

Interfacing Immunization Information Systems with CDC's Vaccine Ordering System: Strategies for Improving Accountability, Efficiency and Provider Satisfaction

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Introduction

Immunization information systems (IIS) are confidential, population-based, computerized databases that record all immunization doses administered by participating providers to persons residing within a given geopolitical area¹. Increased focus on accountability of publicly funded vaccine² and transition to the Vaccine Tracking System (VTrckS), CDC's new national vaccine ordering and inventory management system for publicly purchased vaccine, have led state and local health departments to enhance their IIS to improve accountability and increase efficiency.

By May 2013, all 64 federally funded immunization programs (known as awardees) transitioned from a legacy system called Vaccine Management System (VACMAN) to VTrckS. VTrckS is a component of the CDC Vaccine Management Business Improvement Project. As they transitioned to VTrckS, 47 of the awardees used their IIS or an external information system to collect data before sending to VTrckS, and interfaced or took steps to interface their IIS with VTrckS.

The 47 awardees represent 92% (over 39,000) of the Vaccines for Children (VFC) provider sites (CDC, unpublished data, 2013). These awardees built on existing infrastructure and relationships with vaccine providers, who already used the IIS to record vaccine administrations. *Provider sites* in these jurisdictions interact with a single system – the IIS – to document vaccine administrations, track inventory, and order vaccine. *Vaccine program staff* in these jurisdictions review provider on-hand inventory and approve provider vaccine orders in the IIS; they then log on to VTrckS to upload order and inventory data. Using this approach, awardees leverage VTrckS' powerful back end vaccine ordering capabilities while maintaining control over communications and IIS functions providers can access. In addition, a number of awardees are able to decrement vaccine inventory quantities in the IIS based on vaccine administration data sent via electronic data exchange from providers' Electronic Health Records (EHRs).

Table 1 lists the tasks performed by providers and vaccine program staff. Note that providers perform all of their tasks in the IIS, but vaccine program staff performs some tasks in the IIS and some in VTrckS.

Table 1. Tasks Performed in the IIS and VTrckS.

Tasks Performed in the IIS	Tasks Performed in VTrckS
Providers	
<ul style="list-style-type: none"> • Update contact information • Record inventory on hand • Order vaccine 	
Vaccine Program Staff	
<ul style="list-style-type: none"> • Approve orders • Export provider master data, inventory, and/or order data files • Upload shipment data files • Upload Federal Vaccines List 	<ul style="list-style-type: none"> • Manage rejected orders • Upload data files • Export shipment data • Export Federal Vaccines List

Figure 1 depicts the data collected in the IIS and uploaded to VTrckS, as well as the data available in VTrckS that can be uploaded to the IIS. At a minimum, ExIS awardees upload inventory and order data to VTrckS. Additional interfaces allow providers to enter and update their contact information (i.e., information needed to ensure that orders are delivered to the correct address and person during business hours), allow for inventory to be pre-populated based on vaccine shipments, and ensure that the list of vaccines that can be ordered in the IIS matches the vaccines on CDC's Federal Vaccines List. Although awardees implemented a wide range of

improvements in support of vaccine ordering and inventory tracking, every ExIS awardee's IIS must conform to published specifications for the upload and download interfaces.

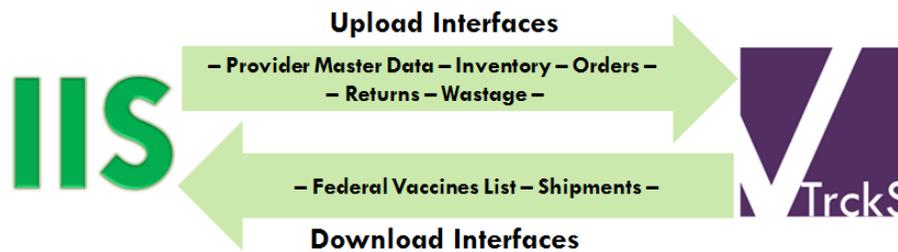


Figure 1. VTrckS Upload and Download Interfaces.

The objective of this paper is to list improvements awardees made to their IIS to support vaccine ordering and inventory tracking and the associated awardee-reported impacts. Results of this effort will be used to inform awardees of additional improvements, and as input to a plan for measuring the public health impact of the improvements to inform future investment decisions.

Methods

In 2011 and 2012, a total of 32 awardees received Prevention and Public Health Fund (PPHF) resources to enhance their IIS to exchange vaccine ordering and inventory data with VTrckS. Some awardees planned to build or enhance related functions such as online provider enrollment, inventory decrementing using data from EHRs, and provider inventory reconciliation.

Data were derived from:

1. Monthly written reports between PPHF awardees and CDC project monitors
2. A one-hour recorded demonstration of vaccine ordering, inventory tracking, and related functions conducted with each PPHF awardee near project completion
3. A monthly call for all awardees to discuss accomplishments and obstacles

CDC project monitors routinely noted “success stories” and other project status information. Success stories were statements made by awardees that tied a change in the IIS or supporting processes to a public health impact. For example, “Inventory pre-populated from VTrckS shipment data ensure that tracking inventory is easier and less error prone.” PPHF project demonstrations were conducted through a web conferencing program and were a primary resource for identifying and cataloging improvements and summarized project impacts. This project was determined to be public health – non-research, and was thus exempt from Institutional Review Board approval

Factors Affecting Design, Development, and Deployment of the ExIS Solution

Awardees linked perceived increases in accountability, efficiency and provider satisfaction to emphasis on accountability, efficiency, and usability during design, development, and deployment of their ordering and inventory solution. Each awardee's approach was additionally influenced by the intended end users of the solution, local laws, policies, and budget. In general, however, awardees reported improved accountability when they added checks and balances to inventory and ordering processes. They reported improved efficiency when they simplified or automated processes and empowered vaccine program staff to take on tasks previously performed by technical development staff. Awardees reported higher provider satisfaction when users had needed information for each task and when the system design prevented errors.

Not every awardee implemented all accountability, efficiency, and usability features discussed in the remainder of this section. As awardees plan enhancements to their ExIS solutions, they should consider the possible benefits of implementing all features described.

Accountability

Awardees strove to ensure that all parties concerned comply with vaccine program policies and can demonstrate compliance. One accountability strategy awardees employed was to build checks and balances into the IIS to give better insight into inventory management and ordering practices in provider offices. Providers were required to verify shipping information, submit supporting documentation with each order, and validate vaccine deliveries against shipment data in the IIS. As part of their review of each order, vaccine program staff were required to review supporting documentation. To promote accountability, vaccine program staff were also supplied with new reports and data quality tools.

Some of the checks and balances awardees incorporated into the ordering and receiving processes included:

- **Require providers to verify shipping information and submit supporting documentation with each order:**
 - **Verify shipping information** – Providers must verify shipping address and hours of operation before they are allowed to submit an order to ensure that the vaccine can be delivered appropriately.
 - **Submit inventory on hand** – Providers must submit National Drug Codes (NDC, a universal product identifier for drugs³) and lot number for doses administered as well as lost, borrowed, and wasted vaccine. Having more than one or two lots of any NDC on hand at a given time might indicate that the provider is not rotating stock in the refrigerator properly. For example, if a provider finds five different lots in their refrigerator for the same NDC, they can take steps to reduce the number of lots for that vaccine to one or two. Providers that report vaccine administrations electronically through data exchange with an EHR must reconcile data on doses administered with the count of inventory on hand before submitting their inventory counts.
 - **Submit temperature logs** – Some awardees require that providers submit temperature logs with orders by e-mail, fax, and/or through data loggers. The IIS for these awardees does not permit providers to order without the required temperature logs.
- **Require providers to validate vaccine shipments** – Providers must verify online that temperatures of shipped vaccine are within acceptable ranges before accepting the vaccine as inventory in the IIS. Providers may need to adjust quantities of on-hand inventory recorded in the IIS to reflect amounts actually received. If there are discrepancies, vaccine program staff are notified either by the provider or automatically through the IIS and may take action as needed.
- **Require vaccine program staff to review supporting documentation before approving an order** – Online tools give staff the information they need to make good decisions. This step involves more work for staff, but helps them to identify issues they might otherwise have missed. For instance, staff can tell if a provider submitted the same inventory two months in a row and can work with the provider to correct the problem. Some IIS also capture returns (vaccines in their original package that can be returned to CDC’s centralized distributor for Federal Excise Tax credit⁴) and wastage for a more complete accounting of inventory. Damaged vaccines, vaccine in partially used multi-dose vials (which cannot be visually quantified), and vaccine from a unit dose vial that was drawn up into a syringe, are characterized as wastage⁴. When vaccine program staff finds issues in the supporting documentation, they can follow up with providers to correct discrepancies and prevent future problems.
- **Supply staff with accountability reports** – Reports that promote accountability include a printable “Product Lot Expiration Report” that assists provider staff in proper stock rotation and a “Vaccine

Accountability” report to view doses administered (total and by age group), doses lost/expired, doses received, doses transferred, and accountability percent for each vaccine. A building block for improved vaccine accountability reporting is the shift to tracking dose level eligibility, the best practice specified in the 2013-2017 IIS functional standards⁵, rather than tracking by patient level or visit level eligibility⁶. This new best practice makes it possible to manage inventory more accurately and to improve accountability for both publicly and privately funded vaccine.

- **Supply staff with data quality tools** – Awardees have a number of tools to improve the quality of data received through EHRs and entered manually in the IIS. Automated data processing, for instance, can help reconcile duplicate records, ambiguous IDs, and user-flagged records. Online enrollment and the ability to update contact information at any time help to ensure that provider contact information is accurate and that orders are delivered to the correct address and person during business hours. Access to real-time information helps staff find and address errors more quickly, potentially reducing their impact.

Efficiency

Two strategies awardees used to improve efficiency were to simplify and/or automate processes and to empower vaccine program staff. A major simplification for ExIS awardees was a single web-based application for providers to track inventory, order vaccine, *and* record doses administered. Many providers were already documenting doses in the IIS, as well as receiving vaccine histories and forecasts. Adding inventory tracking and vaccine ordering offered the benefit of making the IIS a “one-stop shop.” Awardees also simplified and/or automated the vaccine ordering process, implemented online flu prebooking, automated recommended order quantity calculations, allowed providers to update delivery information online, and implemented online review of supporting documents such as temperature logs.

- **Implement online ordering** – Although some IIS already supported aspects of online ordering, many replaced cumbersome and error-prone paper processes. Three advantages of automating the ordering process are no more lost paper forms, less time sorting through faxed or e-mailed orders, and no more need to hand write the NDC and lot numbers needed for accurate vaccine inventory tracking.
- **Implement online flu prebooking** – Integrating influenza vaccine pre-booking into the online ordering process allowed providers to indicate their needs for influenza vaccine each year; supported vaccine program staff as they review and approve the requested amounts; ensures that all parties concerned can see the allocated amounts of vaccine as the influenza season progresses; and permits providers to order surplus influenza vaccine when all pre-booked amounts have been shipped.
- **Automate recommended order quantity calculations** – IIS calculate a recommended order quantity for each provider based on ordering history and other factors. IIS can consistently and quickly calculate recommended order quantity, freeing vaccine program staff for more important aspects of the order review process.
- **Allow providers to update provider delivery information online** – IIS allow providers to update their own data such as delivery hours and contact person changes and free vaccine program staff for other tasks.
- **Implement online supporting documents review** – IIS allow submission of supporting data needed to approve new orders, including inventory on hand, doses administered, and temperature logger readings. Making supporting data easily accessible to vaccine program staff online as they review orders facilitates the process for deciding whether to approve, modify, or deny each order. Having temperature logger data available online also allows staff to see highest and lowest temperatures for comparison

with recommended values. The system automatically sends notifications to vaccine program field staff if temperatures are out of range, enabling them to take action to prevent future temperature incursions.

ExIS awardees reported that granting vaccine program staff access to a web-based application for placing and processing orders not only empowered staff, but also saved on travel to the office during normal operations and supported business continuity in case of an emergency (e.g., during the response to the 2009 H1N1 epidemic). Awardees also built functionality to allow vaccine program staff to configure IIS settings (rather than relying on technical staff to do so), organize their tasks with work lists, and create reports to monitor vaccine ordering operations.

- **Allow program staff to configure IIS settings** – When vaccine program staff can configure and adjust IIS settings, changes can be made quickly and accurately without engaging technical development staff, resulting in higher quality data transmitted to VTrckS and less time spent fixing errors. Settings vaccine program staff can configure include NDCs available for ordering, provider formularies (i.e., sets of vaccines select groups of providers can order), parameters for recommended order quantity calculations, allowable provider ordering frequency, thresholds for notifications that vaccines are soon to expire, and maximum time between inventory reconciliations.
- **Supply staff with work lists** – IIS can help vaccine program staff and providers organize their work. For example, an “Enrollment Work List” helps vaccine program staff track how close each provider is to completing steps for enrolling in the IIS and/or enrolling in the VFC program to receive publicly funded vaccines. An “Orders Work List” indicates the steps each provider must complete to order vaccines and shows vaccine program staff where providers are in the overall process. Sample steps in the process are verifying contact information and business hours; entering/reconciling vaccine inventory; verifying temperature logs; and submitting vaccine orders. Vaccine program staff can search for orders that were saved and not submitted and assist providers in completing orders.
- **Supply staff with operations reports** – Better reporting tools help staff identify and address problems in a timely manner. Sample reports that improve efficiency include:
 - A “Daily Orders” report, which vaccine program staff use to track orders processed each day.
 - Ad hoc reporting, which allows vaccine program and support staff to create need-specific reports easily.

Usability

Awardees employed three usability strategies in their ExIS solutions: 1. ensure that users have the information they need, when they need it; 2. notify users when important events take place or when users need to take action; and 3. build in logic to prevent errors.

Awardees added information to IIS pages to help answer typical provider questions at any point in the ordering process. Beta testing with small groups of providers helped awardees fine-tune messages before widespread deployment. Helpful information added to IIS pages included:

- **Provider information** – Accurate provider information helps to ensure that vaccine is delivered to the right person at the right place during business hours. Because of the importance of this information, the names of primary provider contacts, business hours, and shipping address are located in a prominent position on the ordering page and providers are able to make updates as needed.
- **Inventory information** – A printable inventory page with NDCs, lot numbers, and expiration dates makes it easy for providers to document accurate inventory information quickly. Highlighting soon-to-expire vaccine on the inventory page can also help in stock rotation and prevent wastage.

- **Order information** – Vaccine, trade name, manufacturer, packaging, and NDC are displayed consistently throughout the IIS ordering module to acquaint providers with the values as they report inventory and receive shipments. Designing the online order form to include the minimum/maximum order quantity allowed, doses administered since the last order, and doses on hand (along with the associated lot numbers and expiration dates) makes it easier for providers to select the quantity they need to order and for awardee staff to approve orders. Order status, including provider and vaccine staff comments/questions, helps set provider expectations for order delivery date and prompts providers to take action if needed to keep the process moving.
- **Shipment tracking number** – When the IIS has the capability to import VTrckS shipment data, providers can access shipment tracking numbers and plan to be in the office to accept deliveries.
- **Meaningful error messages** – Meaningful error messages identify problems and help users take appropriate action. An example is an error message displayed when a provider enters an unacceptable multiple for vaccines. Helping the provider to correct the problem ensures that only quality data are entered into the system.

Awardees designed on-screen and e-mail notifications to communicate status and remind users to take appropriate action. Sample notifications include:

- **Onscreen notification at log-on of vaccines that are soon to expire** to help providers minimize possible wastage
- **Order status notifications** (e.g., order approved, order rejected, and impending deliveries) to help reduce the number of questions providers have for vaccine program staff, as well as the time providers spend answering questions about orders with issues
- **Notifications about impending shipments** sent to providers to help reduce the number of failed shipments
- **Notifications when vaccine is wasted and/or logs show out-of-range temperatures** to help avoid future wastage

Another strategy awardees took for improving usability was to present only valid choices to prevent errors from occurring. IIS employed several methods for presenting only valid choices:

- **Ordering Wizards** – Wizards guide providers through the steps for ordering vaccine, including reviewing provider profile information, submitting/reconciling inventory, and ordering acceptable amounts of vaccine.
- **Formularies** – Awardees allow providers to order a subset of available vaccines, called a formulary, depending on provider characteristics. Awardees have a variety of methods for determining the number of formularies within the IIS, including having one formulary for local health departments and another for private providers.
- **Constraints on values entered** – Valid values for NDCs, lot numbers, and expiration dates are available to the IIS from the VTrckS shipment data export and, for some awardees, shipment data from third-party vendors or wholesalers. IIS can use these data to restrict selection or entry to valid choices only.

- **Map user-entered values to acceptable values** – Map information users enter to likely correct answers. An example is a mapping of NDCs on vaccine vials with NDCs on the secondary packages. VTrckS tracks NDCs on the secondary packaging and sends them in the Federal Vaccines List and in shipment data. Providers administering vaccine and counting individual doses in a refrigerator might enter the NDC on the vial.

Successes Reported

ExIS awardees demonstrated the ability to extend the federal vaccine ordering and inventory tracking system by building on existing systems already accessed by providers that administer vaccines in their jurisdictions. In the process, awardees built tools for improved vaccine accountability and reported decreased vaccine order processing time and increased provider satisfaction. These initial indicators are especially important for sustaining a vaccine distribution system that relies on participation and support from the nearly 40,000 VFC providers that administer vaccines and document those vaccines in IIS. Table 2 highlights reported benefits for providers. While not analyzed in this paper, there may be associated cost savings for any of the reported benefits.

Table 2. Benefits Realized by Providers, as Reported by Awardees.

Decreased Vaccine Order Processing Time
<ul style="list-style-type: none"> • The time for providers to place an order dropped from 30-40 minutes to 15-20 minutes. (P)
Improved Tools for Vaccine Accountability
<ul style="list-style-type: none"> • Verification of provider shipping information for every order ensures that vaccine is delivered to the correct address and the appropriate person during business hours. (P, S) • Notifications of impending shipments sent to providers have decreased failed shipments. (L) • Data quality increases when providers no longer have to hand write order and inventory information, including NDCs, lot numbers, and expiration dates. (R, S, T) • Online ordering streamlines the process of collecting lot numbers; by the time providers complete two or three monthly ordering cycles, the accuracy of lot numbers improves in the IIS. (F) • Functionality for tracking and transferring vaccine to where it is needed reduced influenza vaccine wastage. (P) • Inventory decrementing based on data from EHR further increases accountability. (C, F, J, L, M, U, V, W, X) • Improved inventory reports and notifications result in less chance for vaccine to expire before it is administered. (F, L) • Providers must verify online that temperatures of shipped vaccine are within acceptable ranges before accepting it as inventory on hand. (P)
Increased Satisfaction
Provider Satisfaction
<ul style="list-style-type: none"> • Vaccine ordering has been a “carrot” in encouraging additional clinics to participate in the IIS and keeping them in the program. (H) • Improvements to online ordering resulted in an increase from 50% to 75–80% of providers ordering online. (L) • Private providers have been very receptive, with approximately 60-70% ordering vaccine online. (H) • One provider commented (B): <i>“I am pleasantly surprised that the [ordering system] is an improvement over the previous monthly ‘fill out the paper form and fax to DOH’ system which recently had become quite burdensome, so much so that I was questioning my continued participation in the VFC program.”</i>
Specific Aspects Providers Appreciate

- Providers “are ecstatic” that the system was designed with a focus on accountability and usability. (P)
- Providers look forward to the new changes and are glad they have moved away from the paper process, which they say was not user-friendly. (R)
- Elimination of paper forms means no more lost paper forms. (B)
- Providers appreciate not having to enter state-supplied inventory into the IIS by hand. (M)
- Providers appreciate that they can see the status of their orders and the amounts of vaccines ordered. (B, K)
- Most providers rely on the system, even with limited training. (A)
- Providers indicate that the new ordering tool interface is easy to use; vaccine program staff are receiving fewer questions from providers. (H)

Awardees reported only the benefits they observed and may not have reported improvements in all three areas: accountability, efficiency, and provider satisfaction. No awardee reported that changes to their IIS for this project resulted in less accountability, decreased efficiency, and lower provider satisfaction. Although specific awardees are not identified in this section, Table 3 indicates the interfaces implemented by each awardee referenced. Benefits reported by awardees for vaccine program staff and providers are summarized in this section.

Table 3. Interfaces Implemented by PPHF Awardees Referenced in this Paper.

ID	Provider Master Data	Inventory Data	Returns	Wastage	Order Data	Shipment Data	Federal Vaccines List*
A	X	X	X		X		X
B	X	X			X	X	X
C	X	X			X	X	
D	X	X			X		
E	X	X			X	X	
F	X	X			X	X	
G	X	X			X	X	X
H	X	X			X	X	X
I	X	X	X	X	X	X	X
J		X			X	X	
K	X	X	X	X	X	X	
L	X	X			X	X	
M	X	X			X	X	
N	X	X			X	X	
P	X	X			X	X	
Q	X	X			X		
R		X			X		
S	X	X			X	X	
T							
U		X			X	X	
V	X	X			X	X	
W		X			X		X
X	X	X			X	X	X

* Awardees indicated receive e-mail notifications of changes in the Federal Vaccines List. Awardees not indicated use other methods for obtaining this information

Improved tools for vaccine accountability – Awardee N observed that “online ordering makes providers true VFC partners.” This partnership is built, in part, on having better tools for vaccine accountability. When VTrckS shipment data are imported into the IIS, the IIS can send providers notifications of impending shipments;

providers can track shipment deliveries online; and providers can verify shipments when they arrive without having to retype NDCs, lot numbers, and expiration dates. Awardee L observed that notifications of impending shipments led to a decrease in failed shipments. Awardee F stated that online ordering streamlined the process of collecting lot numbers; by the time providers complete two or three monthly ordering cycles, the accuracy of lot numbers has improved in the IIS. Functionality for tracking and transferring vaccine to where it is needed reduced influenza vaccine wastage for awardee P. Decrementing inventory based on doses administered data from EHR is another tool for improving accountability used by a number of IIS inventory management components. Providers that have this capability reconcile the vaccines on hand with the information in the IIS, further increasing the level of accountability. Finally, awardees that require providers to verify online that temperatures of shipped vaccine are within acceptable ranges help to ensure that only viable vaccine is tracked as inventory on hand.

Decreased vaccine order processing time – Both vaccine program staff and providers benefit from decreased vaccine order processing time. Awardee K reported that vaccine program staff save 21 hours weekly – 20 hours because providers now enter orders in the IIS instead of submitting paper forms and an additional hour because the IIS calculates suggested order minimum and maximum, which staff previously calculated by hand. Awardee D estimated a savings of 10 hours per week because vaccine program staff now change settings for IIS functions that previously required technical development staff assistance. Awardees A and B said that vaccine program staff now spend less time communicating order status because providers are able to check order status online. Another benefit for providers in some jurisdictions is reduced ordering time. Awardee P estimated that the time for providers to place an order was reduced from 30-40 minutes to 15-20 minutes per order.

Increased provider satisfaction – Providers have acknowledged the improvements in the process of ordering vaccine and are responding positively, with increases in the numbers of providers ordering online and increased satisfaction of the providers already ordering online. Awardee H noted that online vaccine ordering has been a “carrot” in encouraging additional providers to participate in the IIS and in retaining providers in the program. Several awardees reported increases in the number of providers participating in the IIS. Awardee L, for instance, stated that the percent of providers ordering vaccine through the IIS increased after online ordering enhancements were made, from 50% to 75–80%. Awardees have received positive feedback on their approach to emphasize accountability and usability when implementing and/or improving the IIS ordering capabilities. Specific aspects of the online ordering component that providers especially favor include the move away from a paper ordering process; not having to enter state-supplied inventory by hand into the IIS; and the ability to see order status and approved amounts of vaccine ordered. Focus on usability has enabled providers to use the system with limited training and has reduced the number of questions providers have for vaccine program staff.

Recommendations

Awardees reported improved accountability and efficiency in the vaccine distribution process, resulting in time savings for providers and vaccine program staff as well as increased user satisfaction. Looking ahead, there are more improvements that can be made to IIS and a number of opportunities as well. An evaluation plan for determining the most impactful improvements will guide further investment in improved vaccine ordering and inventory tracking features.

In the near term, awardees would benefit from focusing on:

- Implementing the VTrckS inventory and orders interfaces and any other interfaces they plan to use. Reaching this important milestone will mean that all ExIS awardees have achieved baseline functionality and will be ready for new interfaces when they become available.
- Adopting accountability, efficiency, and usability strategies identified in this report as they build new interfaces and enhance existing ones, as well as exploring improvements based on feedback from vaccine program staff, providers, and other awardees.

- Importing VTrckS shipment data into the IIS, potentially increasing accountability, efficiency, and usability. When VTrckS shipment data are imported into the IIS, the IIS can send providers notifications of impending shipments; providers can track shipment deliveries online; and providers can verify shipments when they arrive and populate their online inventory without having to retype NDCs, lot numbers, and expiration dates.

As VTrckS evolves, there will be more opportunities to leverage IIS to support vaccine ordering and inventory tracking. Three areas of special interest are new interfaces, automated data exchange between the IIS and VTrckS, and barcode technology:

- CDC recently developed returns and wastage upload interfaces. Based on a survey conducted in January 2014, at least 39 awardees have plans to implement these interfaces. Depending on CDC policies, additional interfaces could also be developed.
- Automated near-real-time data exchange between IIS and VTrckS would eliminate or reduce the need for manual file upload and download. In the meantime, generating inventory and order files for manual upload to VTrckS has enabled awardees to collect and export the needed data. When VTrckS has defined protocols for automated data exchange, awardees will need to embark on another development effort to comply.
- Advances in two-dimensional (2D) barcode technologies^{7,8} have allowed for rapid, accurate, and automatic capture of vaccine NDC, lot number, and expiration date by a handheld imaging device or scanner, as well as the ability to populate fields in IIS and EHR with these data. As more vaccines are encoded with 2D barcodes, awardees and providers can continue to improve efficiency by scanning vaccines delivered to their offices and by scanning vaccine inventory on hand. IIS and the related workflows will need to evolve to take advantage of this technology in support of vaccine ordering and inventory tracking.

Limitations

These interfaces and functions will continue to evolve, and there is a significant need for support to ensure that every IIS has the flexibility needed to take advantage of evolution in both IIS and in VTrckS. This project did not assess how well positioned awardees' IIS are to accommodate future changes to vaccine program operations and policies (e.g., provider enrollment process) or the financial impact of such changes. Future projects should address these aspects.

Self-reported data on impact have not been verified and are not representative of all awardees. As a result there is a continued need to gather feedback, input, and lessons learned from the broader community of awardees as they implement these interfaces. Future evaluations should gather data from all stakeholders engaged in this work.

Conclusions

PPHF resources enabled awardees to make progress toward improving the accountability, efficiency, and usability of the vaccine distribution process. The transition to VTrckS has been a significant accomplishment and an impetus for vaccine program staff to work closely with IIS staff on a shared endeavor. Nonetheless, ExIS awardees face a number of challenges that will require vaccine program staff and IIS staff to strengthen and solidify their collaboration, including the following:

- Until automated data exchange between IIS and VTrckS becomes a reality, the process of synchronizing the IIS with VTrckS is manual and susceptible to human error. Ensuring the creation and implementation of data quality protocols and procedures will be essential for protecting the quality of the data and the integrity of the interface.

- EHRs are still evolving in their ability to send complete and accurate data – including data elements for dose level eligibility – to the IIS. High-quality EHR data are critical for recording accurate doses administered data, as well as for decrementing inventory and meeting accountability requirements. IIS and vaccine program staff will need to collaborate to ensure that each provider’s EHR is configured properly and electronically submitted data sent to the IIS meet the necessary requirements.
- PPHF resources from 2011 and 2012 helped to fill a funding gap for 32 awardees to build and enhance their inventory and ordering functionality. Awardees will need funding from other sources for ongoing operations and future enhancements.

CDC and awardees partnered to create a broad and efficient system for distributing and managing publicly funded vaccines. With emphasis on accountability, efficiency, and usability, awardees reported higher accountability, reduced order processing time, and higher provider satisfaction. Continued investments in the most impactful in IIS vaccine ordering and inventory tracking functionality can ensure that ExIS awardees are prepared to streamline the related processes further and improve accountability of publicly purchased vaccine, resulting in significant benefits for providers, awardee staff, and the populations they strive to protect from vaccine-preventable diseases.

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