Electronic medical record alert activation increase hepatitis C and HIV screening rates in primary care practices within a large healthcare system

Hazel Tapp[a], Thomas Ludden[a,*], Lindsay Shade[a], Jeremy Thomas[a], Sveta Mohanan[a], Michael Leonard[b]

[a] Department of Family Medicine, Atrium Health, 2001 Vail Avenue, Suite 400B, Charlotte, NC 28207, United States
[b] Department of Infectious Diseases, Atrium Health, 4539 Hedgemore Drive, Suite 100, Charlotte, NC 28209, United States

A B S T R A C T

Societal and economic burdens of hepatitis C virus (HCV) and human immunodeficiency virus (HIV) continue to grow. The Centers for Disease Control and Prevention recommends a one-time HCV screen for individuals in the Baby Boomer population (those born between 1945 and 1965) and a one-time HIV screen for all individuals between ages 13–64 years regardless of risk factors, with more frequent screening for both conditions based on individual risk factors.

This study took place at Atrium Health, a healthcare system with approximately 12 million patient encounters per year. The aims of this study were to assess the impact of the HCV and HIV electronic medical record (EMR) alerts recently implemented on screening rates and linkage to care.

Data were collected from 12 primary care practices. Implementation of EMR alerts increased HCV and HIV screening from 1,934 of 59,632 (3.2%) to 13,726 of 60,422 (22.7%) and 6,950 of 112,813 (6.2%) to 12,379 of 109,173 (11.3%) respectively. The HCV screening resulted in an increase of patients with antibody positive results having a subsequent RNA test from 68% (122/179) to 98% (430/442). 74 of 81 (91%) of HCV and 15 of 15 (100%) of HIV positive patients were linked into care.

The addition of an EMR alert was associated with improved screening for HCV and HIV in primary care practices. Screening all patients decreases testing stigma since there is a lowered risk of disease transmission for those who test positive. However, post-intervention screening rates indicate further opportunities exist for additional interventions to increase screening rates.

1. Introduction

In the US, it is estimated that approximately 2.4 million people have chronic hepatitis C virus (HCV) and up to 75% of those people with chronic HCV are unaware that they are infected (Edlin et al., 2015; Hofmeister et al., 2019; Centers for Disease Control and Prevention, 2018). Half of cases are related to intravenous drug use, and the remainder from blood transfusions, sexual contact, tattoos, and medical procedures (Smith et al., 2012; Armstrong et al., 2006; Rein et al., 2011). Most patients were infected between 1960 and 1980, and consequently "Baby Boomers" born between 1945 and 1965 account for the majority of all chronic HCV infections in adults (Smith et al., 2012). To improve quality of life and prevent transmission, the Centers for Disease Control and Prevention (CDC) recommends a one-time HCV blood test to screen all adults born between 1945 and 1965 (Smith

et al., 2012). U.S. Preventive Services Task Force (USPSTF) has also made draft recommendations for a one time HCV blood test to screen all adults 18-79 (United States Preventive Services Task Force, 2019). < 20% of Baby Boomers have been screened for HCV as of 2015 (Jemal and Fedewa, 2017).

Recently, increased screening and the development of effective antiviral treatments have led to marked improvements in HCV patient outcomes. Current treatments with direct-acting antiviral agents (DAAs) are highly efficacious with sustained virologic response (SVR) rates of > 95% for the vast majority of patients (Barth, 2015; Jacobson et al., 2017). However, even when patients received appropriate treatments, delayed access to care is associated with a 5–20% increased risk for liver cirrhosis, putting them at high risk for additional complications like hepatocellular carcinoma (HCC) (Barth, 2015). It has been previously shown that HCV alerts can improve screening rates in
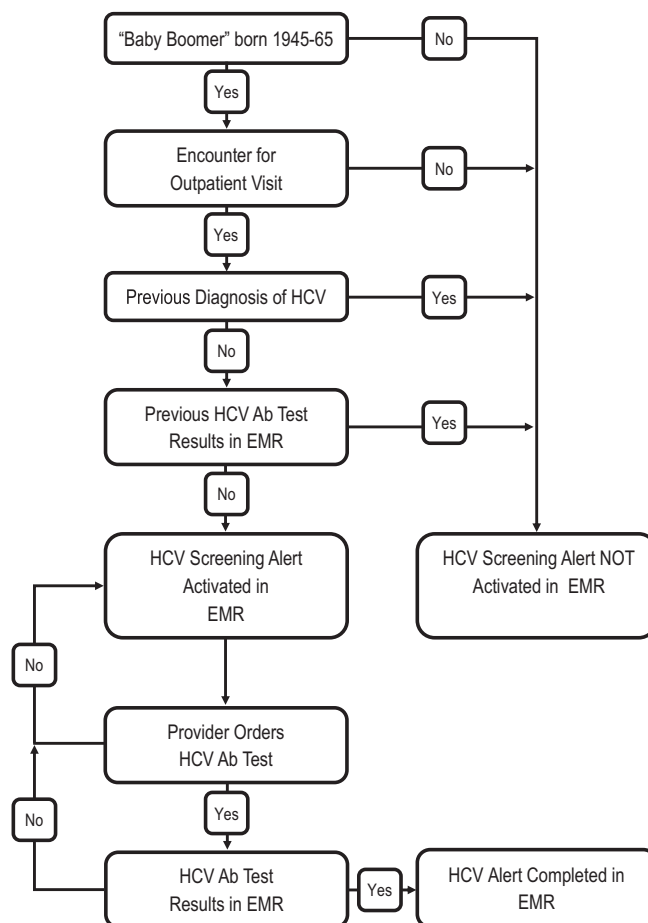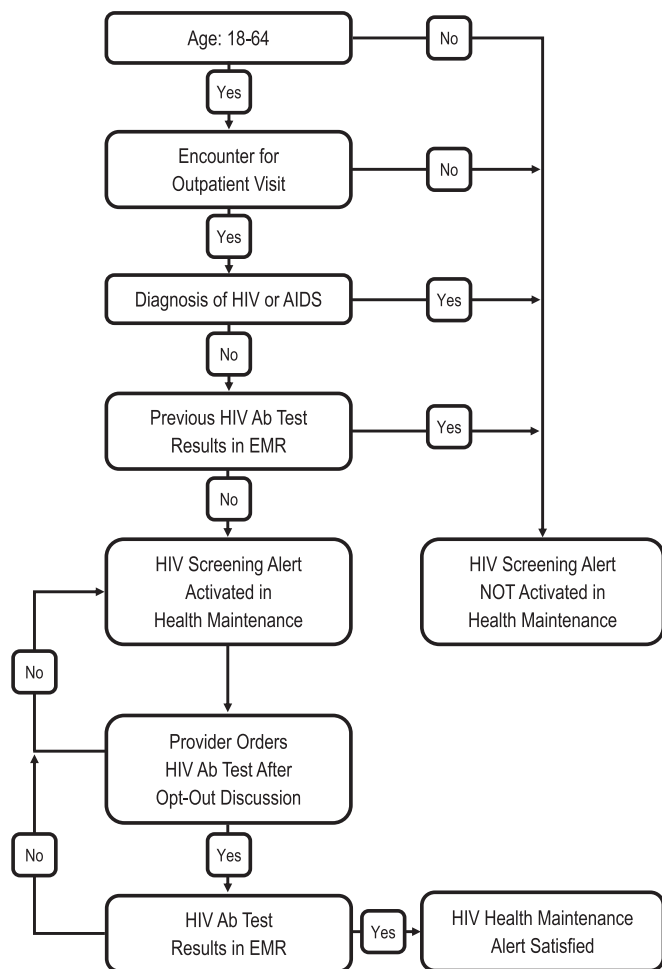
Fig. 2. Algorithm used in the Electronic Medical Record (EMR) to determine process for an HIV Screening in Primary Care with Atrium Health, 2019.

about the HCV screening test. To comply with the alert requirements, either an HCV test will be ordered, and results documented in the EMR thereby satisfying the alert, or if the patient refuses, the alert will remain active in their health maintenance module until satisfied as above. The alert is automatically canceled if a hospice care diagnosis is entered into the EMR.

Secondly, the HIV alert, (Fig. 2), prompted providers to screen adult patients (age 18–64 years), who meet the eligibility criteria for a once in a lifetime HIV screening, and no prior HIV diagnosis or test documented in the EMR. Since October 2017, the alert appears on the ambulatory summary page in the health maintenance section of the EMR and does not include a risk factor-based screen other than age. The alert was restricted to age 18–64 years rather than the CDC recommended guideline of 13–64 years based on concerns regarding extremely low prevalence of HIV in patients < 18 years of age within the healthcare system. When the provider sees the alert, they are encouraged to notify the patient of the screening test using opt-out language. To comply with the alert requirements, either a test will be ordered, and results documented in the EMR thereby satisfying the alert, or if the patient refuses, the alert will remain active in their health maintenance module until satisfied as above. As with HCV, the alert is automatically canceled if a hospice care diagnosis is entered into the EMR.

Statistical analyses were performed using R v3.43 (R Foundation for Statistical Computing, Vienna, Austria). Data were grouped into two time periods: 1) the 12-month time period preceding alert activation; and 2) the 12-month time period after alert activation. The mean proportion of patients who received screening in each time period was

compared using a chi square test. The study was approved by the Atrium Health IRB as quality improvement on 07/15/2016.

In addition to alert activation, 10 of the 12 practices received an in-person provider peer-to-peer educational program with updates on the alerts, disease epidemiology, screening recommendations, and algorithms to guide screening efforts to supplement HCV and HIV screening and linkage to care for positive patients. The training received by the practices did not include the PDSA cycle. However, practices were encouraged to tailor their screening methods to meet the needs of their patients. The remaining 2 practices chose to receive the presentation materials by email either due to time constraints or expression of little need for the educational session. We followed up with practices a year later to present the results of their practice in comparison to the total screening for all practices in the overall project.

3. Results

Overall there was a statistically significant increase in the proportion of patients receiving screenings after the implementation of the alerts for patients seen at the 12 practices evaluated. Out of 59,632 eligible patients, 1,934 (3.2%) were adequately screened for HCV the year prior to the EMR alert. This increased to 22.7% (13,726 patients screened out of 60,422 total eligible patients) after the EMR alert was instituted. Out of 112,813 eligible patients, 6,950 (6.2%) were adequately screened for HIV the year prior to the EMR alert. This increased to 11.3% (12,379 patients screening out of 109,173 total eligible patients) after the EMR alert was instituted.

3.1. HCV screening results

Numbers of primary care patients who were eligible for screening, completed screening of antibody tests, were RNA positive, and linked into care across differing demographic groups one-year prior and one-year post initiation of a Baby Boomer HCV alert are shown in Table 1. In the 12 months prior to activation of the HCV alert from May 2015 to April 2016, 1,934 of 59,632 (3.2%) patients were screened at the 12 practices. In the 12 months following the HCV alert from May 2016 to April 2017, 13,726 of 60,422 (22.7%) patients were screened at the 12 practices, a 19.5% absolute increase compared to the year prior ($p < 0.001$, Table 1). The HCV screening resulted in an increase of antibody positive results having an RNA test performed from 68% (122/179) to 98% (430/442). Before the alert, 66 RNA positive HCV patients were detected increasing to 81 with the alert, and linkage to care increased from 59 (89%) to 74 (92%) patients post alert.

Notably, when looking at screening rates broken down into different demographics, African American patients increased screening rates from 4.7% to 28.2% ($p < 0.001$) and Caucasian 2.9% to 23.1% ($p < 0.001$). Additionally, males increased their screening rates from 3.6% to 23.9% ($p < 0.001$) and females 3.0% to 22.0% ($p < 0.001$). All categories of payor status showed significantly increased screening rates post the EMR alert ($p < 0.001$). Notably, lower proportions of African American patients (36% v 31%) and higher proportions of Caucasian (56% vs 62%) patients completed HCV screening after the alert ($p < 0.001$). However, proportions of African American patients who completed screening before and after the EMR alert were still significantly higher than the eligible patient populations. Additionally, a lower proportion of males (45% vs 42%) and a higher proportion of females (55% vs 58%) completed the screening after the alert ($p < 0.05$). Finally, the payor status proportions of the eligible patient populations screened were also significantly different before and the alert as well.

3.2. HIV screening results

Table 2 outlines the numbers of primary care patients who were eligible for screening (patients aged 18–64 years), completed screening

Table 1
Numbers of primary care patients one-year prior and one-year post initiation of a hepatitis C virus alert for baby boomers born 1945–1965.

Table 1.	Eligible for Screening		Completed Ab Test (% of Eligible)[a]		Ab + (RNA Tested)		RNA Positive (Linked to Care)	
HCV Alert	Pre-Alert	Post-Alert	Pre-Alert	Post-Alert	Pre-Alert	Post-Alert	Pre-Alert	Post-Alert
Total	59 632	60 422	1 934 (3.2)	13 726 (22.7)	172(122)	442(430)	66(59)	81(74)
Race								
African American	*25%*	*25%*	*36%*	*31%*	*52% (48%)*	*54%(55%)*	*59%(61%)*	*60%(58%)*
	14 908	15 106	696 (4.7)	4 255 (28.2)	89(58)	240(2 3 5)	39(36)	49(43)
White	*61%*	*61%*	*56%*	*62%*	*38%(45%)*	*40%(40%)*	*30%(31%)*	*33%(35%)*
	36 376	36 857	1 083 (2.9)	8 510 (23.1)	66(55)	175(1 7 1)	20(18)	27(26)
Asian	*1%*	*1%*	*2%*	*1%*	*2%(2%)*	*2%(2%)*	*2%(2%)*	*1%(0%)*
	596	604	39 (6.5)	137 (22.3)	4(2)	8(7)	1(1)	1(0)
Other/Unknown	*13%*	*13%*	*6%*	*6%*	*8%(6%)*	*4%(4%)*	*9%(6%)*	*6%(7%)*
	7 752	7 855	116 (1.5)	824 (10.5)	13(7)	19(17)	6(4)	4(5)
Gender								
Male	*40%*	*40%*	*45%*	*42%[b]*	*59%(61%)*	*52%(52%)*	*67%(66%)*	*57%(57%)*
	23 853	24 169	870 (3.6)	5 765 (23.9)	102(74)	230(2 2 4)	44(39)	46(42)
Female	*60%*	*60%*	*55%*	*58%[b]*	*40%(39%)*	*48%(48%)*	*34%(34%)*	*43%(43%)*
	35 779	36 253	1 064 (3.0)	7 961 (22.0)	70(48)	212(2 0 6)	22(20)	35(32)
Age	*59.0*	*60.0*	*58.2*	*60.4*	*58.0(57.8)*	*60.8(60.6)*	*56.9(57.9)*	*60.3(60.8)*
Payor								
Medicaid	*3%*	*3%*	*5%*	*3%*	*24%(22%)*	*10%(10%)*	*21%(21%)*	*11%(10%)*
	1 789	1 813	97 (5.4)	412 (22.7)	41(27)	44(42)	14(12)	9(7)
Medicare	*24%*	*25%*	*21%*	*23%*	*18%(20%)*	*14%(14%)*	*18%(21%)*	*19%(17%)*
	14 312	15 106	406 (2.8)	3 157 (20.9)	31(24)	61(60)	12(12)	15(13)
Commercial	*65%*	*66%*	*63%*	*69%*	*31%(34%)*	*57%(58%)*	*32%(33%)*	*54%(55%)*
	38 761	39 879	1 218 (3.1)	9 471 (23.7)	54(42)	253(251)	21(19)	44(41)
Self-Pay/Other	*8%*	*6%*	*11%*	*5%*	*27%(24%)*	*19%(18%)*	*29%(25%)*	*16%(18%)*
	4 770	3 624	213 (4.4)	686 (18.9)	46(29)	84(77)	19(16)	13(13)

Change from pre-alert ([a]All variables except for Gender = $p < 0.001$; [b] = $p < 0.1$); Baseline May 2015 - April 2016; Y1 May 2016 - April 2017, Atrium Health.

(eligible patients), completed screening (all patients regardless of age), were viral load positive, and linked to care across differing demographic groups one year prior and one-year post initiation of an HIV alert for adults age 18–64. From October 2016 to September 2017, the 12 months prior to activation of the HIV alert, 6,950 of 112,813 (6.2%) eligible patients were screened at the 12 practices. In the 12 months following activation of the HIV alert from October 2017 to September 2018, 12,379 of 109,173 (11.3%) eligible patients were screened at the 12 practices, a 5.1% absolute increase compared to the year prior ($p < 0.001$).

Similarly to HCV, for HIV, African American patients increased screening rates from 13.7% to 20.9% ($p < 0.001$) and Caucasians increased from 2.8% to 7.3% ($p < 0.001$). Both females and males increased screening rates (6.3% vs 12.5%) and (6.1% to 10.6%) respectively ($p < 0.001$). Finally, by average age, eligible patients screened after the alert were slightly older (40.0 v 43.6 years; $p < 0.001$). Similar difference was observed for all patients who completed screening.

Table 2
Numbers of primary care patients one-year prior and one-year post initiation of an HIV alert for eligible adults age 18–64 and all patient regardless of age.

Table 2.	Eligible for Screening		Completed Screening (% of Eligible Patients)		Completed Screening(All Patients)		Viral Load Positive(All Patients)		Linked to Care (All Patients)	
HIV Alert	Pre-Alert	Post-Alert[a]	Pre-Alert	Post-Alert[b]	Pre-Alert	Post-Alert[b]	Pre-Alert	Post-Alert	Pre-Alert	Post-Alert
	112 813	109 173	6 950 (6.2)	12 379 (11.3)	7 105	13 370	19	15	17	15
Race										
African American	*26%*	*26%*	*58%*	*48%*	*58%*	*45%*	*74%*	*60%*	*76%*	*60%*
	29 331	28 385	4 031 (13.7)	5 942 (20.9)	4 121	6 017	14	9	13	9
Caucasian	*54%*	*53%*	*25%*	*34%*	*26%*	*33%*	*21%*	*20%*	*24%*	*20%*
	60 919	57 862	1 738 (2.8)	4 209 (7.3)	1 847	4 412	4	3	4	3
Asian	*2%*	*2%*	*1%*	*2%*	*1%*	*2%*	*0%*	*0%*	*0%*	*0%*
	2 256	2 183	70 (3.1)	248 (11.3)	71	267	0	0	0	0
Other/Unknown	*18%*	*19%*	*16%*	*16%*	*15%*	*20%*	*5%*	*20%*	*0%*	*20%*
	20 307	20 743	1 111 (5.5)	1 980 (9.5)	1 066	2 674	1	3	0	3
Gender										
Male	*38%*	*39%*	*39%*	*43%*	*40%*	*43%*	*74%*	*80%*	*82%*	*80%*
	42 869	42 577	2 711 (6.3)	5 323 (12.5)	2 842	5 749	14	12	14	12
Female	*62%*	*61%*	*61%*	*57%*	*60%*	*57%*	*26%*	*20%*	*18%*	*20%*
	69 944	66 596	4 240 (6.1)	7 056 (10.6)	4 263	7 621	5	3	3	3
Age	*43.3*	*44.0*	*38.3*	*42.7*	*40.0*	*43.6*	*31.1*	*44.2*	*30.8*	*44.2*
Payor										
Medicaid	*6%*	*7%*	*18%*	*14%*	*17%*	*14%*	*21%*	*27%*	*29%*	*27%*
	6 769	7 642	1 251 (18.5)	1 733 (22.7)	1 208	1 872	4	4	5	4
Medicare	*4%*	*3%****	*2%*	*4%*	*4%*	*4%*	*0%*	*7%*	*0%*	*7%*
	4 513	3 275	139 (3.1)	495 (15.1)	284	535	0	1	0	1
Commercial	*79%*	*65%****	*56%*	*54%*	*56%*	*54%*	*63%*	*33%*	*59%*	*33%*
	89 122	70 962	3 892 (4.3)	6 685 (9.4)	3 979	7 220	12	5	10	5
Self-Pay/Other	*11%*	*25%*	*24%*	*28%*	*23%*	*28%*	*16%*	*33%*	*12%*	*33%*
	12 409	27 294	1 668 (13.4)	3 466 (12.7)	1 634	3 743	3	5	2	5

Change from pre-alert ([a] = $p < 0.001$ for Payor only; [b] = $p < 0.001$ for all variables); Baseline Oct 2016 – Sept 2017; Y1 Oct 2017 – Sept 2018, Atrium Health.

The racial proportions screened before and after the alert were also significantly different than the eligible populations within the 12 practices before and after the alert. There were a higher proportion of males (40% vs 43%) and a lower proportion of females (60% vs 57%) for all patients who completed the screening after the alert (p < 0.001). Similar differences in gender proportions were observed for eligible patients who completed screening. All patients screened were on average older after the alert (40.0 v 43.6; p < 0.001). A similar difference in ages was observed for eligible patients who completed screening. The payor status proportions of the eligible populations were also significantly different before and after the alert as well. A similar difference in payor status proportions was also observed for both eligible patients and all patients screened.

The percentage linked into care improved from 90% to 100% with all 15 newly diagnosed HIV patients linked after the alert. Although Mecklenburg County had a high diagnosis rate, the practices in this study had a slight decrease in new diagnoses (17 prior year, 15 post year) which is in line with a slight downward trend in new diagnoses across both the state and metropolitan area of Charlotte seen since 2016 (Centers for Disease Control and Prevention, 2018).

4. Limitations

The results of this analysis have several limitations. Atrium Health has 1.2 million primary care patients and the screening data presented here represents less than 10 percent of the primary care population of the healthcare system. Practices receiving the educational program were selected based on having the highest number of patients who fell into the Baby Boomer cohort, a number not representative of all practices in the system. In addition, the results only apply to the patients who were seen within Atrium Health and any other screening and/or linkage to care information outside the healthcare system was not included. These results apply to patients living in a large, Southeast, metropolitan region and are not applicable to other regions of the United States. Impact of the educational program could not be evaluated separately from the impact of the alert. The tests highlighted in the algorithms developed were identified as the ones used by Atrium Health for HCV and HIV testing. Other tests such as antibody and RNA testing are available and may be utilized by other healthcare facilities. While the linkage to care rates are high, this may be influenced by the low overall number of positive patients.

5. Discussion and conclusion

In line with previous studies in primary care (Federman et al., 2017; Goel et al., 2017; Kershaw et al., 2018; Marcelin et al., 2016; Centers for Disease Control and Prevention, 2019), the addition of an EMR alert was associated with improved screening for HCV and HIV in primary care practices within a large healthcare system. As compared to another urban healthcare system in Kansas City, KS, their absolute increase in HCV screenings was 25% in the birth cohort as compared to 19% in North Carolina (Al-Hihi et al., 2017). Our increase in screening rates for HCV were more in line with a study in two New York City practices where absolute increase in screening rates increased 20% compared to 19% in North Carolina (Goel et al., 2017). As compared to a Midwest study, their absolute increase in HIV screenings was 1.5% as compared to 5.1% in North Carolina. Another study in another urban healthcare system in Boston, MA had an absolute increase in HIV screenings of 15% (Kershaw et al., 2018).

Because of the concern of alert fatigue and maintaining the response time of EMRs, making changes to the EMR to include these screening alerts requires institutional committee reviews that require multiple levels of approvals before alerts can be activated (Sittig and Singh, 2012). However, once these institutional requirements are met, EMR alerts enhance routine HCV and HIV screening within medical settings and provide an opportunity to screen all who access the healthcare system without the need for the patient to acknowledge risk.

At a population level, screening all patients decreases stigma associated with being testing, as well as allowing for improved outcomes and lowered risk of disease transmission for those who test positive. Additionally, for the individual who tests positive within an integrated healthcare system with streamlined connection to specialty care, this enhanced support allows for high rates of linkage to care. Interventions such as EMR alerts, educational programs, coordinated mental health, substance abuse, and hepatitis treatment services, have been shown to independently improve HCV treatment uptake, adherence, and cure compared to usual care (Zhou et al., 2016).

For patients testing positive for the HCV antibody, subsequent RNA testing is necessary to determine current infection status. Unfortunately, this two-step process has associated inefficiencies such as the patient not returning for follow-up which can lead to incomplete testing for accurate diagnosis of HCV (McGibbon et al., 2013). Possible improvements would be implementation of reflex HCV RNA testing. Although not yet addressed by the US Preventive Services Task Force, the European Association for the Study of the Liver gives a grade B1 recommendation that reflex testing for HCV RNA in patients found to be HCV antibody-positive should be applied to increase linkage to care (European Association for the Study of the Liver, 2018). Reflex testing allows infection status to be determined without requiring a follow-up visit for blood draw and streamlines the process of ensuring that patients who screen HCV antibody-positive get the additional testing necessary; and patients with positive RNA can be immediately counseled about measures for protecting their liver and begin evaluation for antiviral treatment (McGibbon et al., 2013; Casas et al., 2018).

This study adds to the evidence on large-scale use of EMR alerts and offers other healthcare systems evidence that such large-scale alert implementation and education support can significantly improve outcomes through screening and linkage to care for infectious diseases.

Stakeholder engagement was key throughout the design and implementation of this initiative. Key stakeholders were providers who lent their medical and clinical expertise and the healthcare system quality team who championed the alert activation through partnership with EMR technology.

EMR modifications along with availability of connect-to-care partners within a large, vertically integrated healthcare system can significantly enhance screening and linkage to care for patients with HCV and HIV, however, the low post-intervention screening rates indicate there are additional interventions required to increase screening rates further.

CRediT authorship contribution statement

Hazel Tapp: Conceptualization, Methodology, Writing - original draft, Supervision, Funding acquisition. **Thomas Ludden:** Formal analysis, Writing - review & editing. **Lindsay Shade:** Resources, Writing - review & editing, Project administration. **Jeremy Thomas:** Data curation, Writing - review & editing. **Sveta Mohanan:** Writing - review & editing. **Michael Leonard:** Writing - review & editing.

local public health departments. FOCUS funding supports HIV, HCV, and HBV screening and linkage to the first medical appointment after diagnosis. FOCUS partners do not use FOCUS awards for activities beyond linkage to the first medical appointment.

References

Al-Hihi, E., Shankweiler, C., Stricklen, D., Gibson, C., Dunn, W., 2017. Electronic medical record alert improves HCV testing for baby boomers in primary care setting: adults born during 1945–1965. BMJ Open Quality 6 (2), e000084-e.

Armstrong, G.L., Wasley, A., Simard, E.P., McQuillan, G.M., Kuhnert, W.L., Alter, M.J., 2006. The prevalence of hepatitis C virus infection in the United States, 1999 through 2002. Ann. Int. Med. 144 (10), 705–714.

Barth, H., 2015. Hepatitis C virus: is it time to say goodbye yet? Perspectives and challenges for the next decade. World J. Hepatol. 7 (5), 725–737.

Casas, P., Navarro, D., Aguilera, A., Garcia, F., 2018. A pilot study on the implementation of reflex testing for the diagnosis of active hepatitis C virus infection. Enferm Infecc Microbiol. Clin. 37 (5), 348–349.

Centers for Disease Control and Prevention, 2015. National HIV/AIDS Strategy: National HIV/AIDS Strategy: Updated to 2020. Available from: < https://www.hiv.gov/federal-response/national-hiv-aids-strategy/nhas-update > .

Centers for Disease Control and Prevention, 2018. Hepatitis C Questions and Answers for Health Professionals. US Department of Health and Human Services, Centers for Disease Control and Prevention: Atlanta. Available from: < https://www.cdc.gov/hepatitis/hcv/hcvfaq.htm > .

Centers for Disease Control and Prevention, 2018. HIV Surveillance Report. Available from: < http://www.cdc.gov/hiv/library/reports/hiv-surveillance.html > .

Centers for Disease Control and Prevention, 2019. HIV Surveillance Report. Available from: < https://www.cdc.gov/hiv/statistics/overview/index.html > .

Edlin, B.R., Eckhardt, B.J., Shu, M.A., Holmberg, S.D., Swan, T., 2015. Toward a more accurate estimate of the prevalence of hepatitis C in the United States. Hepatology (Baltimore, Md) 62 (5), 1353–1363.

Eisinger, R.W., Dieffenbach, C.W., Fauci, A.S., 2019. HIV Viral Load and Transmissibility of HIV Infection: Undetectable Equals Untransmittable. JAMA 321 (5), 451–452.

European Association for the Study of the Liver, 2018. EASL Recommendations on Treatment of Hepatitis C. J. Hepatol. 69 (2), 461–511.

Fauci, A.S., Redfield, R.R., Sigounas, G., Weahkee, M.D., Giroir, B.P., 2019. Ending the HIV epidemic: a plan for the United States. JAMA 321 (9), 844–845.

Federman, A.D., Kil, N., Kannry, J., Andreopolous, E., Toribio, W., Lyons, J., et al., 2017. An electronic health record-based intervention to promote hepatitis C virus testing among adults born between 1945 and 1965: a cluster-randomized trial. Med. Care 55 (6), 590–597.

Goel, A., Sanchez, J., Paulino, L., Feuille, C., Arend, J., Shah, B., et al., 2017. A systematic model improves hepatitis C virus birth cohort screening in hospital-based primary care. J. Viral Hepatitis 24 (6), 477–485.

Herwehe, J., Wilbright, W., Abrams, A., Bergson, S., Foxhood, J., Kaiser, M., et al., 2012. Implementation of an innovative, integrated electronic medical record (EMR) and public health information exchange for HIV/AIDS. J. Am. Med. Inf. Assoc.: JAMIA 19 (3), 448–452.

Hofmeister, M.G., Rosenthal, E.M., Barker, L.K., Rosenberg, E.S., Barranco, M.A., Hall, E.W., et al., 2019. Estimating Prevalence of Hepatitis C Virus Infection in the United States. Hepatology 69 (3), 1020–1031.

Jacobson, I.M., Lawitz, E., Gane, E.J., Willems, B.E., Ruane, P.J., Nahass, R.G., et al., 2017. Efficacy of 8 Weeks of Sofosbuvir, Velpatasvir, and Voxilaprevir in Patients With Chronic HCV Infection: 2 Phase 3 Randomized Trials. Gastroenterology 153 (1), 113–122.

Jemal, A., Fedewa, S.A., 2017. Recent hepatitis C virus testing patterns among baby boomers. Am. J. Preventive Med. 53 (1), e31–e33.

Kershaw, C., Taylor, J.L., Horowitz, G., Brockmeyer, D., Libman, H., Kriegel, G., et al., 2018. Use of an electronic medical record reminder improves HIV screening. BMC Health Serv. Res. 18 (1), 14.

Konerman, M.A., Thomson, M., Gray, K., Moore, M., Choxi, H., Seif, E., et al., 2017. Impact of an electronic health record alert in primary care on increasing hepatitis c screening and curative treatment for baby boomers. Hepatology 66 (6), 1805–1813.

Lin, J., Mauntel-Medici, C., Heinert, S., Baghikar, S., 2017. Harnessing the power of the electronic medical record to facilitate an opt-out HIV screening program in an urban academic emergency department. J. Public Health Manag. Pract. 23 (3), 264–268.

Marcelin, J.R., Tan, E.M., Marcelin, A., Scheitel, M., Ramu, P., Hankey, R., et al., 2016. Assessment and improvement of HIV screening rates in a Midwest primary care practice using an electronic clinical decision support system: a quality improvement study. BMC Med. Inf. Decis. Making 16 (1), 76.

McGibbon, E., Bornschlegel, K., Balter, S., 2013. Half a diagnosis: gap in confirming infection among hepatitis C antibody-positive patients. The Am. J. Med. 126 (8), 718–722.

Mecklenburg County Health Department, 2018. Getting to Zero Mecklenburg: A Community Plan to Reduce New Cases of HIV in Mecklenburg County. Available from: < https://www.mecknc.gov/HealthDepartment/CDControl/HIVSTDSurveillance/Documents/Getting%20to%20Zero%20Mecklenburg.pdf > .

Moyer, V.A., Force USPST, 2013. Screening for hepatitis C virus infection in adults: U.S. Preventive Services Task Force recommendation statement. Ann. Int. Med. 159 (5), 349–357.

Rein, D.B., Wittenborn, J.S., Weinbaum, C.M., Sabin, M., Smith, B.D., Lesesne, S.B., 2011. Forecasting the morbidity and mortality associated with prevalent cases of pre-cirrhotic chronic hepatitis C in the United States. Digestive and Liver Dis. 43 (1), 66–72.

Sittig, D.F., Singh, H., 2012. Electronic health records and national patient-safety goals. The New England J. Med. 367 (19), 1854–1860.

Smith, B.D., Morgan, R.L., Beckett, G.A., Falck-Ytter, Y., Holtzman, D., Teo, C.G., et al., 2012. Recommendations for the identification of chronic hepatitis C virus infection among persons born during 1945–1965. MMWR Recommendations and reports: morbidity and mortality weekly report Recommendations and reports. Centers for Disease Control 61 (RR-4), 1–32.

United States Department of Health & Human Services, 2018. Office of the National Coordinator for Health Information Technology. HealthIT.gov. Available from: < http://www.healthit.gov/providers-professionals/benefitselectronic-health-records-ehrs > .

United States Preventive Services Task Force, 2019. Draft Recommendation Statement: Hepatitis C Virus Infection in Adolescents and Adults: Screening. https://www.uspreventiveservicestaskforce.org/Page/Document/draft-recommendation-statement/hepatitis-c-screening1.

Zhou, K., Fitzpatrick, T., Walsh, N., Kim, J.Y., Chou, R., Lackey, M., et al., 2016. Interventions to optimise the care continuum for chronic viral hepatitis: a systematic review and meta-analyses. The Lancet Infect. Dis. 16 (12), 1409–1422.