Improving Adolescent Depression Screening in Pediatric Primary Care

Valerie S. Harder, PhD, MHS; Sara E. Barry, MPH[1]; Sarah French, BS;
Alyssa B. Consigli, RD; Barbara L. Frankowski, MD, MPH, FAAP

From the Departments of Pediatrics (VS Harder, SE Barry, S French, AB Consigli, and BL Frankowski); and Psychiatry (VS Harder), Vermont Child Health Improvement Program, University of Vermont, Burlington
The authors have no conflicts of interest to disclose.
Address correspondence to Valerie S. Harder, PhD, MHS, Vermont Child Health Improvement Program, University of Vermont, 1 S. Prospect St, Burlington, VT 05401 (e-mail: Valerie.Harder@med.uvm.edu).
Received for publication August 9, 2018; accepted February 10, 2019.

ABSTRACT

OBJECTIVE: Depression among adolescents is a leading public health problem. Although screening for adolescent depression in primary care is strongly recommended, screening rates remain low. Effective quality improvement (QI) initiatives can facilitate change. This study aims to assess the impact of a QI learning collaborative on adolescent depression screening and initial plans of care in primary care.

METHODS: Seventeen pediatric-serving practices in Vermont participated in a QI learning collaborative aimed at improving practitioner knowledge and office systems around adolescent depression screening. Monthly medical record reviews provided monitoring of adolescent depression screening and initial plans of care over 7 months for QI. Randomly sampled annual medical record review data allowed comparison of screening and initial plans of care after the QI learning collaborative between participating and 21 control practices.

RESULTS: As practices improved their office systems around adolescent depression screening and initial plans of care, data showed marked improvement in depression screening at all 17 practices, from 34% to 97% over 7 months. Adolescents at participating practices had 3.5 times greater odds (95% confidence interval [CI], 1.14−10.98, $P = .03$) of being screened for depression and 37.5 times greater odds (95% CI, 7.67−183.48, $P < .0005$) of being screened with a validated tool than adolescents at control practices, accounting for patient characteristics.

CONCLUSIONS: There were significant within practice increases in adolescent depression screening after a QI learning collaborative, as well as in comparison with control practices 1 year later.

KEYWORDS: adolescent mental health; primary care; quality improvement

ACADEMIC PEDIATRICS 2019;19:925−933

WHAT'S NEW

A quality improvement project focused on adolescent depression leads to improved adolescent depression screening with sustained improvements out to a year compared with controls.

DEPRESSION IS COMMON among adolescents in the United States, with a point prevalence of approximately 12.5% of 12- to 17-year-old adolescents experiencing a major depressive episode in 2015.[1] Point prevalence in Vermont between 2009 and 2013 was comparable with the national average.[2] For most healthy adolescents, the primary care practitioner is the only health care professional with whom they come in regular contact.[3] According to the American Academy of Pediatrics (AAP) 59th Periodic Survey in 2004, 80% of pediatricians believed that they were responsible for screening for mental illnesses, including depression.[3] The US Preventive Services Task Force recommended in 2009 and 2016 that all adolescents 12−18 years be screened for depression if adequate supports existed to diagnose and treat patients.[4,5]

Over the past 10 years, the AAP increased efforts to provide education and tools to pediatricians supporting efforts to increase depression screening, initiate care, and make referrals.[6] However, a comparison of the 2004 and 2013 AAP Periodic Surveys showed that the percentage of all pediatricians surveyed who "inquire or screen" for depression hasn't changed significantly, and although the percentage of those willing to treat, manage, or co-manage patients with depression did increase, it remained low (<25%).[6] One recent study showed increases in mental health screening of 0- to 21-year-old patients 6 months after a quality improvement (QI) learning collaborative.[7] Both a clinical trial[8] and QI project[9] showed short-term increases in adolescent depression screening and treatment after focusing on education for pediatric-serving physicians around adolescent mental health and related office systems changes. Further research is needed to determine whether these changes are an improvement compared with a control group.

With >18 years of experience, the Vermont Child Health Improvement Program (VCHIP) is the oldest

---

[1] Present address of Sara E. Barry: OneCare Vermont, University of Vermont Medical Center, 356 Mountain View Dr, Colchester, VT 05446

running improvement partnership nationally, aiming to "optimize the health of Vermont children by initiating and supporting measurement-based efforts to enhance public and private child health practice."[10] In 2012, VCHIP created Child Health Advances Measured in Practice (CHAMP), a voluntary QI network of pediatric-serving (pediatric and family medicine) practices. The first year's QI learning collaborative focused on immunization coverage among children and adolescents.[11] The second year focused on adolescent depression screening and initial plans of care.

The overall objective of this study was to evaluate the impact of the QI learning collaborative on adolescent depression screening and initial plans of care. The specific aims were 1) to increase adolescent depression screening at health supervision visits to at least 95%, and 2) to increase initial plans of care among those screening positive to at least 95%.

METHODS

INTERVENTION

In 2013, VCHIP received funding through the Vermont Department of Health to conduct an adolescent depression QI learning collaborative. At this time, the CHAMP network included approximately one quarter of the pediatric-serving practices in the state, providing primary care for approximately one third of children and adolescents. To our knowledge, there were no other primary care QI projects for adolescent depression in Vermont until this learning collaborative. All practices in the CHAMP network were recruited to participate in the QI collaborative, modeled after the Institute for Healthcare Improvement Breakthrough Series Collaborative.[12] As an incentive, physicians were offered 25 credits toward Part IV, Maintenance of Certification (MOC) and up to 20 hours of continuing medical education. Participants were motivated by the shared learning opportunity both within and across practices. Participating practices formed multidisciplinary (physicians, nurses, and administrative staff) teams responsible for setting practice goals, implementing changes, and measuring improvements on a monthly basis. Team members were required to attend a day-long learning session and at least 3 of 6 project calls over 7 months.

VCHIP staff (project director, coordinator, principal investigator, and physician lead) launched the QI collaborative at the learning session. Practice-specific data were reviewed with practice teams to demonstrate gaps between adolescent depression screening with validated tool percentages (27%, 27%, and 41% of 14-, 15-, and 16-year-old adolescents, respectively) and national recommendations to screen 100% of adolescents. Clinical guidelines[13,14] concerning adolescent depression and suicide screening, assessment, and initial management were presented in workshops, eg, addressing near-positive scores as an opportunity to engage adolescents in discussions. Ideas for implementing office systems changes across 5 domains outlined in the AAP's Mental Health Practice Readiness Inventory (MHPRI; Supplementary Table 1 and Appendix)[15,16] were discussed. Each practice team completed an MHPRI, and they discussed improvements that would help their practice.

Practices chose the depression screening tool that worked best for their practice from those listed in the AAP Mental Health Toolkit.[14] Practice teams met at least monthly to make plans for modifying workflows to incorporate depression screening and complete monthly Plan-Do-Study-Act (PDSA) cycles to test their changes systematically. Teams submitted PDSA worksheets to VCHIP each month along with medical record review data. In response, VCHIP provided visualizations of their data and team-specific coaching for improvement, such as next steps in PDSA cycles, engaging practice staff, and techniques to improve office workflow.

VCHIP identified successes and challenges among practice teams and addressed these during 6 all-practice calls. Topics included review of screening tools and implementation strategies; coding and billing issues; improving communication with referral resources including crisis services for suicidality; substance abuse resources; use of patient registries to recall patients for annual health supervision visits; and impact of the QI collaborative on office systems. Attendance on calls ranged from 7 to 16 practices with an average of 14 practices per call. Eighty-two percent (14/17) of participating practices attended 5 or all 6 calls.

DATA SOURCES

OVERVIEW

There were 2 sources of medical record review data analyzed for this study. First, small convenience medical record samples of 12- to 18-year-old patient health supervision visits were collected monthly by practitioners participating in the QI collaborative. These convenience samples of "Monthly" data were used by VCHIP and practices to track monthly improvements in depression screening and initial plans of care. Second, VCHIP conducted a larger randomly sampled medical record review of all CHAMP network practices that could be used to test the impact of participation in the year after the QI collaborative compared with the year before. These random samples of "Annual" data contained visits for 14- to 16-year-old patients in participating and control practices sampled in the year after the QI collaborative (2014) paired with their own visit data before the start of the QI collaborative (2012). VCHIP collected both medical record reviews under existing Business Associates Agreements with practices and with approval from the University of Vermont's Institutional Review Board. Details of the data samples, measures, and analyses for "Monthly" and "Annual' medical record reviews are presented in the sections to follow.

MONTHLY SAMPLE

In 2013, 17 practices in the CHAMP network voluntarily participated in the QI collaborative (Fig. 1). Practitioners at

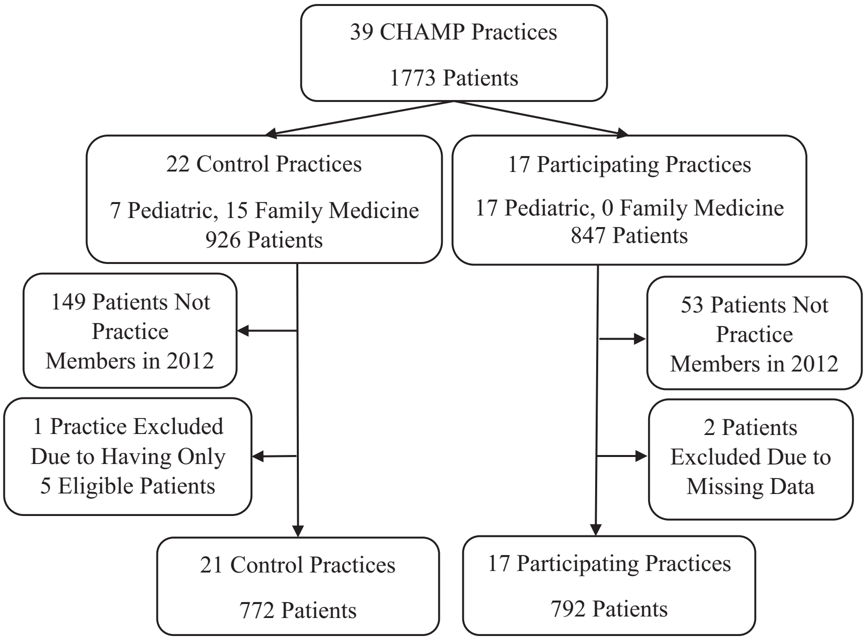

Figure 1. *Study sample selection of participating and control practices and number of patients from the CHAMP network. CHAMP indicates Child Health Advances Measured in Practice.*

these practices submitted 7 months of medical record review data to VCHIP using a standard data collection form provided by VCHIP. The eligible population included 12- to 18-year-old patients attending a health supervision visit in the past month. Participating practices were required to submit a convenience sample of 10 adolescents each month, and because some practices had more than 1 practitioner receiving MOC, some practices chose to submit >10. On average, each practice submitted data on 14 adolescents per month, and 2 practices missed 1 month of data submission. For QI purposes, convenience samples were adequate to provide signals of change in processes of care delivery.[17]

MONTHLY MEASURES

In the monthly QI samples, practices reported to VCHIP whether depression screening was performed using a validated screening tool. Sixteen practices used the validated Patient Health Questionnaire (PHQ)-9[18] modified and validated for adolescents,[19] encouraged by VCHIP because it asks about functioning and suicidality. One practice used the PHQ-2, also validated for adolescents[20], followed by the PHQ-9 when positive. Practices reported whether the patient screened positive for possible depression (PHQ-9 score ≥10), and if yes, whether an initial plan of care was documented, including in-office intervention, follow-up visit with primary care practitioner, referral to a mental health professional, or other plan (such as starting depression medication, patient already receiving mental health services, or patient screened positive but symptoms due to another disorder).

Practices also assessed their office systems and supports by completing the MHPRI at the beginning and end of the QI collaborative.[15] The MHPRI had 32 items, scored on a 3-point scale: 1) We do this well; 2) We do this to some extent; or 3) We do not do this well. Items were grouped into 5 domains, described by Foy et al[16]: community resources, health care financing, support for children and families, clinical information systems, and decision support for clinicians (Supplementary Table 1 and Appendix).

MONTHLY ANALYSES

VCHIP tracked the monthly percentage of adolescents screened for depression, positive for depression, and with initial plans of care following a positive screen (Table 1). Figure 2 is a run chart showing the percentage screened for depression monthly, allowing visualization of individual practice improvement over 7 months. If a practice did not screen any adolescents or did not find any positive screens in a particular month, the practice was excluded from the denominator to calculate the percent screening positive or with initial plans of care, respectively. Since we expected positive screens at practices to be around 10%,[1,21] the small number of positive screens was collapsed across practices and averaged at the patient level each month to calculate the average percent with any initial plan of care for adolescents with positive screens (Table 1).

MHPRI item scores were averaged to give a single score ranging from 1 to 3 overall and within each of the 5 domains. The average MHPRI scores at the end of the QI collaborative were compared with the average scores from the beginning using paired t tests, with $P < .05$ indicating statistical significance. Analyses dropped missing observations from 5 practices missing 1 item and 1 practice missing 6 of the 32 items.

Table 1. Patient-Level Summary of Adolescents' Medical Records Reviewed, Screened for Depression With a Validated Tool, and Positive on the Screen Over 7 Months

	Month						
	1	2	3	4	5	6	7
Number of medical records reviewed, N	206	242	257	240	227	244	224
Number screened, n_1 (%)	80 (39)	179 (74)	248 (97)	228 (95)	214 (96)	237 (97)	213 (95)
Number of positive screens, n_2 (%)	14 (18)	32 (18)	49 (20)	40 (18)	45 (21)	36 (15)	36 (17)
Initial plans of care following positive screen							
Any initial plan of care, %	79	88	94	95	87	97	100
In-office intervention, %	64	53	86	78	67	69	78
Follow-up with primary care practitioner, %	64	56	67	73	51	67	81
Referral to mental health professional, %	36	41	37	40	42	42	53
Other plan, %	43	50	33	40	33	42	44

Among the adolescents with a positive screen, the percent with any initial plan of care and the percent with specific types of plans is shown.

N = number of medical records reviewed in the quality improvement (QI) data sample; n_1 = number of adolescent patients screened in the QI data sample; n_2 = number of screens positive for possible depression out of all adolescents screened. Percentages (%) do not add up across the different types of initial plans of care to total "Any initial plan" because 1 adolescent may have multiple plan types. There was 1 practice in month 5 and 1 in month 7 that did not submit data. "Other plan" included plans such as starting depression medication, patient already receiving mental health services, or patient screened positive but symptoms due to another disorder.

ANNUAL SAMPLE

By 2014, there were 39 practices in the CHAMP network (17 QI participants and 22 controls) with 1773 adolescent patients randomly selected for medical record review (Fig. 1) by independent reviewers hired and trained by VCHIP clinical and data management staff. The eligible population included adolescents from the whole practice (not just patients of practitioners participating in the QI collaborative), 14- to 16-year-old patients in 2014, and therefore 12- to 14-year-old patients in 2012, with at least 1 health supervision visit ever at the practice, and with at least 1 in-person visit in the past 3 years. VCHIP's goal was to randomly sample 50 charts of the eligible population in 2014 from each practice. Eight of the practices had only 40 to 49 eligible patients, and 3 had 10 to 20. Patients were excluded if they were not practice members in 2012 (N = 202), had missing data on a single variable (N = 2), or were at the one practice with few eligible patients (N = 5). The final annual sample of 38 practices had 1564 patients (Fig. 1).

ANNUAL MEASURES

Acute and health supervision visits occurring in 2014 and 2012 were reviewed for the eligible population selected in 2014. Reviewers collected patient demographics, indicated any depression screening and screening with a validated tool (PHQ-2/PHQ-9), and recorded initial plans of care (follow-up with primary care practitioner, referral to mental health professional, or depression already being addressed) for the eligible population. The reviewers did not assess in-office interventions or all the details of other plans in the annual data due to the

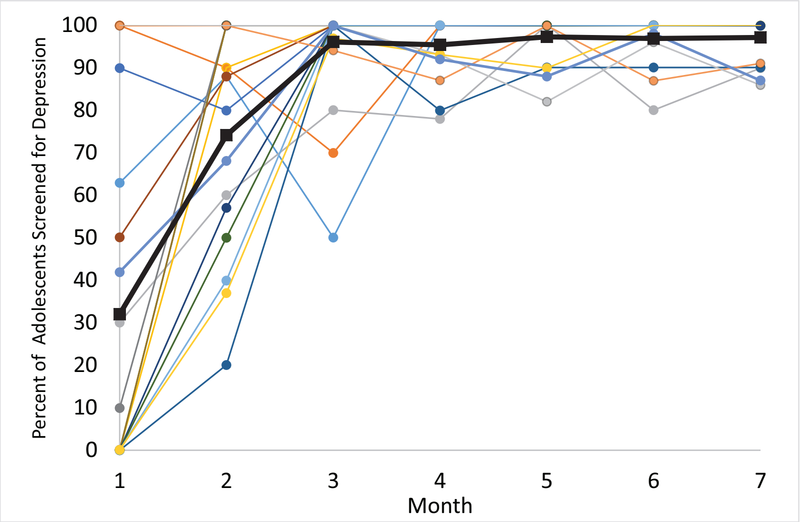

Figure 2. *A practice-level run chart showing the percent of adolescents screened for depression increasing over the 7-month quality improvement project at 17 practices. The* bold black line *with the* squares *is the overall average percent of adolescents screened for depression.*

Table 2. Patient Characteristics at Participating Practices Versus Control Practices

	Participating Practices (N = 17; n = 792)	Control Practices (N = 21; n = 772)	*P* Value
Male, n (%)	376 (47)	375 (49)	.66
Medicaid, n (%)	263 (33)	306 (40)	.008
Screened for depression in 2012, n (%)	264 (37)	261 (39)	.37
No visit in 2012, n (%)	73 (14)	104 (20)	.005
In largest metropolitan area, n (%)	375 (47)	237 (31)	<.001
Federally qualified/certified rural, n (%)	86 (11)	217 (28)	<.001

N = number of practices; n = number of adolescents. The *P* values indicate whether there are differences in the percentage of adolescents within each variable comparing those at participating with control practices. All adolescents had a visit in 2014, and "No visit in 2012" indicates the adolescent was a practice member but did not have a visit in 2012.

time involved in reading practitioner notes. There was 95% inter-rater reliability between different chart reviewers resampling 178 charts across all practices.

ANNUAL ANALYSES

We predicted adolescent depression screening in 2014 (any screening and screening with a validated tool), by participation in the QI collaborative. Confounders included patient sex (male vs female) and insurance (Medicaid vs other), practice location (largest metropolitan hospital service area vs others), federal designation (federally qualified or certified rural health center vs others), and a categorical variable for depression screening status in 2012 (reference category 0 = not screened in 2012, 1 = screened in 2012, and 2 = no visit in 2012). Confounders were chosen based on theoretical associations with the outcome, and we tested the associations between confounders and QI participation using Chi-square tests (Table 2). A secondary outcome was percentage receiving an initial plan of care in 2014 after screening positive for possible depression, predicted by participation in the QI collaborative, including the same confounders. One control practice did not have any positive depression screens and therefore was not included in the analysis of initial plans of care. Generalized linear mixed effects logistic regression models were used for both outcomes (depression screening and initial plans of care) comparing patients at participating with control practices. This modeling approach accounted for the correlation due to clustering of patients within individual practices and tested the likelihood of the outcome in 2014 controlling for confounders. Statistical analyses were conducted using Stata, version 15 (StataCorp LLC, College Station, Tex), with $P < .05$ indicating statistical significance.

RESULTS

MONTHLY

In the first month of the QI collaborative, 8 of 17 practices were not screening for depression at all, but by month 2, all practices were screening using a validated tool and continued to screen for all 7 months. The average percentage of adolescents screened for depression at the practice-level increased from 34% to 97%, with many practices increasing from zero to 100% over 7 months (Fig. 2). Only 1 practice was <60% by month 3, and all practices were >80% for months 5 through 7. By month 7, 11 practices reported 100% of their sample of adolescents were screened for depression. Each month there was at least 1 practice (range 1−5 practices) with no positive screens. Overall, in any given month, 15% to 21% of adolescents screened positive for depression at the individual patient-level (Table 1). The average percentage of positive depression screens with a documented initial plan of care steadily increased over time from just <80% in month 1 to 100% by month 7 (Table 1).

The average practice MHPRI score improved significantly (12.9%) from before (mean [M] = 2.03, standard deviation [SD] = 0.29) to after the QI collaborative (M = 1.77, SD = 0.44), t(16) = −2.64, $P = .02$. Two of the 5 MHPRI domains showed significant improvement. Clinical information systems scores improved significantly (9.3%) from before (M = 2.19, SD = 0.43) to after the QI collaborative (M = 1.98, SD = 0.38), t(16) = −2.27, $P = .04$. Decision support scores improved significantly (21.6%) from before (M = 2.11, SD = 0.45) to after the QI collaborative (M = 1.66, SD=0.59), t(16) = −2.93, $P = .01$.

ANNUAL

In 2014, 90% (N = 712/792) of children at participating practices were screened for depression, compared with 75% (N = 579/772) of controls (Chi-square = 60.2, $P < .001$), and 77% (N = 607/792) were screened using a validated tool at participating practices compared with 32% (N=246/772) of controls (Chi-square = 316.1, $P < .001$). Among 219 patients who screened positive for depression in 2014, there was a borderline significantly lower percentage at participating practices (81%, N = 105/129) compared with control practices (91%, N = 82/90) that had an initial plan of care in 2014 (Chi-square = 4.0, $P = .05$). The Chi-square analyses on characteristics for 1564 patients (Table 2) suggested there were significantly fewer patients at participating practices who were on Medicaid insurance, had no office visit in 2012, or were at federally qualified or certified rural health center, and there was a significantly greater percentage at participating practices who were within the largest metropolitan area. Regression results show that adolescents at participating practices had three and a half times greater odds of having any depression screening in 2014 than controls,

Table 3. The Adjusted Odds Ratio of a Patient Being Screened for Depression, and if Positive, the Adjusted Odds Ratio of Having an Initial Plan of Care, Comparing Patients at Participating Practices With Patients at Control Practices

	Screened for Depression (Yes vs No)			Screened for Depression With a Validated Tool (Yes vs No)			Initial Plan of Care (Yes vs No)		
		95% Confidence Interval			95% Confidence Interval			95% Confidence Interval	
Predictor Variables	Adjusted Odds Ratio	Lower	Upper	Adjusted Odds Ratio	Lower	Upper	Adjusted Odds Ratio	Lower	Upper
At control practice	Ref	–	–	Ref	–	–	Ref	–	–
At participating practice	3.53*	1.14	10.98	37.51†	7.67	183.48	0.36	0.11	1.16
Other insurance	Ref	–	–	Ref	–	–	Ref	–	–
Medicaid	0.83	0.59	1.18	1.02	0.73	1.44	2.67*	1.06	6.70
Female	Ref	–	–	Ref	–	–	Ref	–	–
Male	0.68*	0.48	0.95	0.78	0.57	1.07	1.42	0.56	3.60
Not screened in 2012	Ref	–	–	Ref	–	–	Ref	–	–
Screened in 2012	2.88*	1.78	4.67	1.42	0.95	2.13	6.07*	1.80	20.43
No visit in 2012	1.41	0.83	2.37	0.92	0.53	1.62	1.78	0.41	7.79
All other areas	Ref	–	–	Ref	–	–	Ref	–	–
Largest metropolitan area	1.74	0.54	5.65	0.70	0.14	3.53	3.20	0.86	11.92
All other practices	Ref	–	–	Ref	–	–	Ref	–	–
Federally qualified / certified rural practice	0.59	0.15	2.35	0.23	0.55	0.93	0.68	0.17	2.77

Ref indicates reference group.
*$P < .05$.
†$P < .0005$.

and being female and screened for depression in 2012 were also independent predictors (Table 3). More striking was the finding that adolescents at participating practices had 37.5 times greater odds of being screening using a validated tool than controls, with no significant confounders. Results from our regression model predicting initial plans of care showed no difference in the odds of having an initial plan of care documented at participating practices compared with controls, but having Medicaid and being screened for depression in 2012 were independent predictors of having an initial plan of care in 2014.

DISCUSSION

Adolescent depression screening and documenting initial plans of care improved over a 7-month QI collaborative in 17 primary care practices, confirming the findings of similar QI initiatives.[9,22] A strength of the study was the randomly sampled larger medical record review data 1 year beyond the end of the QI collaborative. We are encouraged by results from regression analyses of these data indicating that the odds of any depression screening and screening with a validated tool were significantly greater at participating than control practices. However, we were surprised there was no difference in documentation of initial plans of care.

The Guidelines for Adolescent Depression in Primary Care indicated that a structured QI collaborative that used active rather than passive learning and encouraged practice change was more likely to lead to improvement.[23] Structured QI collaboratives in other states reported improvements to adolescent depression screening similar to our increase from 34% to 97%. A QI collaborative in Cincinnati aimed at increasing depression screening in adolescents with chronic health conditions showed increases from <5% to 96% screened over the course of a year.[22] Another QI collaborative in Washington, DC, resulted in an increase in screening for mental health problems from 1% to 74% during a 15-month QI collaborative.[7] Similarly, our high percentage (increasing from 79% to 100%) of documenting initial plans of care were also seen in a New Hampshire −based QI collaborative.[9] We expected this high percentage of initial plans of care among our monthly sample because our practitioners were following the US Preventive Services Task Force recommendation to implement screening only if adequate systems were in place for effective treatment and follow-up.[4,5] It was beyond the scope of this study to track individual patients over time to determine follow-through on initial plans of care, or to investigate individual responses to treatment, but this is important work that needs further study.

Participating practices demonstrated their ability to make changes in office systems to support their QI efforts over 7 months. Overall, practices demonstrated a nearly 15% improvement in MHPRI scores,[15] with significant improvements in the domains of clinical information systems and decision support for clinicians. Improvements in these 2 domains were hypothesized because our QI focused on using a validated depression screening tool at adolescent health supervision visits. We hypothesized improvement in the health care financing domain because we gave practices information on coding and billing for depression screening. However, the specific procedure code had not been used previously by many practices, and not all payers covered that code, so practices stopped using it. A comparable study in Washington, DC,[7] showed a 17% overall improvement in their practices' MHPRI scores and identified the most improvements in the domains of health care financing and community resources. This is the only other study published using the MHPRI to date, so it is difficult to judge the clinical significance of our improvements to office systems.

A strength of the study was our ability to assess whether practice improvements to depression screening and documenting initial plans of care were sustained. Indeed, after the QI collaborative end, participating practices had significantly greater proportions of adolescents screened for depression (any and using a validated tool) sustained into the year following the project compared to control practices. Our study was unique in that it examined both any depression screening and screening using a validated tool. Although control practices had a relatively high reported depression screening in 2014, their use of validated tools was much lower and indicates the importance of QI collaboratives to support the use of validated screening tools. The null finding of no difference in documentation of initial plans of care following a positive screen between participating and control practices may have been due to the fact that improving documentation of initial plans of care was at the practitioner-level, in contrast to changing office systems around depression screening (a practice-level improvement) where other team members were involved. Sometimes only 1 or 2 practitioners from each practice were receiving MOC credit, yet the annual medical record review data were sampled randomly from the whole practice.

These models also revealed possibly interesting associations between confounders and outcomes that require further investigation. Previous screening for depression in 2012 was associated with greater odds of having any depression screening in 2014, and also for having an initial plan of care in 2014, possibly because some practices instituted routine screening before 2012. Female patients had significantly greater odds of being screened for depression, possibly because adolescent females had more health supervision visits than males, and depression screens were more likely to be administered at these visits.[24] During the QI collaborative, there was a discussion on one of the phone calls about screening all adolescents at any visit, not just at health supervision visits, and this might be a more central focus of a future collaborative. Finally, although not more likely to be screened for depression, patients with Medicaid had greater odds of initial plans of care, possibly due to greater need for mental health services, but further investigation is needed.

LIMITATIONS

Our findings were encouraging, but our study had limitations. First, practices self-selected to participate, and the monthly data came from convenience samples, so there was a chance for bias toward improvement. Participating practices submitted baseline convenience samples for only the first month, and there were no control convenience samples. In general, convenience sampling limited the generalizability of our findings within and across each practice. However, our Annual data comparing patients at participating practices with controls helped to resolve some of these potential limitations. Second, the costliness of medical record reviews limited the age range of the Annual sample to 14−16 years, so we couldn't extrapolate findings to older adolescents and limited our ability to collect details about in-office intervention and other plan information from practitioner notes. Third, before the project, many practices had low screening rates or were not screening at all, resulting in too few positive screens to evaluate on initial plans of care in 2012. Fourth, this QI project did not include a balancing measure, but in subsequent collaboratives, balancing measures were incorporated. Finally, we offered MOC credit for family medicine, but none volunteered to participate. VCHIP responded the next year by engaging the Department of Family Medicine at the academic medical center, recruited 5 new family medicine practices, and saw increased involvement from family medicine. Analysis of subsequent CHAMP QI data will allow for statistical modeling accounting for practice type.

CONCLUSIONS

This study showed significant improvement in adolescent depression screening in primary care over a 7-month QI collaborative focused on practitioner education and office systems change. One year after the QI collaborative, adolescents at participating practices had much greater odds of being screened for depression using a validated tool than controls. Future studies should investigate follow-up of initial plans of care and treatment outcomes for adolescents with depression.

ACKNOWLEDGMENTS

We thank the practitioners and staff at the CHAMP practices for their engagement and dedication to improving adolescent depression screening and initiating plans of care.

Financial disclosure: Although this work product was funded in whole or in part with monies provided by or through the State of Vermont, the State does not necessarily endorse the researchers' findings and/or conclusions. The findings and/or conclusions may be inconsistent with the State's policies, programs, and objectives.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.acap.2019.02.014.

REFERENCES

1. Center for Behavioral Health Statistics and Quality. Key substance use and mental health indicators in the United States: results from the 2015 National Survey on Drug Use and Health. Available at: http://wwwsamhsa.gov/data/. Published September 2016. Accessed August 8, 2018.
2. Substance Abuse and Mental Health Services Administration. Behavioral health barometer: Vermont, 2014 . Available at: https://www.samhsa.gov/data/sites/default/files/NSDUH-FFR1-2015/NSDUH-FFR1−2015/NSDUH-FFR1−2015.pdf. Published January 2015. Accessed August 8, 2018 .
3. Stein RE, Horowitz S, Storfer-Isser A, et al. Do pediatricians think they are responsible for identification and management of child mental health problems? Results of the AAP periodic survey. *Ambul Pediatr*. 2008;8:11–17.
4. US Preventive Services Task Force. Screening and treatment for major depressive disorder in children and adolescents: US Preventive Services Task Force Recommendation Statement. *Pediatrics*. 2009;123:1223–1228.
5. Siu AL. US Preventive Services Task Force. Screening for depression in children and adolescents: U.S. Preventive Services Task Force Recommendation Statement. *Ann Intern Med*. 2016;164:360–366.
6. Stein RE, Storfer-Isser A, Kerker BD, et al. Beyond ADHD: how well are we doing? *Acad Pediatr*. 2016;16:115–121.
7. Beers LS, Godoy L, John T, et al. Mental health screening quality improvement learning collaborative in pediatric primary care. *Pediatrics*. 2017: 140.
8. Asarnow J, Jaycox L, Duan N, et al. Effectiveness of a quality improvement intervention for adolescent depression in primary care clinics: a randomized controlled trial. *JAMA*. 2005;293:311–319.
9. NH Pediatric Improvement Partnership. Teen Mental Health Project. Available at: https://www.nhpip.org/node/8/submission/14656. Accessed 8 August 2018.
10. Shaw JS, Norlin C, Gillespie RJ, et al. The National Improvement Partnership Network: state-based partnerships that improve primary care quality. *Acad Pediatr*. 2013;13:S84–S94.
11. Harder VS, Barry SE, Ahrens B, et al. Quality improvement to immunization coverage in primary care measured in medical record and population-based registry data. *Acad Pediatr*. 2018;18:437–444.
12. Institute for Healthcare Improvement. The Breakthrough Series: IHI's Collaborative Model for Achieving Breakthrough Improvement. Available at: www.IHI.org. Published 2003. Accessed August 8, 2018.
13. Zuckerbrot RA, Cheung AH, Jensen PS, et al. Guidelines for Adolescent Depression in Primary Care (GLAD-PC): I. Identification, assessment, and initial management. *Pediatrics*. 2007;120:e1299–e1312.
14. American Academy of Pediatrics. Addressing Mental Health Concerns in Primary Care: A Clinician's Toolkit. Available at: https://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Mental-Health/Pages/Addressing-Mental-Health-Concerns-in-Primary-Care-A-Clinicians-Toolkit.aspx. June 2010. Accessed August 8, 2018 .
15. American Academy of Pediatrics. Appendix S3: Mental Health Practice Readiness Inventory. *Pediatrics*. 2010;125:S129–S132.
16. Foy JM, Kelleher KJ, Laraque D. Enhancing pediatric mental health care: strategies for preparing a primary care practice. *Pediatrics*. 2010;125:S87–S108.
17. Perla RJ, Provost LP, Murray SK. Sampling considerations for health care improvement. *Qual Manag Health Care*. 2014;23:268–279.
18. Spitzer RL, Kroenke K, Williams JB. Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. Primary Care Evaluation of Mental Disorders. Patient Health Questionnaire. *JAMA*. 1999;282:1737–1744.
19. Richardson LP, McCauley E, Grossman DC, et al. Evaluation of the Patient Health Questionnaire-9 Item for detecting major depression among adolescents. *Pediatrics*. 2010;126:1117–1123.
20. Richardson LP, Rockhill C, Russo JE, et al. Evaluation of the PHQ-2 as a brief screen for detecting major depression among adolescents. *Pediatrics*. 2010;125:e1097–e1103.

21. Mojtabai R, Olfson M, Han B. National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics*. 2016: 138.
22. Corathers S, Kichler J, Yayah Jones N, et al. Improving depression screening for adolescents with type 1 diabetes. *Pediatrics*. 2013;123:e1395–e1402.
23. Zuckerbrot RA, Cheung A, Jensen PS, et al. Guidelines for Adolescent Depression in Primary Care (GLAD-PC): Part I. Practice preparation, identification, assessment, and initial management. *Pediatrics*. 2018: 141.
24. Nordin JD, Solberg LI, Parker ED. Adolescent primary care visit patterns. *Ann Fam Med*. 2010;8:511–516.