

# Successful Hepatitis C Birth Cohort Screening and Linkage to Care in a US Community Health System

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## ABSTRACT

**Context:** Birth cohort (“baby boomer”) screening represents a well-validated strategy for the identification of asymptomatic hepatitis C–infected patients. However, successful linkage of newly diagnosed patients to antiviral therapy has been more difficult to accomplish.

**Objective:** To analyze the results of a systemwide birth cohort screening program in a US community health care system.

**Design:** We analyzed the data from an ongoing hepatitis C virus (HCV) screening and treatment program that was established at NorthShore University Health System in 2015. Hepatitis C virus screening by primary care providers was prompted through automated Best Practice and Health Maintenance alerts. Patient visits and screening orders were tracked using a customized HCV dashboard. Virologic, demographic, and treatment data were assessed and compared with those of a cohort of patients with previously established HCV infection.

**Results:** Since program inception, 61 8161 (64.3%) of the entire NorthShore baby boomer population of 96 001 patients have completed HCV antibody testing, and 160 patients (0.26%) were antibody positive. Of 152 antibody-positive patients who underwent HCV RNA testing, 53 (34.2%) were viremic. A total of 39 of 53 patients (73.6%) underwent antiviral therapy and achieved a sustained virologic response. Compared with patients identified through screening, a comparison cohort of patients with previously established HCV had more advanced fibrosis and significantly lower dropout rates. The COVID-19 pandemic was associated with a decrease in the number of outpatient visits of screening-eligible patients and with a reduction in HCV screening rates.

**Conclusion:** Our data demonstrate the electronic medical records–assisted systemwide implementation of HCV birth cohort screening and successful linkage to antiviral therapy in a community-based US multihospital system.

**KEY WORDS:** antiviral therapy, birth cohort screening, cascade of care, electronic medical records, hepatitis C

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A worldwide strategy to control and largely eliminate hepatitis C virus (HCV) infection by 2030 was initiated by the World Health Organization in 2016.<sup>1</sup> This ambitious target was inspired by the realization of the public health implications of untreated chronic hepatitis C and by the deployment of highly effective direct-acting antiviral medications in 2014. Eradication of HCV at the health system level requires a multipronged approach that includes the identification of asymptomatic, infected patients through systematic screening. In the United States, the high prevalence of infection in baby boomer prompted a recommendation by the Centers for Disease Control and Prevention (CDC) to support the one-time HCV testing of persons born during 1945–1965 without prior ascertainment of their HCV risk (“baby boomer screening”) in 2012.<sup>2</sup>

Over the past decade, HCV birth cohort screening programs have been implemented in a wide range of

US health systems. Significant increases in screening rates have been achieved by incorporating electronic medical records (EMR)-based alerts for the primary care physicians. However, these improvements did not necessarily translate into better follow-up care or increased antiviral treatment rates,<sup>3</sup> due to imperfect follow-up steps during the “HCV cascade of care.”<sup>4</sup>

We present the results of an EMR-facilitated HCV birth cohort screening program that was established at the NorthShore University Health System, a community-based multihospital system in the Northern suburbs of Chicago. Our data demonstrate that high screening rates and successful linkage to antiviral treatment can be accomplished at the health system level.

## Methods

### ***NorthShore University Health System***

NorthShore currently serves a population of 4.2M patients in the greater Chicago area, corresponding to approximately one-third of the Illinois population. It comprises 9 hospitals and more than 300 practice sites. Approximately, 190 primary care physicians participated in the HCV screening program between the years of 2017 and 2022.

### ***Demographic analysis of the birth cohort population***

Demographic data on the NorthShore baby boomer population were extracted from the medical record system. They included information on race, ethnicity, age, gender, and insurance status. In addition, the patients' home addresses were analyzed and graphically displayed as a heat map.

### ***EMR-facilitated HCV screening alert***

The development and implementation of a health systemwide screening alert have been previously described in detail.<sup>5</sup> The program was coordinated by a team of primary care lead physicians, a hepatologist (C.J.F.), a nurse practitioner (K.F.N.), and a pharmacist (P.L.). It was championed by the institutional leadership and supported by a member of the clinical analytics team (P.I.). The alert was designed and implemented in 2015, and systematic data collection began in October of 2016. Test-naïve patients born between January 1, 1945, and December 31, 1965, were identified within the EMR system at the time of their primary care clinic visits. Hepatitis C virus-specific Best Practice Alerts and Health Maintenance Alerts were embedded in the EMR to prompt an order

for hepatitis C antibody testing in patients for whom no such information was available in the records. If the physician placed an order for the test, a health maintenance record was generated in the EMR system. If the date of at least 1 encounter resulting in the screening alert preceded the date of the test entry, it was assumed that the test order was placed in response to the alert, regardless of whether the physician chose to place the test order immediately or at a later time point (“qualifying encounter”). Once a screening order had been placed for a given patient, any subsequent encounters for this patient were excluded from the count, since the screening requirement had been fulfilled.

### ***Data collection***

The number of HCV-screening prompts and the subsequent physician responses were tabulated for each patient, and stored in a secure, password-protected file within the institutional research drive. The data were extracted from the EMR via an ETL (“Extract, Transform, Load”) algorithm built by the health system's data warehouse. A data source was created that included all data and calculations to be used for the dashboard. The study was approved by the NorthShore University Health System Institutional Review Board.

### ***Dashboard construction***

A computer dashboard was created to track physician responses to the screening alert. The dashboard was designed using “Tableau,” a visual analytics platform ([www.tableau.com](http://www.tableau.com)). Starting in July of 2017, the dashboard was published monthly in the NorthShore production environment.

### ***Linkage to care***

A dedicated hepatitis C clinic was established at one of the health system's hospitals in 2014. Following the implementation of the screening alert in 2015 and the completion of the HCV dashboard in 2017, lists of newly identified HCV antibody-positive patients were provided to the clinic staff on a monthly basis. Patients were contacted directly or through their primary care physician's office and advised to undergo confirmatory polymerase chain reaction testing. If necessary, multiple reminders were generated by the clinic staff, using protected patient email messaging, phone calls, or written notifications. Viremic patients underwent blood testing for HCV genotyping. Fibrosis staging was performed by transient elastography, magnetic resonance elastography, or liver biopsy. Fibrosis stages

0 to 2 were classified as “no or mild fibrosis,” fibrosis stage 3 as “advanced fibrosis,” and fibrosis stage 4 as “cirrhosis.” Antiviral therapy was provided following guidelines published by the American Association for the Study of Liver Diseases (AASLD) ([www.HCVguidance.org](http://www.HCVguidance.org)).

**Statistical analysis**

Differences between groups of patients were compared using  $\chi^2$  and Fisher exact testing. *P* values of .05 and less were considered significant.

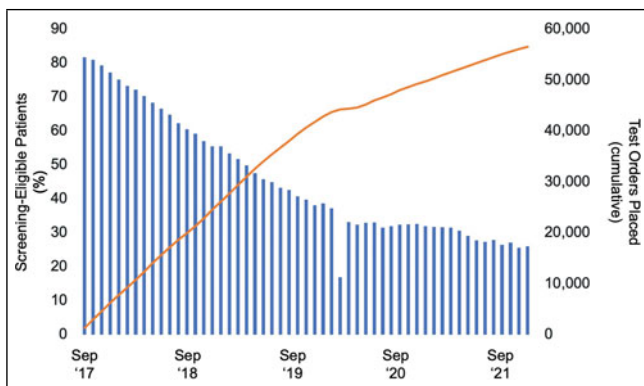
**Results**

**Patient demographics**

Details of the demographic analysis are provided in Supplemental Digital Content Figure 1, available at <http://links.lww.com/JPHMP/B18>, and Supplemental Digital Content Table 1, available at <http://links.lww.com/JPHMP/B19>. Patients were predominantly White. Insurance coverage included commercial plans (53.2%) or Medicare (43.4%), with a small Medicaid contribution (1.9%). The catchment area of the screening project was analyzed by displaying the frequency distribution of patients’ zip codes within a map of Chicago and its Northern suburbs.

**Dashboard analysis**

The results of our HCV dashboard analysis are summarized in Figure 1. During the early phase of the program, more than 80% of patient visits met the EMR-defined screening criteria (Figure 1). With successful program implementation, the percentage of unscreened patients declined steadily to



**FIGURE 1** Cumulative Effect of Birth Cohort Screening Program<sup>a</sup>

<sup>a</sup>The figure shows a progressive decline in the percentage of screening-eligible patients (blue column) and a corresponding increase in the cumulative number of hepatitis C virus-antibody test orders (red line) during the time period of August 2018 to December 2021. This figure is available in color online ([www.JPHMP.com](http://www.JPHMP.com)).

approximately 26% by February 2022. This was mirrored by a steady increase in the cumulative number of tests placed. Screening activity declined in March 2020, concomitant with the first lockdown phase of the COVID-19 pandemic. Since then, progress of the screening program has been slow in comparison with the first years following implementation. A screenshot of the HCV dashboard is provided in Supplemental Digital Content Figure 2, available at <http://links.lww.com/JPHMP/B20>.

**Screening results**

The results of the screening program are summarized in the Table. Overall, 96 001 birth cohort patients were identified who had not previously been tested for HCV. In response to the screening alert, 61 861/96 001 patients (64.3%) completed the

**TABLE 1**  
Results of HCV Testing, Disease Staging, and Antiviral Treatment Outcomes

Patient Group	N (%)
Test eligible	96 001
Testing completed	61 681 (64.3)
Testing incomplete	34 320 (35.7)
HCV Ab-positive patients	160 (0.26)
HCV RNA-positive	53/152 (34.2)
Viremic men	29/62 (46.8)
Viremic women	24/90 (26.7)
HCV genotype	
1	45 (85.0)
2	4 (7.5)
3	3 (5.7)
4	1 (1.9)
Fibrosis stage	
0-1	36 (69.2)
2	6 (11.5)
3	4 (7.7)
4	6 (11.5)
SVR (initial treatment)	38
Relapse (initial treatment)	1
SVR pending	3
Treatment pending	1
Dropouts	10 (18.9)
Patients retreated	1
SVR (retreatment)	1 (100)
SVR (ITT)	39/53 (73.6)
SVR (completed treatment)	39/39 (100)

Abbreviations: HCV, hepatitis C virus; ITT, intention to treat; SVR, sustained virologic response.

HCV antibody test, whereas the remaining 34 320 patients (35.7%) have not completed testing to date. Overall, 160 of 61 269 patients (0.26%) of birth cohort patients tested positive for the HCV antibody. Of these, 152 underwent polymerase chain reaction testing and 53 (34.2%) were confirmed to be viremic. The remaining 8 patients were lost to follow-up. The percentage of HCV antibody-positive men who were viremic (29/62, 46.8%) was higher than that of viremic women (24/90, 26.7%) ( $P < .05$ ). Genotype information was available on all patients with confirmed viremia. The majority (85%) were infected with HCV genotype 1.

Fibrosis staging was performed in 52 of 53 patients. The majority (80.7%) had no or mild fibrosis, (stages 0-1: 69.2%, stage 2: 11.5%, respectively). The remainder of patients had advanced fibrosis or cirrhosis (stage 3: 7.5%, stage 4: 11.5%).

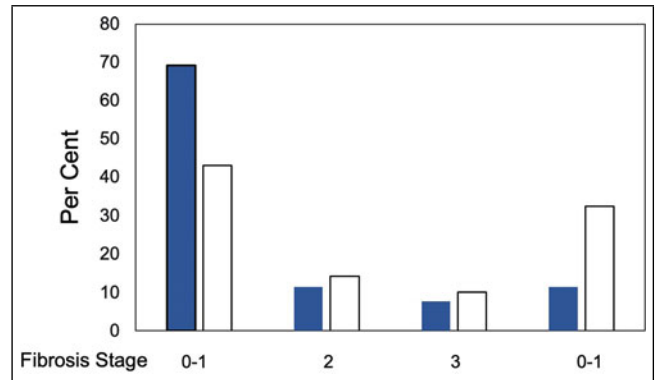
To date, 39 of 53 viremic patients have been successfully treated with direct-acting antiviral medications and have achieved a documented sustained virologic response (SVR). This included 1 patient who failed on initial treatment but achieved SVR after retreatment with sofosbuvir/velpatasvir/voxilaprevir. An additional 3 patients are currently being treated, 1 patient is scheduled to start treatment, and 10 patients (18.9%) have dropped out.

When measured on an intention-to-treat basis, 73.6% of viremic patients achieved documented SVR, with an SVR rate of 100% in patients who completed antiviral therapy and the necessary posttreatment testing.

### Comparison to patients with established HCV

Since the Food and Drug Administration approval of direct-acting antiviral medications, 657 patients were referred to our HCV clinic for treatment. The HCV genotype distribution of this patient group was similar to that of birth cohort patients (genotype 1: 79.6%, genotype 2: 9.8%, genotype 3: 9.1%, and genotype 4: 1.5%,  $P = .77$ , non-significant). Compared with birth cohort patients, patients with established infection were significantly less likely to have no or mild fibrosis and more likely to have stage 4 fibrosis (stages 0-1: 43.0%, stage 2: 14.3%, stage 3: 9.4%, stage 4: 30.3%,  $P < .005$ ) (Figure 2). A total of 128 of 657 (19.4%) patients had previously failed antiviral therapy (Figure 3).

The SVR rate on an intention to treat (ITT) basis was 91.3%, significantly higher than in birth cohort patients ( $P = .001$ ). The SVR rate of patients who completed antiviral therapy and who underwent posttreatment testing was 98.5%, not significantly different from the screening group.

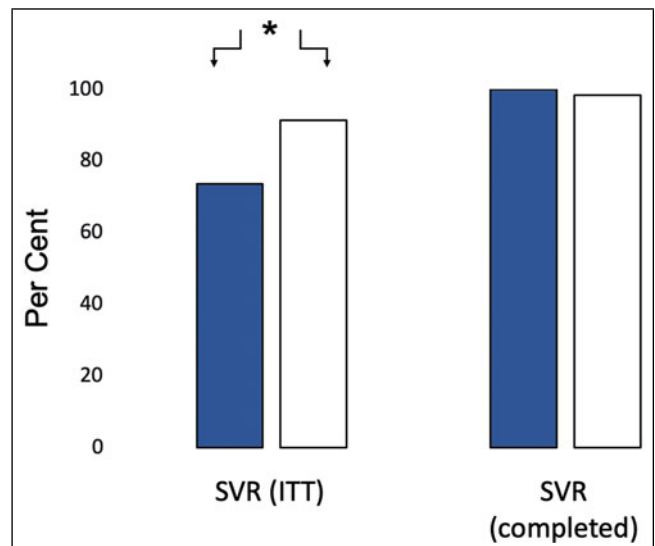


**FIGURE 2** Fibrosis Staging<sup>a</sup>

<sup>a</sup>The figure shows the fibrosis stages of patients identified via screening (blue) and of patients with known infection (white). The difference between the 2 groups was statistically significant ( $\chi^2$  statistic,  $P = .002$ ). This figure is available in color online ([www.JPHMP.com](http://www.JPHMP.com)).

### Discussion

We present the results of an EMR-facilitated HCV birth cohort screening program that was established at NorthShore University Health System, a community-based multihospital system in the Northern suburbs of Chicago. Over the past years, the majority of baby boomer patients have been screened, and continued screening can be expected to result in a further increase in the screening rate. Thus, our study demonstrates the feasibility and potential impact of this approach at the health system level.<sup>6,7</sup>



**FIGURE 3** Response to Antiviral Therapy<sup>a</sup>

Abbreviations: ITT, intention to treat; SVR, sustained virologic response. <sup>a</sup>The figure shows the SVR rates in patients whose infection was newly identified through birth cohort screening (blue) and in patients with known infection who were referred for treatment (white). \* $P < .05$ . This figure is available in color online ([www.JPHMP.com](http://www.JPHMP.com)).

As shown in Figure 1 and in Supplemental Digital Content Figure 1, available at <http://links.lww.com/JPHMP/B18>, the percentage of screening-eligible patients presenting to their primary care providers gradually declined throughout the period of observation, a trend that was mirrored by the rising cumulative number of HCV antibody tests ordered. To date, the majority of the ordered tests (64.3%) have been completed (Table). The robust and steady screening rates during the time period between September 2017 and the beginning of 2020 resulted in a reduction of unscreened (“screening-eligible”) patients by almost 50%. Based on this trend, we initially predicted completion of the screening program by 2022. However, the onset of the COVID-19 pandemic in 2020 resulted in a slowdown of the screening program, with smaller number of patients added to the cumulative effort (Figure 1, red line), and a more gradual decline of the percentage of unscreened patients. Similar decreases in HCV testing and treatment during the COVID-19 pandemic have recently been reported by others<sup>8</sup> and will likely have a negative impact on birth cohort screening in the United States and worldwide.

The HCV-antibody prevalence in our patient population was 0.26%, substantially below the reported national average of 1.7%.<sup>9</sup> We suspect that this result is due to the demographic features of our patient population, which comprises an affluent, well-insured, suburban community (see Supplemental Digital Content Table 1, available at <http://links.lww.com/JPHMP/B19>, and Supplemental Digital Content Figure 1, available at <http://links.lww.com/JPHMP/B18>). Furthermore, we deliberately did not include emergency department patients in our program since a large percentage of these patients lacked a primary care provider or the necessary insurance coverage for direct-acting antiviral medications. Previous studies have shown high HCV positivity rates in emergency department patients particularly in urban locations that serve non- or underinsured patients with high-risk features such as intravenous drug use.<sup>10</sup> The demographic features of our target population very likely contributed to the successful linkage of care and treatment success, while limiting its overall impact. Addressing the tradeoffs involved in HCV screening will require continued efforts directed against all individual steps in the care cascade.<sup>11</sup>

The percentage of antibody-positive patients with confirmed viremia (34.2%) was within the range of previous reports. Similarly, the significant difference in viremia rates between male and female patients was expected on the basis of prior studies.<sup>12</sup> The HCV genotype distribution reflected the demographics of

our patient population.<sup>13</sup> With regard to fibrosis staging, approximately 80% of patients had no or mild fibrosis, whereas approximately 20% had advanced fibrosis or cirrhosis. This distribution is similar to that reported in previous reports.<sup>14</sup>

We consider the successful linkage to care as an important benefit of our strategy, as 43 of 53 (81.1%) newly diagnosed patients presented to our clinic for staging and antiviral therapy. This result compares favorably with similar efforts reported in the literature.<sup>15-18</sup> Several factors may have contributed to this outcome, including our persistent efforts to contact the patients directly, via phone calls, emails, and letters, or indirectly—through their primary care providers. However, despite our emphasis on “linkage,” we found that 18.9% of patients would not submit to a staging evaluation or antiviral treatment course. As a result, the SVR rate in an ITT analysis was 73.6% (39/53). An additional 3 patients are currently undergoing antiviral therapy, and 1 patient has been approved for treatment. Assuming successful treatment of the remaining 5 patients, the maximal potential SVR rate on an ITT basis will be 43 of 53 (81.1%). The problem of patient dropout in screening HCV-screening programs has been raised in several studies. For example, a recent report on a nationwide HCV-screening and treatment program in the country of Georgia revealed surprisingly low treatment rates in newly diagnosed patients, despite a streamlined testing strategy that included reflex HCV-cAg testing.<sup>19</sup> The authors point out several barriers to treatment, including a lack of disease awareness within the target population.

The unique features of our screening population become evident in a comparison with a group of 657 patients who were referred to our hepatitis C clinic for antiviral therapy. The patients in this cohort had significantly higher fibrosis stages, and a large percentage had previously failed antiviral therapy. The ITT SVR rate in this highly motivated cohort was 91.3%, significantly higher than in the screening cohort. This may not be surprising as these patients actively pursued a clinic evaluation due to their disease awareness and their desire to undergo (re)treatment. Raising awareness and educating the birth cohort patient population will be required close this gap in the HCV care cascade.

### Limitations

The success of our program required the sustained efforts of our primary care providers who embraced the EMR-screening alerts and referred their HCV antibody-positive patients to our liver clinic. Additional contributing factors included the strong

## Implications for Policy & Practice

- Population-wide screening of birth cohort patients for hepatitis C infection was introduced as an important public health policy goal by the CDC and the United States Preventive Services Task Forces in 2012. It was recently superseded by a recommendation to expand screening to all adults older than 18 years.
- Despite these ambitious goals, the implementation of the screening mandates has had limited success, due to low screening rates and to ineffective linkage of diagnosis to antiviral treatment.
- Our article highlights a straightforward and successful strategy to meet the HCV-screening goals with an efficient linkage to care.

institutional support, the establishment of a dedicated HCV clinic within the health system, and the support by our medical IT group, in particular, the development of a dashboard that allowed continuously updated monthly tracking of the program. As such, the applicability of our findings will be limited to health systems with comparable infrastructure and support.

Since the implementation of our program, the CDC has endorsed broader screening recommendations, which call for one-time testing of all individuals between the ages of 18 and 74 years.<sup>20</sup> The adaptation of our baby boomer program to reflect the new screening criteria would be straightforward from IT perspective. However, it remains to be determined whether similar success rates can be accomplished under the new guidelines.

## Conclusions

Our study demonstrates the feasibility of an EMR-facilitated, sustained HCV-screening program in a suburban health system. To date, 64.3% of the entire health system baby boomer population have completed screening, and 73.6% of patients with confirmed viremia have been successfully treated with direct-acting antiviral medications. We hope that our approach may be applicable to other health care systems and could be adapted to larger target populations to meet the updated CDC screening guidelines.

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