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Experience and Compliance with Scanning Vaccine's 2D Barcodes to Record Data

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Abstract

Automated population of data into health information system fields offers the potential to increase efficiencies and save time. Increasingly, as 2D barcoded vaccine products and barcode scanning technology become more widely available, manual recording of vaccine data can be reduced. This evaluation explores how often 2D barcodes on vaccine vials and syringes were scanned and the perceived benefits and challenges reported by vaccine providers. Eighty-two facilities that administer vaccines completed the evaluation. Twenty-seven of those facilities provided records from vaccines administered between July 2014 and January 2015. Among the 63,179 2D barcoded vaccine administrations recorded, 12,408 (19%) were scanned. We received 116 user surveys from 63 facilities; using content analysis we identified perceived benefits of scanning, workflow challenges, scanning challenges, and other challenges. The findings of this evaluation can guide health information system developers, vaccine manufacturers, and vaccine providers on how to remove potential barriers to using 2D barcode scanning.

Keywords

2D barcode; Health Information Systems; immunization; vaccines

Background

Since the National Childhood Vaccine Injury Act (NCVIA) of 1986, vaccine providers are required to record specific information about vaccines they administer, including lot numbers and other data elements.¹ Documentation of vaccine data in patient records helps determine whether recalled or expired vaccines have been administered and can be used to

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identify specific lots associated with adverse events. These data fields are also useful for vaccine management processes, and some practices use health information system (HIS) inventory modules to decrement vaccines from practice inventory as doses are entered into patient records. Typically, vaccine data are recorded in patient records by nurses, medical assistants, physician assistants, physicians or other health care providers who manually type information into free-text fields or select from dropdown lists. The American Academy of Pediatrics and the Centers for Disease Control and Prevention (CDC) support expanded information capture beyond NCVIA requirements, including expiration date.^{2,3} However, even required data are often not fully and accurately captured. Based on the 2014 Immunization Information System (IIS) annual report, all records indicated the administered vaccine type and vaccination date, but fewer specified the lot number (81% complete) or manufacturer (78% complete).⁴

Linear barcodes contain a vaccine's national drug code (NDC), or product identifier;⁵ however, size constraints on vials and syringes prevent inclusion of additional information in this type of barcode. A 2011 waiver to the 2004 Food and Drug Administration (FDA) rule requiring linear barcodes containing the NDC has expanded opportunities to automate the process for capturing critical vaccine data. This waiver allows vaccine manufacturers to use alternative symbology, such as two-dimensional (2D) barcodes, which can hold more data than linear barcodes.^{6,7} In addition to the NDC/product identifier, 2D barcodes can hold lot number and expiration date and will fit on small vials and syringes.³

Research suggests that scanning 2D barcodes on vaccines improves HIS data quality for required elements in vaccine records (e.g., lot number) rather than typing or selecting from dropdown lists.^{8,9,10} However, recording comprehensive information about vaccines can be limited by the functionality of an HIS as well as by the type of barcode. HISs generally contain lot number and expiration date fields but may not include fields for other data elements, such as the vaccine funding source, that vaccine providers may be asked to record. An HIS may not have a dedicated field or be configured to adequately convert other data embedded in the barcode (e.g. the vaccine manufacturer). Vaccine providers may not routinely scan vaccine labels, even if they have barcodes, opting to use their traditional method of data entry (e.g., manually typing the data or using dropdown menus). Additionally, some vaccines do not have 2D barcodes on the unit-of-use (e.g., vial or syringe), and vaccine providers often use a mix of products with and without 2D barcodes, although the number of vaccines with 2D barcodes has grown in recent years. As of the end of June 2016, four vaccine manufacturers had introduced more than 90 2D barcoded vaccines, constituting the majority of vaccines available for purchase in the United States (U.S.).¹¹

Potential benefits of 2D barcode scanning will not be fully realized until scanning is widely adopted and regularly used. As this is a relatively new and potentially beneficial public health practice,^{8,9,10} we examined the implementation of 2D barcode scanning at facilities across the U.S.

Evaluation Design and Methods

Design

We conducted an evaluation to assess: 1) how often 2D barcodes were scanned when vaccines with 2D barcodes were administered (hereafter referred to as “compliance with scanning”); and, 2) experiences reported by persons who scanned barcodes, including benefits of and barriers to using 2D barcode scanning with vaccines. The project was reviewed by the CDC National Center for Immunization and Respiratory Diseases Human Subjects Advisor and was determined to be non-research public health practice and therefore did not require Institutional Review Board (IRB) oversight.

We recruited facilities through four mechanisms. First, we solicited facilities that had responded to a call for volunteers for a prior CDC 2D vaccine barcode evaluation but had not participated. Second, the American Pharmacists Association sent announcements to their distribution list. Third, we conducted targeted recruitment of non-pediatric facilities that had previously been underrepresented in evaluation of vaccine barcodes. Fourth, several facilities proactively expressed interest in participating after learning of the evaluation through other mechanisms. We included publicly- and privately-funded facilities, retail and independent pharmacies, and mass vaccinators (i.e. mobile vaccination clinics) facilities if they: 1) responded that they were likely to use vaccines with 2D barcodes during the project data collection period; 2) volunteered to scan 2D barcoded vaccines near the time of vaccine administration; 3) were willing and able to submit de-identified vaccine administration record level data from HISs, including electronic medical records (EMRs); 4) used an HIS to capture vaccine administration data that could be recorded with 2D barcode scanning; 5) agreed to use a program that would ascertain if the lot number and expiration date for a specific vaccine was captured using a 2D barcode scanner; and 6) agreed to have vaccine providers complete online surveys. We sent interested facilities a recruitment survey for completion, which was used to assess these inclusion criteria.

Mass vaccinators were recruited but excluded from the analyses presented in this paper because, unlike other facilities, we were not able to use an indicator to confirm scanning occurred and had to assume scanning occurred as it was supposed to be the only available method of data entry. Additionally, the mass vaccination clinics did not have permanent staff, and therefore it was not feasible to identify individuals to include in the survey. Ninety-four facilities were enrolled in the broader evaluation; seven facilities (7%) opted-out over the course of the evaluation. Additionally, the five mass vaccination facilities were excluded from the analysis; therefore, 82 facilities were included in this analysis.

We provided and installed the same model of corded, handheld image scanners in each participating facility and programmed them to enter data from scanned 2D barcoded vaccines into the facilities’ HISs. The team conducted in-person barcode scanner trainings for facility staff. Introducing vaccine barcode scanning inherently changed the process for inputting vaccine administration data into the HIS, so the team operated a helpdesk to answer questions and troubleshoot technical issues and other challenges throughout the data collection phase. To understand more about the overall implementation process, we

instructed facility staff to use supplied scanners to populate HIS fields for lot number and expiration date fields for all administered vaccines with 2D barcodes.

HIS Data and Scan Logs—Participating facilities electronically transmitted de-identified HIS vaccine administration record data to us. We used de-identified HIS data collected from July 1, 2014 through January 31, 2015 in our analysis. These HIS data included a record-level indicator of whether the information was populated using a 2D barcode scanner. For facilities that used an HIS that was already capable of tracking which vaccine records were entered into the system via a 2D barcode scanner (a native scan log), we utilized the system-populated flag as the record-level indicator of a scanned record (i.e., a flag indicated that a record was populated by scanning rather than manual entry, and no flag indicated that data were entered via traditional methods). Some facilities with HISs that did not have this functionality allowed us to install project-customized software to record data from the scanner into a separate text file (an installed scan log). At facilities with an installed scan log, where the text file matched a record of an administered vaccine in the HIS data on both lot number and date recorded were also considered scanned. HIS vaccine administration records that did not have an associated text file record were considered to have been entered via traditional methods. Both flagged records (from native scan logs) and matched records (from installed scan logs) were identified as scanned in our analysis.

Reference File—Three manufacturers supplied data that included trade names, lot numbers, and 2D barcode presence/absence for vaccines distributed from July 2013 through January 2015, a timeframe that includes the study period and one year prior. Since there were some non-2D barcoded products on the market, these data served as a reference for identifying an administered vaccine with a 2D barcode in the de-identified HIS vaccine record data. To determine the total number of 2D barcoded vaccines administered, we matched the vaccine lot number and expiration dates provided by manufactures in the reference file with both lot number and expiration date in the de-identified HIS data.

Calculating Compliance—Compliance with scanning was quantified as percentage of all records of 2D barcoded vaccines administered that were scanned. To calculate compliance, we divided the total number of 2D barcoded vaccines scanned by the total number of 2D barcoded vaccines administered. The result was multiplied by 100 to create a percentage. We used SAS 9.2 (Cary, NC) to perform all descriptive analyses of the HIS data and the characteristics of the survey respondents as well as to identify HIS vaccine administration records of 2D barcoded vaccines by matching with the reference file list of 2D barcoded vaccines.

User Experience Surveys—At each of the facilities participating in the evaluation, the facility primary contact identified individuals who administered vaccines (users) to complete the User Experience Survey. The survey instrument included four domains: 1) general information about the user/respondent, 2) experiences with recording 2D barcode vaccine inventory, 3) experiences with recording 2D barcode vaccines in a HIS record, and 4) additional feedback on using 2D barcode scanning. The survey included six open-ended, optional questions to ascertain perceived barriers and benefits of 2D barcode scanning.

These questions, listed in Figure 1, were used to help identify challenges the users faced (four questions), perceived benefits (one question), and other insights (one question). The survey was developed using *Qualtrics* software and pretested with five eligible respondents for face validity. We used skip patterning, and therefore not all respondents saw all questions. The survey instrument was distributed via email during January 2015. Responses were collected through February 2015. The emails contained individualized links for each recipient that allowed us to associate respondents with their facility.

We used content analysis to evaluate the qualitative data from the open-ended questions regarding user experiences. We began our analysis by reviewing the open-ended question responses. We used an inductive process in which text was grouped into themes and subsequently into sub-theme categories. We did not limit the number of relevant categories we could assign to an open text response. Each response was reviewed and independently coded by two of the authors (AD, HE). After coding a sample of the responses, coding was compared, discrepancies were discussed, and codes were refined. Inter-coder agreement averaged 86 percent across questions. Frequently mentioned subthemes appeared in more than 20 responses; the subthemes indicated by some respondents (or less frequently identified) appeared in between five and 16 responses.

Results

Of the 82 facilities included in this analysis, 66 facilities (77%) were included in the survey analysis, since they provided at least one user survey, and 27 (33%) were included in the scanning compliance analysis. As described in the methods, the facilities that were included in the compliance analysis were those where we are able to determine if scanning took place as they provided HIS data and had HIS software that captured an indicator of whether scanning took place (a native scan log) or allowed this function to be installed (installed scan log).

Compliance with Scanning 2D Barcoded Vaccines

Compliance Facilities—As described in Table 1, facilities providing HIS data most frequently specialized in pediatrics ($n = 15$, 56%), while the remaining facilities ($n = 12$, 44%) self-identified as one of the following: family medicine provider, health department, health maintenance organization, pharmacy, hospital, or Federally Qualified Health Center. Sixteen (59%) facilities that provided HIS data had scan logs that were native to the HIS (native scan logs), while 11 (41%) had logs installed by the project team (installed scan logs). Most HIS data sites ($n = 19$, 70%) administered 400[†] or fewer vaccinations per week.

In total we analyzed 63,179 records of 2D barcoded vaccines administered from HIS data, of those 12,408 were scanned. The remainder were entered using other methods. Therefore, overall compliance with scanning was 19 percent. The following are the percentages of compliance by the facility types outlined in Table 1.

[†]Facility volume ranged from an average of 14 to 2,714 vaccine administrations per week, with a median of 400.

Compliance by Facility Type—Privately funded facilities had 19 percent compliance with scanning (11,327 of 59,641 records of 2D barcoded vaccines were scanned). Compliance was 31 percent at publicly funded facilities (1,081 of 3,538 records of 2D barcoded vaccines were scanned). Private practice pediatrics were compliant 19 percent of the time 2D barcoded vaccines were recorded (8,572 of 44,594 records of 2D barcoded vaccines were scanned). Other specialties had 21 percent compliance (3,836 of 18,585 records of 2D barcoded vaccines were scanned).

Facilities with existing HIS software functionality that allowed for recording whether scanning occurred (native scan log) had 18 percent compliance (10,327 of 56,631 records of 2D barcoded vaccines were scanned). Compliance at the 11 facilities where software to track whether scanning occurred was installed for the purposes of the evaluation (installed scan log), was 32 percent (2,071 of 6,548 records of 2D barcoded vaccines were scanned).

Of all records of 2D barcoded vaccine administrations, facilities that administered more than 400 vaccines per week had 30 percent compliance (7,563 of 25,210 records of 2D barcoded vaccines were scanned). Compliance was 14 percent at facilities where 400 or fewer vaccines were administered per week (4,895 of 34,969 records of 2D barcoded vaccines were scanned).

Compliance Over Time—There was a decline in compliance by month over the course of the evaluation period, as shown in Figure 2. Compliance was highest at the start of the evaluation period (25% in July and August) and lowest in December 2014 (16%) and January 2015 (14%).

Vaccine Provider Experience Survey

We sent surveys to 210 users from all of the 82 participating facilities. Most frequently, between one and three users responded per facility. We received 116 surveys, representing 63 facilities, for a 55 percent response rate. Of the surveys we received, 71 (61%) had text in at least one of the six open text fields for the questions analyzed. We analyzed all 179 open text responses from these surveys.

Vaccine providers who responded to the survey described perceived benefits and challenges with adoption of 2D barcode technology for vaccine data capture. In our analysis, responses fell into the following four themes: perceived benefits to scanning, challenges related to scanning technology, challenges related to workflow, and other perceived issues. The following are the major themes and sub-themes; illustrative comments for each are captured in Table 2.

Perceived Benefits—With the exception of one, the questions were designed to identify challenges users had while trying to scan 2D barcoded vaccines, but benefits of scanning were identified in response to several questions. Respondents frequently reported that scanning increased accuracy of data. Some users also indicated that scanning saved them time.

Scanning Technology Challenges—Users also reported four areas of challenges with scanning. A frequently reported challenge with scanning was that scanners ‘did not scan’ or that it took multiple attempts to record vaccine data. To a lesser extent, respondents identified that the physical scanner (hardware) may not work correctly, that barcodes could be difficult to scan, or that there were challenges generally related to the HIS.

Workflow Challenges—Survey respondents noted that workflow may be disrupted by scanning for several reasons. Users frequently stated that the facility had few vaccines that were 2D barcoded, which suggested that it was not their regular process to scan. Some users indicated that the scanners were not readily available (i.e., not physically close to where vaccine was administered or another vaccine provider was using the scanner). Others indicated that they had a need or preference for manual entry of data.

Other Perceived Issues—Respondents noted three other challenges when scanning. Users frequently noted that not all the information populates in the HIS record when they scan or that scanning takes longer than their traditional method of data entry. Some users also indicated that the information populated via scanning was inaccurate.

Discussion

Even when available, users did not typically scan the 2D barcode on the vaccine unit-of-use product. On average, users successfully scanned 2D barcodes less than one out of every five times (19%) they had the opportunity to do so, although it is not clear to what extent they chose not to scan and to what extent challenges prevented scanning. Additionally, compliance decreased over time during the period of observation, from 25% to 14% (Figure 2). We explored a number of possible causes for the low compliance with scanning through the responses from the survey.

Scanning Challenges and Compliance

While neither the users nor the evaluation team can definitively determine whether issues with scanning identified in this cross-sectional survey are attributable to the scanner, the barcode itself, or the HIS, these challenges could have contributed to low compliance because 1) data were entered manually after failed attempts to comply or 2) because previous challenging experiences with scanning led users to opt not to try scanning with subsequent 2D barcoded vaccines. Consistent with other research, users indicated issues with the scanner or the barcode (e.g., responding that the scanner took multiple scans to successfully record or the scanner would not scan),^{9,12} but the source of the problem (scanner or barcode) is not clear.

Similarly, some survey respondents indicated that the scanned barcoded data did not populate correctly into the HIS fields. There are several reasons this could have occurred. For example, incorrect data could result from compatibility issues with HISs, where HISs do not correctly translate or populate the data from barcodes into the appropriate fields in the HIS. Possible reasons for data populating incorrectly should be further explored by partnering with HIS vendors to improve compatibility and user experience.

A number of respondents identified issues with scanning and attributed them to either the barcode or the scanner (e.g., quality of barcode resulted in not being able to scan the data), similar to other research on barcode scanning.¹² User error may also have contributed to technical problems attributed to the barcode or scanner. All of these perceived issues could have reduced user compliance.

Workflow and Compliance

For this evaluation, we asked nurses and other vaccine providers to start scanning 2D barcoded vaccines to capture vaccine data, which required a change in their workflow for vaccine data entry. While we provided trainings at the beginning of the period of observation, we did not provide ongoing interventions to encourage 2D barcode scanning or remind users to scan, and we did not hold individuals accountable for compliance.

Other challenges may have also discouraged compliance with scanning. Limited availability of ready-to-use scanners either in the exam room or at the time of data entry was a challenge identified by some respondents. Survey respondents also reported that there were not enough 2D barcodes to make it worthwhile changing their traditional method of manual data entry. The number of 2D barcoded products on the market continues to rise with over 90 products on the market as of June 2016, which will make this less of a challenge going forward.

Facilities with an installed scan log had higher compliance. Since logging was not visible to users, this may be due to selection bias, as those facilities that were willing to have software installed may have had more leadership commitment to scanning, which in turn may have influenced the culture among users. It is also possible that the installed software was better able to track whether scanning occurred than the native software. Facilities that administered a high volume of vaccines also had higher compliance. This may be in part due to more effective, efficient, streamlined workflow designs and scanning being performed more regularly.

Data and Compliance

Both the accuracy and quantity of data populated through scanning are potential reasons to increase the use of 2D barcode scanning of vaccines.^{8,9} Data accuracy was reported by respondents as both a benefit of and challenge with 2D scanning of vaccines. While some noted that the limited data that populate at the time of scanning was a challenge (e.g., because they still had to manually enter other vaccine data), other respondents indicated that ability to record additional data would be beneficial.

Scanned lot number and expiration date data in an HIS tend to be more accurate, and some respondents noted improved data accuracy with 2D barcode scanning. However, others indicated scanned data could be inaccurate. There are several reasons why users may have perceived data populated via scanning to be inaccurate, though we were not able to identify the exact issues. Possible technical issues affecting data entry include: inaccuracy of prepopulated tables created during inventory at some facilities to input data into the HISs; incorrect barcoded information, though unlikely as it is tested by the manufacturers using special verification tools; barcodes that were damaged or printed in a way that led to the scanner misreading the data (e.g., not enough contrast between light and dark); limited HIS

software compatibility and functionality with 2D scanning where the barcode or the barcoded information is translated into incorrect characters; or users intentionally or unintentionally edited the data within fields that were already populated via scanning since they are able to edit data after a scan is completed (e.g., at some facilities the letter P was appended to the lot number manually to indicate a funding source for a vaccine).

Increasing the fields automatically populated through scanning a 2D barcode may be another opportunity to increase scanning compliance. Some vaccine-related data are encoded in 2D barcodes, including product ID, manufacturer (which can be derived from the product ID), lot number, and expiration date, but at the time of the evaluation some HISs could not record manufacturer from the 2D barcode. HIS users indicated they wanted a scan to capture comprehensive data so they do not need to scan a barcode to record lot number and expiration date and then also manually enter other data for a single vaccine administration. Users may also erroneously believe that 2D barcodes include additional data elements (e.g. funding source) that facilities record for vaccines administered. Similarly, many HISs are not designed to capture all of the data that a 2D barcode contains; expanded 2D barcode functionality of HISs could address the need to capture more vaccine information in the HIS record.

Time to Scan and Compliance

While some respondents reported that scanning saved time, others reported it took longer. While time savings can be an incentive to scan,^{9,10} we do not know how user perception about the time it took to scan is linked to a facility's compliance overall. It is possible that those who thought it took more time are also those who reported challenges such as changes to workflow, inconvenient access to scanners, and lower volume of 2D barcodes (i.e. less experience with scanning), which may have increased the time it took them to scan. They may also have had to scan a barcode several times for the information to populate due to issues with the barcode image, scanner, or interface with the HIS.

Lessons Learned

As research has shown, perceived barriers to using barcode scanning may result in use workarounds that could lessen the potential benefits for patient safety, ^{12–15} such as reducing data quality through manually entering data or using dropdowns.^{8,9} Further improvement and integration of 2D scanner and HIS technology, improved barcode quality, and increased number of 2D barcoded vaccines will help to remove barriers to scanning 2D barcoded vaccines. Removal of these barriers could lead to greater usage of scanning by ensuring the process happens quickly, accurately, and consistently. Figure 3 includes summarized actions that can be taken by vaccine manufacturers, HIS vendors and health care facilities to support use of scanning. Increasing the number of 2D barcoded vaccines available will also propagate use of scanning, which in turn could further incentivize vaccine manufacturers and HIS to improve barcodes and integrate 2D functionality.

Facilities can promote scanning by ensuring that scanners are easily accessible and consistent with the facility's workflow and that there is a sufficient quantity of appropriately

located scanners. As technology advances, scanner prices continue to drop, making having an adequate number of scanners on site more attainable.

Since compliance was higher in facilities that administered high volumes of vaccines, it is possible that when vaccinations are more regularly part of the vaccine providers' workflow, vaccinators are more experienced in the process and scanning seems less disruptive. This could make users more inclined to follow this newer process.

Increased and ongoing adoption of scanning 2D barcoded vaccines and greater number of products with 2D barcodes on the unit-of-use on the market may create incentives for HIS vendors to incorporate 2D barcode functionality and ensure vaccine data will populate in the HIS with scanning.

Strengths and Limitations

The information presented in this manuscript is primarily exploratory using descriptive statistics and qualitative data. While this approach provides a preliminary understanding of the perceived challenges and benefits with implementation of 2D barcode scanning, additional research is needed to determine the relationships between compliance and the user experience. Not all sites had an indicator of scanning and thus were not included in the compliance analysis. The survey responses represented a more diverse set of participating facilities, but fewer users responded to the survey than anticipated. We could not identify which user entered a vaccine record; therefore, we could not determine whether an individual's experience scanning related to their personal likelihood of complying with scanning. Since there were typically one to three users who responded from a given facility, we were not able to make inferences about their experience as representative of the facility as a whole. Self-selection bias may also be a factor as those invested or with a stronger opinion may have been more likely to respond to the survey. Additionally, most of the survey questions focused on challenges or suggested improvements to 2D barcode technology whereas only one of the six questions analyzed for this study was designed to elicit information about perceived benefits of this technology.

Conclusion

For the benefits of 2D barcode scanning to be realized, barriers must be removed. Despite the potential benefits of scanning of 2D barcoded vaccines, the presence of a 2D barcode on a vaccine product, availability of scanners, and completion of training may not be sufficient to ensure that vaccine providers use the 2D barcodes to enter vaccine information. Users see the potential for time saving, increased accuracy of data, and improved patient safety with 2D barcode scanning, yet low compliance suggests that perceived barriers must be addressed to promote regular scanning of 2D barcoded vaccines. HIS vendors can increase functionality of HISs to record additional vaccine data, vaccine manufacturers can expand the number of vaccine products that are 2D barcoded and improve print quality of barcodes so it is more easily read by scanners, and research can guide interventions aimed at encouraging vaccine providers to scan barcodes. Expansion of the number of vaccine products that are 2D barcoded by the manufacturers will likely promote increased use of scanning and improve data quality and efficiency.

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Survey questions related to benefits and challenges of 2D scanning

- Please describe the benefits realized or anticipated with the use of 2D barcode scanners to record vaccine data.
- You previously indicated that you either disagree or strongly disagree with the following statement, "It was easy to integrate 2D barcode scanning into my normal work procedures." Please describe what specifically made it difficult to integrate 2D barcode scanning into your normal work procedures for recording data about vaccines administered to patients.
- What additional challenges (if any) did you have integrating 2D barcodes into your process for recording data about vaccines administered to patients?
- Please describe any additional challenges, beyond those previously mentioned in this survey, that you or the facility have encountered when using 2D barcode scanning.
- Please provide any suggestions you have to improve the process of recording vaccine data by scanning 2D barcodes.
- What else would you like to share with us about your experience using 2D barcode scanning during the project?

Figure 1.
User Experience Survey Questions Analyzed

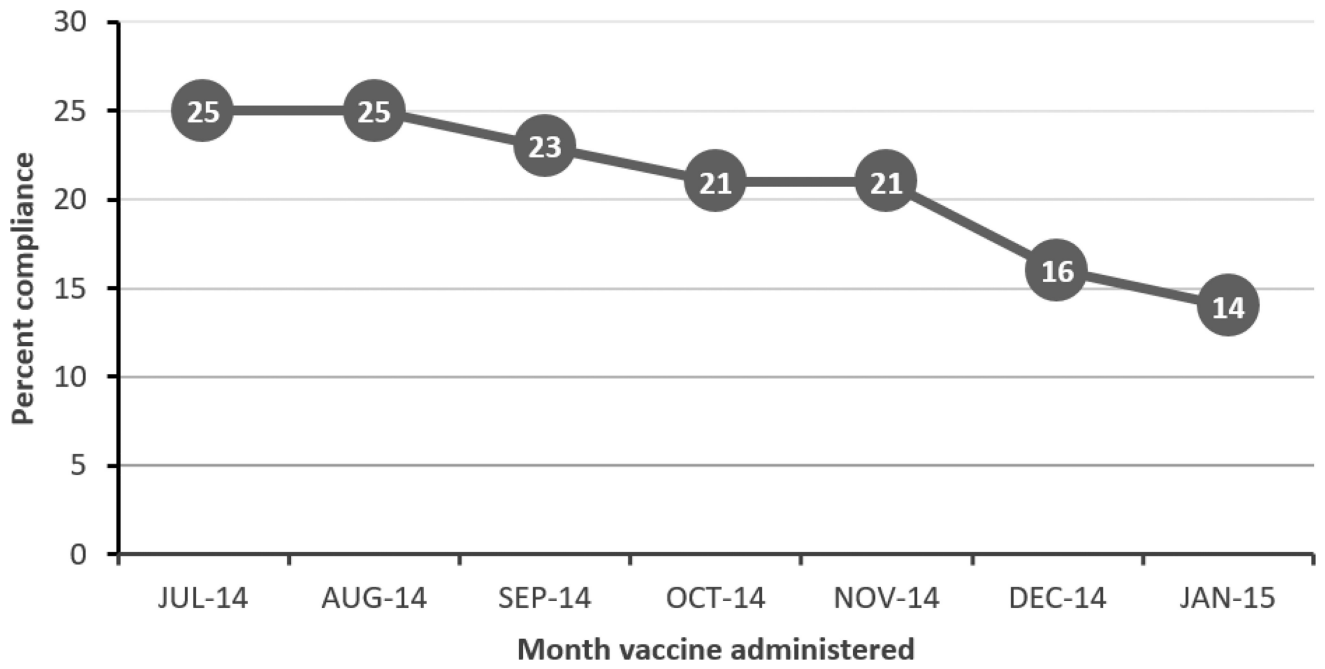


Figure 2.
Compliance with scanning 2D Barcoded Vaccines for administration records by month

Vaccine Manufacturers can:	HIS Vendors can:	Health Care Facilities can:
<ul style="list-style-type: none"> • Include 2D barcodes on all vaccine vials and syringes • Improve quality of 2D barcodes printed so they are more easily read by scanners 	<ul style="list-style-type: none"> • Collaborate with users to improve compatibility with 2D barcode scanning • Increase number of fields populated through scanning 	<ul style="list-style-type: none"> • Place scanners in easily accessible location(s) in sufficient quantity • Provide feedback to HIS vendors about using 2D scanning and how functionality can be improved

Figure 3. Actions Vaccine Manufacturers, HIS Vendors, and Health Care Facilities can take to support use of 2D barcode scanning

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Characteristics of participating facilities providing 2D barcoded vaccine record data and facilities providing user surveys

Table 1

Characteristic	Scan Log Facilities and 2D Barcoded Vaccine Data				User Survey Facilities and Data			
	All included Facilities N = 82 n (%)	Scan log facilities N = 27 (31) n (%)	Records of all 2D barcoded vaccines administered N = 63,179 n (%)	Records of 2D barcoded vaccines administered and scanned N = 12,408 n (%)	Compliance with scanning 2D barcodes (% barcoded records scanned) 19%	Facilities with at least one user survey N = 63 (72) n (%)	Total user surveys N = 116 n (%)	User surveys with open text response N = 71 (61) n (%)
Facility Type								
Privately-funded vaccinators	54 (67)	19 (70)	59,641 (94)	11,327 (92)	19%	45 (71)	85 (73)	50 (70)
Publicly-funded vaccinators	15 (18)	8 (30)	3,538 (6)	1,081 (8)	31%	8 (13)	18 (16)	13 (18)
Pharmacies ^a	13 (15)	0 (0)	--	--	--	10 (16)	13 (11)	8 (11)
Facility Specialty								
Private Practice Pediatrics	30 (37)	15 (56)	44,594 (71)	8,572 (69)	19%	26 (41)	48 (41)	35 (49)
Community Health Care	11 (13)	0 (0)	--	--	--	10 (16)	19 (17)	9 (13)
Other specialties ^b	41 (50)	12 (44)	18,585 (29)	3,836 (31)	21%	27 (43)	49 (42)	27 (38)
Number of physicians								
0	16 (20)	0 (0)	--	--	--	10 (16)	13 (11)	8 (11)
1 or more	66 (80)	27 (100)	63,179 (100)	12,408 (100)	20%	53 (84)	103 (89)	63 (89)
Scan Log								
Native HIS functionality	16 (20)	16 (59)	56,631 (90)	10,337 (83)	18%	14(22)	29 (25)	19 (27)
Installed for the purpose of the evaluation	11 (13)	11 (41)	6,548 (10)	2,071 (17)	32%	7 (11)	11 (9)	8 (11)
None	55 (67)	0 (0)	--	--	--	42 (67)	76 (66)	44 (62)

Characteristic	Scan Log Facilities and 2D Barcoded Vaccine Data				User Survey Facilities and Data			
	All included Facilities	Scan log facilities	Records of all 2D barcoded vaccines administered	Records of 2D barcoded vaccines administered and scanned	Compliance with scanning 2D barcodes (% barcoded records scanned)	Facilities with at least one user survey	Total user surveys	User surveys with open text response
	N = 82 n (%)	N = 27 (31) n (%)	N = 63,179 n (%)	N = 12,408 n (%)	19%	N = 63 (72) n (%)	N = 116 n (%)	N = 71 (61) n (%)
Facility Vaccinations Administered								
>400 vaccines / week	23 (28)	8 (30)	25,210 (40)	7,563 (61)	30%	13 (21)	28 (24)	16 (23)
400 vaccines / week	59 (72)	19 (70)	34,969 (60)	4,895 (39)	14%	50 (79)	88 (76)	55 (77)

^aChain and independent pharmacies

^bFamily medicine, Health Department, HMO, pharmacy, Hospitals, and Federally Qualified Health Centers

Table 2

User perceived challenges/improvements and benefits to 2D barcode scanning

Theme and sub-themes	Illustrative user comments
Perceived Benefits	
Increased accuracy of data *	<ul style="list-style-type: none"> • “Love the accuracy of reporting the info.” • “It will be so much more accurate for the facility as well as for our patients!” • “If/when the scanners did work, they made entering info so much quicker and accurate.” • “Less chance of making mistakes.”
Scanning takes less time	<ul style="list-style-type: none"> • “It tends to be easier to scan barcodes for vaccines and it's quicker than manually typing in the information.” • “It is a fast way to document important information that often does not get recorded in the computer system.” • “Once this is perfected, this will be an efficient way of entering the data.”
Scanning Challenges	
Scanner not scanning/ multiple tries *	<ul style="list-style-type: none"> • “The scanner would scan with one patient, then the next patient it would read ‘error’...” • “Frustration with not scanning on first three attempts, altering techniques to get better scanning results.” • “It was frustrating trying to scan the vial and keep getting error codes or the scanner not working, it wouldn't scan the vial period.”
Scanner (hardware)	<ul style="list-style-type: none"> • “It is very hard to scan vaccines due to having to put it under the scanner for a long time until it finally read if we are lucky. Not all vaccines - the wire is in the way.” • “The scanner did not work. It would not scan the vaccine barcode.” • “[Use] wireless 2D scanners.”
Barcode hard to scan	<ul style="list-style-type: none"> • “[Barcodes] must be printed darker on vaccine bottles and syringes.” • “The only problem is the barcodes that won't scan.” • “[A challenge is] getting the angles correct for scanning more quickly.”
HIS challenge	<ul style="list-style-type: none"> • “Currently we are using as shipments arrive not at time of administration because of not having enough data populate the immunization information area in our [HIS].” • “[Scanned barcodes] still not crossing over into our [HIS] system and us having to enter them manually.”
Workflow Challenges	
Few vaccines with 2D barcode *	<ul style="list-style-type: none"> • “Simply not having all vaccines 2D barcoded. Often I give a set of vaccines with only 1 of the 3 containing a 2D barcode so then you are using both systems which is disruptive.” • “I think that if these are going to be used more is going to be needed. All medications should have a 2D barcode.” • “The only problem is just that 70% of our vaccine[s] still don't have barcodes which [could] have something to do with the batches of vaccines we are receiving.” • “Most vaccines don't have barcodes and some do, so instead of looking which ones do and don't I just put it [in] manually because it takes less time.”
Scanner location/not readily available	<ul style="list-style-type: none"> • “Only one computer was linked with system, so could only use scanner in one place. If computer was needed for other things, scanning was not completed.” • “It was an added step, that required me to bring the administered vials or syringes back to my work site (my desk) where the computer and scanner were. I don't like bringing [them back].”

Theme and sub-themes	Illustrative user comments
	<ul style="list-style-type: none"> • “More 2D barcode scanners [at] all patient care areas, both inpatient and outpatient.”
Manual entry needed or preferred	<ul style="list-style-type: none"> • “Sometimes all the vaccine data is not in the computer therefore requiring the nurse to have to manually key the info in, i.e. lot [number], exp[iration] date.” • “Able to manually enter expeditiously and efficiently.”
Other Perceived Issues	
Not all desired information populates in the HIS *	<ul style="list-style-type: none"> • “Due to [the fact that] some of the information still has to be put into the system, we still have to [manually] put in the lot numbers and the dosage being used.” • “Currently we are using [scanning] as shipments arrive, not at time of administration because of not having enough data populate the immunization information area in our EHR. Too time consuming doing both until improvement with that.” • “[I] would like for all info to be scanned into system...example manufacturer.”
Takes more time *	<ul style="list-style-type: none"> • “[It takes] To much time spent discerning which [vaccines] have [a 2D barcode] and have not. If no 2D [barcode], then use other barcode. Would be much simpler just to enter manually.” • “It takes a lot of time sometimes to pick up the barcode.” • “I feel it takes up more time than manually entering the information.”
Scanned data populates incorrectly	<ul style="list-style-type: none"> • “Sometimes inaccurate data was imputed after scanning. For example wrong lot number or expiration date or the lot number would record and not the date or part of the lot number would be left off.” • “If I can't trust the scanners to record accurate data, I prefer not to use them.”

* Mentioned more than 20 times in write-in responses