
Female	9 (20.0)	14 (31.1)	16 (35.6)	6 (13.3)	–	–
Sex not reported	1 (50.0)	–	–	1 (50.0)	–	–
Lung cancer						
Male	9 (37.5)	8 (33.3)	6 (25.0)	1 (4.2)	–	–
Female	22 (48.9)	14 (31.1)	1 (2.2)	4 (8.9)	4 (8.9)	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–	–
Mammography						
Male	12 (50.0)	10 (41.7)	2 (8.3)	–	–	–
Female	31 (68.9)	13 (28.9)	–	1 (2.2)	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–	–
Obesity						
Male	10 (41.7)	9 (37.5)	2 (8.3)	3 (12.5)	–	–
Female	28 (62.2)	13 (28.9)	1 (2.2)	3 (6.7)	–	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–	–
Osteoporosis (older)						
Male	6 (25.0)	6 (25.0)	7 (29.2)	3 (12.5)	2 (8.3)	–
Female	15 (33.3)	18 (40.0)	7 (15.6)	–	5 (11.1)	–
Sex not reported	1 (50.0)	–	–	1 (50.0)	–	–
Osteoporosis (younger)						
Male	4 (16.7)	3 (12.5)	10 (41.7)	6 (25.0)	1 (4.2)	–

Table A9 (*continued*)

Recommendation/Sex	Always	Often	Sometimes	Rarely	Never	No answer
	No. (%)					
Female	7 (15.6)	12 (26.7)	13 (28.9)	6 (13.3)	7 (15.6)	–
Sex not reported	1 (50.0)	–	–	1 (50.0)	–	–
Skin cancer counseling						
Male	3 (12.5)	6 (25.0)	4 (16.7)	8 (33.3)	3 (12.5)	–
Female	7 (15.6)	11 (24.4)	14 (31.1)	9 (20.0)	4 (8.9)	–
Sex not reported	–	–	1 (50.0)	1 (50.0)	–	–
Statin						
Male	8 (33.3)	12 (50.0)	3 (12.5)	–	1 (4.2)	–
Female	27 (60.0)	12 (26.7)	5 (11.1)	1 (2.2)	–	–
Sex not reported	1 (50.0)	–	–	–	1 (50.0)	–
STI counseling						
Male	7 (29.2)	4 (16.7)	9 (37.5)	3 (12.5)	1 (4.2)	–
Female	21 (46.7)	15 (33.3)	9 (20.0)	–	–	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–	–
Syphilis counseling						
Male	4 (16.7)	6 (25.0)	7 (29.2)	7 (29.2)	–	–
Female	9 (20.0)	14 (31.1)	9 (20.0)	10 (22.2)	3 (6.7)	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–	–
Tobacco						
Male	10 (43.5)	10 (43.5)	3 (13.0)	–	–	1
Female	29 (65.9)	12 (27.3)	2 (4.5)	1 (2.3)	–	1
Sex not reported	2 (100.0)	–	–	–	–	–
Tuberculosis screening						
Male	3 (12.5)	3 (12.5)	3 (12.5)	7 (29.2)	8 (33.3)	–
Female	2 (4.4)	6 (13.3)	9 (20.0)	15 (33.3)	13 (28.9)	–
Sex not reported	–	–	1 (50.0)	1 (50.0)	–	–

Table A10

Self-reported knowledge stratified by physician sex (multicenter).

Recommendation/Sex	Know in detail	Mostly know	Know a little	Do not know	No answer
	No. (%)				
Abdominal aortic aneurysm					
Male	9 (37.5)	13 (54.2)	1 (4.2)	1 (4.2)	–
Female	13 (28.9)	30 (66.7)	2 (4.4)	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Alcohol use disorder					
Male	9 (37.5)	12 (50.0)	3 (12.5)	–	–
Female	20 (44.4)	21 (46.7)	4 (8.9)	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Aspirin					
Male	2 (8.3)	11 (45.8)	8 (33.3)	3 (12.5)	–
Female	8 (17.8)	12 (26.7)	19 (42.2)	6 (13.3)	–
Sex not reported	–	–	2 (100.0)	–	–
Blood pressure					
Male	15 (62.5)	7 (29.2)	2 (8.3)	–	–
Female	31 (68.9)	13 (28.9)	1 (2.2)	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
BRCA-related genetic counseling					
Male	1 (4.2)	5 (20.8)	13 (54.2)	5 (20.8)	–
Female	5 (11.1)	8 (17.8)	23 (51.1)	9 (20.0)	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Breast cancer chemoprophylaxis					
Male	–	4 (16.7)	9 (37.5)	11 (45.8)	–
Female	–	3 (6.7)	17 (37.8)	25 (55.6)	–
Sex not reported	–	–	1 (50.0)	1 (50.0)	–
Cervical cancer					
Male	17 (70.8)	7 (29.2)	–	–	–
Female	42 (95.5)	2 (4.5)	–	–	1
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Chlamydia screening					
Male	11 (45.8)	9 (37.5)	4 (16.7)	–	–
Female	27 (60.0)	14 (31.1)	3 (6.7)	1 (2.2)	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Colorectal cancer					
Male	22 (91.7)	2 (8.3)	–	–	–
Female	41 (91.1)	4 (8.9)	–	–	–
Sex not reported	2 (100.0)	–	–	–	–
Depression					
Male	18 (75.0)	6 (25.0)	–	–	–
Female	36 (80.0)	8 (17.8)	1 (2.2)	–	–

Table A10 (*continued*)

Recommendation/Sex	No. (%)				
	Know in detail	Mostly know	Know a little	Do not know	No answer
Sex not reported	2 (100.0)	–	–	–	–
Diabetes					
Male	12 (50.0)	11 (45.8)	1 (4.2)	–	–
Female	18 (40.9)	24 (54.5)	2 (4.5)	–	1
Sex not reported	–	2 (100.0)	–	–	–
Falls					
Male	7 (29.2)	11 (45.8)	4 (16.7)	2 (8.3)	–
Female	9 (20.0)	21 (46.7)	10 (22.2)	5 (11.1)	–
Sex not reported	–	1 (50.0)	1 (50.0)	–	–
Folic acid					
Male	13 (54.2)	8 (33.3)	3 (12.5)	–	–
Female	29 (64.4)	13 (28.9)	2 (4.4)	1 (2.2)	–
Sex not reported	–	2 (100.0)	–	–	–
Gonorrhea screening					
Male	9 (37.5)	12 (50.0)	2 (8.3)	1 (4.2)	–
Female	27 (60.0)	15 (33.3)	2 (4.4)	1 (2.2)	–
Sex not reported	–	2 (100.0)	–	–	–
HBV screening					
Male	11 (45.8)	9 (37.5)	4 (16.7)	–	–
Female	12 (26.7)	18 (40.0)	14 (31.1)	1 (2.2)	–
Sex not reported	–	1 (50.0)	1 (50.0)	–	–
HCV screening					
Male	16 (66.7)	7 (29.2)	1 (4.2)	–	–
Female	30 (66.7)	11 (24.4)	3 (6.7)	1 (2.2)	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Healthy diet					
Male	7 (29.2)	9 (37.5)	6 (25.0)	2 (8.3)	–
Female	8 (17.8)	23 (51.1)	8 (17.8)	6 (13.3)	–
Sex not reported	–	1 (50.0)	1 (50.0)	–	–
HIV screening					
Male	12 (52.2)	6 (26.1)	2 (8.7)	3 (13.0)	1
Female	30 (66.7)	11 (24.4)	3 (6.7)	1 (2.2)	–
Sex not reported	–	1 (50.0)	1 (50.0)	–	–
HIV pre-exposure prophylaxis					
Male	9 (37.5)	8 (33.3)	5 (20.8)	2 (8.3)	–
Female	10 (22.2)	23 (51.1)	8 (17.8)	4 (8.9)	–
Sex not reported	–	–	2 (100.0)	–	–
Intimate partner violence					
Male	10 (41.7)	9 (37.5)	4 (16.7)	1 (4.2)	–
Female	24 (53.3)	19 (42.2)	2 (4.4)	–	–
Sex not reported	–	1 (50.0)	1 (50.0)	–	–
Lung cancer					
Male	12 (52.2)	11 (47.8)	–	–	1
Female	22 (48.9)	20 (44.4)	2 (4.4)	1 (2.2)	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Mammography					
Male	13 (54.2)	8 (33.3)	1 (4.2)	2 (8.3)	–
Female	36 (80.0)	7 (15.6)	1 (2.2)	1 (2.2)	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Obesity					
Male	5 (21.7)	6 (26.1)	9 (39.1)	3 (13.0)	1
Female	6 (14.0)	19 (44.2)	11 (25.6)	7 (16.3)	2
Sex not reported	–	1 (50.0)	1 (50.0)	–	–
Osteoporosis (older)					
Male	8 (33.3)	10 (41.7)	5 (20.8)	1 (4.2)	–
Female	15 (33.3)	24 (53.3)	4 (8.9)	2 (4.4)	–
Sex not reported	–	1 (50.0)	1 (50.0)	–	–
Osteoporosis (younger)					
Male	8 (33.3)	10 (41.7)	5 (20.8)	1 (4.2)	–
Female	12 (27.3)	17 (38.6)	14 (31.8)	1 (2.3)	1
Sex not reported	1 (50.0)	–	1 (50.0)	–	–
Skin cancer counseling					
Male	6 (26.1)	4 (17.4)	11 (47.8)	2 (8.7)	1
Female	13 (28.9)	16 (35.6)	9 (20.0)	7 (15.6)	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Statin					
Male	10 (41.7)	12 (50.0)	2 (8.3)	–	–
Female	21 (47.7)	20 (45.5)	3 (6.8)	–	1
Sex not reported	–	1 (50.0)	1 (50.0)	–	–
STI counseling					
Male	7 (29.2)	5 (20.8)	7 (29.2)	5 (20.8)	–
Female	9 (20.0)	10 (22.2)	16 (35.6)	10 (22.2)	–
Sex not reported	1 (50.0)	–	1 (50.0)	–	–

Table A10 (*continued*)

Recommendation/Sex	No. (%)				
	Know in detail	Mostly know	Know a little	Do not know	No answer
Syphilis counseling					
Male	6 (25.0)	13 (54.2)	4 (16.7)	1 (4.2)	–
Female	16 (36.4)	21 (47.7)	5 (11.4)	2 (4.5)	1
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Tobacco					
Male	15 (62.5)	8 (33.3)	1 (4.2)	–	–
Female	27 (60.0)	18 (40.0)	–	–	–
Sex not reported	1 (50.0)	1 (50.0)	–	–	–
Tuberculosis screening					
Male	3 (12.5)	6 (25.0)	14 (58.3)	1 (4.2)	–
Female	6 (13.3)	14 (31.1)	22 (48.9)	3 (6.7)	–
Sex not reported	–	–	2 (100.0)	–	–

Table A11

Comparison of national sample demographics to family medicine residents (multicenter).

Variable	No. (%)		
	Survey respondents	ACGME data book	p-value[a]
All residents	71 (100)	13,116 (100)	
Age, years, mean (SD)	30.1 (2.9)	30.3[b] (–[c])	–[d]
Sex			
Male	24 (34.8)	6019 (46.4)	0.069
Female	45 (65.2)	6964 (53.6)	
Not reported	2	133	
Race/Ethnicity[e]			
Asian	12 (17.1)	2421 (21.4)	–[f]
Black	3 (4.3)	857 (7.6)	
White	51 (72.9)	6470 (57.3)	
Other/Multiple	4 (5.7)	665 (5.9)	
Hispanic	–	882 (7.8)	
Not reported	1	1821	
Resident level			
1st Year/PGY-1/R1	25 (35.2)	4563 (34.8)	0.908
2nd Year/PGY-2/R2	22 (31.0)	4388 (33.5)	
3rd Year/PGY-3/R3	24 (33.8)	4116 (31.4)	
4th Year/PGY-4/R4	–	49 (0.4)	

[a] Fisher exact test. Participants who did not report a variable are excluded from the analysis.

[b] Mean age of Year 1 residents.

[c] Information on the variance in resident mean age is not available in the ACGME data book.

[d] Statistical comparison cannot be carried out due to lack of information on age variance in the ACGME data book. The point estimates, however, are nearly identical (30.1 years vs 30.3 years); even if there were a statistically detectable effect, its absolute magnitude is negligible (0.2 years = 73 days).

[e] There were methodological differences in the collection of race and ethnicity data in our survey and the ACGME data book. Our survey treated race and ethnicity as orthogonal variables (consistent with the US census bureau definition) whereas the ACGME data book treated Hispanic ethnicity as a race and clarified "White" to mean "Non-Hispanic White" and "Black" to mean "Non-Hispanic Black." These data are, therefore, not directly comparable.

[f] Statistical comparison is inappropriate due to differences in methodology.

excellent for both knowledge ($R^2 = 0.88$, **Appendix** Fig. A7) and implementation ($R^2 = 0.90$, **Appendix** Fig. A8). There do not, therefore, appear to be important differences between early and late respondents.

Second, we compared the demographic profile of respondents to family medicine residents generally, compiled from the most recent Accreditation Council on Graduate Medical Education (ACGME) data book (Accreditation Council for Graduate Medical Education, 2021) (**Appendix** Table A11). The average age of residents in our multicenter sample is nearly identical to the national mean (30.1 years vs 30.3 years)

and there were no detectable differences in the distribution of sex (p = 0.069) or level of training (PGY1 vs PGY2, etc.; p = 0.908). Methodological differences (see **Appendix** Table A11 footnote E) precluded a direct statistical comparison between the racial distribution of our respondents and the ACGME data book distribution, but the overall trends are broadly similar. We conclude that demographic features of our sample mirror those of family medicine residents generally.

Third, we found high concordance between results in the local sample and multicenter sample. The overall response profiles are similar (compare Fig. 1 versus **Appendix** Fig. A1, and Fig. A2 versus **Appendix** Fig. A3), and there is strong correlation between the local and multicenter results for both knowledge (Spearman $R^2 = 0.59$, **Appendix** Fig. A2) and implementation (Spearman $R^2 = 0.77$, **Appendix** Fig. A4).

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