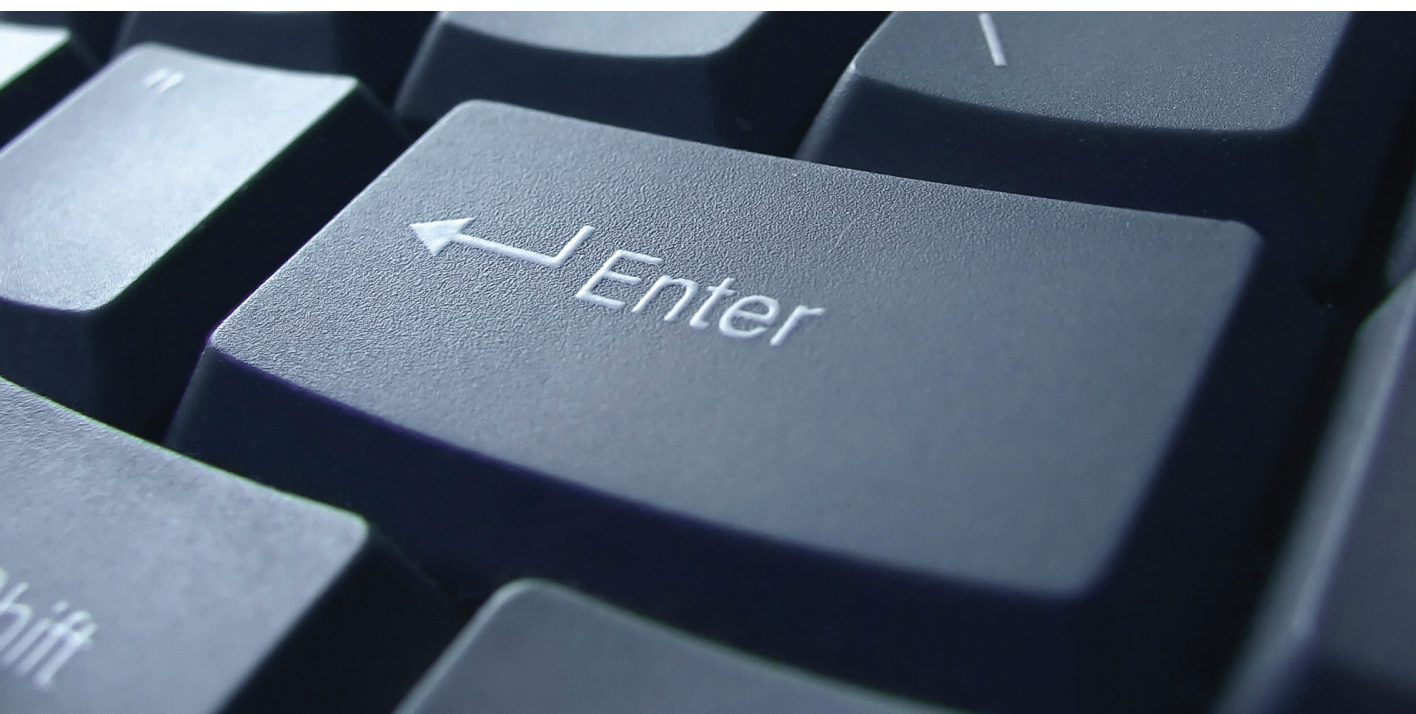
AIRA
AMERICAN IMMUNIZATION REGISTRY ASSOCIATION

Vaccination Level De-duplication

IN IMMUNIZATION INFORMATION SYSTEMS (IIS)



One of the major functions of an Immunization Information System (IIS) is to create and maintain an accurate and timely record of an individual's immunizations. Such a record enables more accurate forecasting for vaccine administration according to Advisory Committee on Immunization Practices (ACIP) recommendations, supports correct and clinically meaningful immunization decision-making and allows providers and analysts to produce a timely and complete immunization record. However, IIS often receive vaccination data from multiple sources—the administering physician, the insurance billing system and others—causing the IIS to frequently contain multiple records for the same vaccination event. The IIS is then challenged with first determining if similar records represent the same vaccination event, and if they do, what to do with those duplicate entries.

To address this issue, a national group of immunization subject matter experts developed rules and procedures IIS staff can use as the basis for creating automated algorithms that identify and manage potentially duplicate records for a single vaccination event. The work group used a consensus-based process to develop these best practice guidelines around vaccine level de-duplication in IIS, and subsequently published them in *Vaccination Level De-duplication in Immunization Information Systems.*

This mini-guide highlights the work group's recommended actions—actions any IIS program can undertake to ensure an accurate and complete representation of a vaccination event when compiling vaccination history from multiple data sources. The mini-guide assumes that patient level de-duplication, the process of determining whether similar records in the IIS represent the same patient, has already occurred, as this step should always precede vaccination level de-duplication.

Vaccine Level De-duplication in Three Phases

Vaccination level de-duplication can be addressed in three phases: Selection, Evaluation and Resolution. The Selection phase identifies and selects those records that may be duplicates, the Evaluation phase examines selected records to establish which are duplicates, and the Resolution phase determines what to do with those duplicate records.

In each phase, Principles and Business Rules are applied to key variables to determine what actions to take. Variables may be the actual fields in the vaccination record, or occasionally may be derived from the values found in one or more fields. Variables are written in the form of Entity – Attribute; for example, Vaccination Encounter – Date. A Principle reflects a recommended business practice and often provides high-level direction for the development of more specific Business Rules. A Business Rule describes a condition and specifies the action to take based on that condition. The described variables, Principles and Business Rules may be used as the basis for algorithms that could automate the de-duplication process.

Variables Used in the De-duplication Process

ENTITY – ATTRIBUTE	DEFINITION
Vaccine – Family/Group Name	Broad categories of vaccines that generally correspond to individual antigens and are related by vaccine type; for example, Hib-PRP-T and Hib-HbOC have the Hib Vaccine Family/Group Name. Sometimes a Vaccine – Family/Group Name corresponds to a group of multiple vaccine types that are typically given in a combination vaccine; for example MMR and DTP.
Vaccination Encounter – Date	The date the patient received one or more doses of one or more vaccines.
Vaccine – Type	A numerical code that designates the vaccine administered in a vaccination event; for example, CPT and CVX codes.
Provider Organization – Name	This name can be a corporate name and may include a number of different provider offices/sites and physician groups.
Vaccine Event Submission – Record Source Type	Values: Administered or Historical. "Administered" means that submitter attests that (s)he administered the vaccination (gave the shot) at the vaccination event. All other cases are considered to be "Historical."
Vaccination Event – Compromised Dose (flag)	A Valid/Invalid flag indicating that a dose of vaccine should not be considered when evaluating the immunization history. An Invalid flag indicates that a dose administered to a patient is considered substandard and therefore not a valid dose.
Vaccine – Trade Name	The name under which the manufacturer copyrights the vaccine(s). Trade name is synonymous with the Brand name. A trade name usually assigned by manufacturer to identify vaccine type.
Vaccine – Lot Number	The manufacturer-assigned number for a specific batch of vaccine developed and distributed. This is the tracking number of the administered vaccine.

Vaccination Level De-duplication:

- Supports correct and clinically meaningful immunization decision-making
- Enables more accurate forecasting for vaccine administration
- Allows providers and analysts to produce an accurate and timely vaccination record
- Enables immunization history from an IIS to be a component of an electronic Personal Health Record

The 3 Phases of De-duplication

1. **SELECTION:** Identify and group multiple vaccination records that potentially represent the same vaccination event.
2. **EVALUATION:** Examine pairs of potential duplicate vaccination records to determine if they match or differ.
3. **RESOLUTION:** Select the best record among duplicate records and produce a single consolidated record for the vaccination event.

Phase 1: Selection

The Selection phase of vaccine level de-duplication results in identification and grouping together of vaccination records that potentially represent the same vaccination event. The following table lists and describes the specific variables, Principles and Business Rules that should be examined and applied in this phase.

VARIABLES	
	Vaccine – Family/Group Name **Vaccination Encounter –** Date

PRINCIPLES	
P04	We would like to be more inclusive than exclusive.

BUSINESS RULES	
BR01	If vaccination events for the same Vaccine – Family/Group occur within a maximum window of 23 days, they need to be examined. An IIS can set a tighter constraint, based on: • Staffing for manual review • A trend analysis of the IIS data (then it can be constrained appropriately in favor of processing time) • Knowledge of IIS data
BR02	A record for the vaccination event must be compared with all and any of the vaccination event records with the same Vaccine – Family/Group.
BR03	Identical records should not be selected for de-duplication. If there are identical records for the vaccination event, all of them but one has to be deleted.

NOTE: Principles and Business Rules do not always follow a sequential numbering scheme to allow for development of additional Principles and Business Rules in each phase if later found to be necessary.

UNDERSTANDING THE VARIABLES

The Vaccine – Family/Group Name, often taken from the Vaccine – Type variable, can actually match more than one Vaccine – Type. For example, the Hib Vaccine – Family/Group includes the following Vaccine – Types: Hib-PRP-T, Hib-HbOC, Hib-PRP-OMP and Hib-Unspecified. If two records have the same Vaccine – Family/Group Name, then there is an increased likelihood they are duplicates. This likelihood increases further if the Vaccination Encounter – Dates for the two records are the same or within a few days of each other.

UNDERSTANDING BR01

BR01 is applied before applying any of the other business rules. BR01 recommends that an IIS should select for further evaluation vaccination events for the same Vaccine – Family/Group that occur within a maximum window of 23 days. This is a recommended *maximum* window size; each IIS should specify this size based on its unique data and staffing constraints. In fact, Medicaid data analyzed from Washington State's CHILD Profile IIS provides some evidence that a window of no more than 10 days may be adequate. Generally, a narrow window is more likely to miss duplicates because a duplicate entry could fall just outside of the window. Conversely, a broad window is less likely to miss duplicates, but requires more time and resources to examine additional records the broader window includes.

SELECTION SCENARIO

The following scenario illustrates how the Principles and Business Rules are applied to the key variables to determine if two or more records should be selected as potential duplicates for further evaluation.

Scenario:

Record A has a Vaccine Encounter – Date of 5/1/2006 and a Vaccine – Family/Group Name of DTaP and Polio and HepB (derived from CPT for Pediarix®).

Record B has a Vaccine Encounter – Date of 5/1/2006 and a Vaccine – Family/Group Name of Polio.

Record C has a Vaccine Encounter – Date of 5/1/2006 and a Vaccine – Family/Group Name of HepB.

Result: Records A, B and C are selected for further evaluation as potential duplicates.

Explanation: BR01 is first applied. While all three records have the same Vaccine Encounter – Date and therefore meet the 23-day maximum window requirement, it is unclear if the three records have the same Vaccine – Family/Group Name. Applying BR02 helps make this determination. Record A is a combo vaccine, so it belongs to more than one Vaccine – Family/Group Name. The Vaccine – Family/Group Name value for records B and C are both individual components of record A's Vaccine – Family/Group Name, so according to BR02, Record B and Record C have the same Vaccine – Family/Group Name as Record A. Because all three records have the same Vaccine – Family/Group Name and fall within the 23-day maximum window, all three must be selected as potential duplicates.

Phase 2: Evaluation

In the Evaluation phase, groups of potential duplicate records selected in the Selection phase are examined to determine if they are true duplicates. Evaluation results in three possible outcomes: the records *match* (are duplicates) because they represent the same vaccination event, they *differ* because they represent different vaccination events or a *don't know* determination is made that requires a manual review. The variables, Principles and Business Rules in the table below should be examined and applied when evaluating potential duplicates; however, IIS may use additional variables as they deem necessary. In this phase, each variable is assigned a level of importance. Variables with a higher level of importance are more useful in making a match or differ determination.

VARIABLES	
	Vaccination Encounter – Date. High (when the same) or Low (when different). **Vaccine –** Type. Medium. **Vaccine –** Trade Name. Medium (when different) or Low (when the same). **Vaccine –** Lot Number. High (when different) or Low (when the same). **Provider Organization –** Name. Low. **Vaccine Event Submission –** Record Source Type. Medium (when both are administered), Low (when both are historical) and Low (when different or absent in one record). **Vaccination Event –** Compromised Dose (flag). High.

PRINCIPLES	
P09	A match in some variables is more important than others.
P10	The degree of confidence in the data should be taken into consideration.
P11	If vaccination encounter dates are different in records under evaluation, the proximity of these dates has to be taken into consideration.
P12	Considerations of front-end vs. back-end processing should not impact the match/differ decision for the evaluated records.*
P13	IIS should track the variable "Vaccination Event Submission – Record Source Type" (administered vs. historical) for each record.

BUSINESS RULES	
BR09	Records selected for evaluation at the Selection phase should be considered different until proven to be duplicates.
BR10	If vaccine lot numbers are different in evaluated records, these records are most likely to be different (not duplicates).
BR11	If vaccination encounter dates are the same in evaluated records, these records are most likely to be duplicates.
BR12	Distinctive combinations of variables should be considered for the evaluation of candidate records.
BR13	High-confidence and/or most discriminating rules (variables and combinations of variables) should be evaluated first.
BR14	Some immunizations are supposed to be given within 2 days of each other.
BR15	If Record Source Types are "Administered" in evaluated records and are from different providers, these records are most likely to be different (not duplicates). If Record Source Type is "Administered" in one record and "Historical" in another record and vaccination dates are close (P11), these records are most likely to be duplicates.

* In this context, front-end processing means looking for potential matches prior to or when adding a new record to the IIS. If a match is found, the existing record is used and the new record is not added, thus minimizing the number of duplicate records. Back-end processing means examining records for potential matches after they have been entered in the IIS. Back-end matching allows users to enter records into the IIS without having to initially worry about duplicate entries.

** For example, Rabies.

APPROACHES TO EVALUATION

The IIS can take two approaches when evaluating potentially duplicate records: the Sequential Approach or the Weights-based Approach. Both approaches provide the basis for implementations of automated algorithms.

Sequential Approach to Evaluation

The Sequential Approach applies decision rules to individual and distinctive combinations of variables in the selected vaccination records. These rules first examine those variables or combinations of variables that most clearly indicate the records match or differ. For example, the combination of the two variables Vaccination Encounter – Date and Vaccine – Lot Number provides a strong basis for a match or differ decision. These variables would be examined first, and if present and the same in both records, the records are deemed a match. Although more complex sequences of variables may need to be examined, this example illustrates the sequential, or deterministic approach. The results of the Sequential Approach should be validated by actual analysis of the data in each IIS.

The Weights-based Approach to Evaluation

The Weights-based Approach evaluates possible matches by comparing multiple variables from one record with those same variables in a second record. Each possible outcome of the comparison is assigned a numerical value or "weight." For example, the following hypothetical weights could be assigned to the three possible outcomes of Vaccine – Lot Number comparisons:

If Vaccine – Lot Number is the same for the two records, assign a value of 25

If Vaccine – Lot numbers are different for the two records, assign a value of -25

If Vaccine – Lot Number is present for only one record, assign a value of 10

The higher the score for a variable comparison, the more likely the two records are duplicates. In this case, the highest score is when the Vaccine Lot Numbers are the same for the two records. Although this example examines a single variable, the Weights-based Approach requires weights to be applied to all variables being evaluated and sums the weights into an Aggregate Score. The higher the aggregate score of all the variables the higher the probability that the two records match, or are duplicates. Conversely, the lower the aggregate score, the more likely the records differ. The Weights-based Approach applies the specific calculations and rules in the highlighted area.

REDUCING ERRORS OF EVALUATION RESULTS

Strategies have been developed to reduce the errors inherent with each approach. The Sequential Approach reduces errors by analyzing additional variables and adding more sophisticated evaluation logic. The Weights-based Approach reduces errors by manipulating and fine-tuning assigned weights. Automated tools that simulate the outcomes of both approaches as the values of variables are manipulated may be useful during system development for fine-tuning weights against a set of test data. Despite potential errors, both approaches deliver high-quality de-duplication, especially when one approach is used to confirm the outcome of the other.

Calculations for the Weights-based Approach

S = Aggregate Score (summed values of all variable weights)

Smax = Highest possible value for S

Smin = Lowest possible value for S

R = S – Smin/(Smax – Smin) called the Relative Aggregated Score

Rules for the Weights-based Approach

If R > RH, the records match

If R > RL, the records differ

If RL < R < RH, the evaluation is inconclusive (don't know)

RH and RL are the high and low decision thresholds, respectively, as determined from analysis of IIS data.

The mini-guide and the original best practices guidelines provide general guidance for assigning weights. IIS vendors will need to assign weights for an IIS based on real data from the IIS and using sound statistical methods.

Phase 3: Resolution

Based on the results of the Evaluation phase, the IIS may take one of three different actions with the records:

- If the records *Differ,* then both records from the selection phase are maintained as is in the IIS and no further action is required.
- If the records *Match,* then more extensive resolution actions should be undertaken.
- If a *don't know* determination made, then more extensive resolution actions should be undertaken.

RECORDS MATCH

If the records match, or are duplicates, then a single record must be created that describes the vaccination event. IIS staff may create this record by selecting the best record among duplicate records and then merging, variable by variable, information from the matching records into a single, consolidated record. In some states, however, only the owner of a clinical record may change it; yet providers and public health entities still need aggregated records in adverse events, for administrative purposes, to maintain an accurate vaccine inventory and for other purposes.

To satisfy the need for a consolidated record without violating state regulations, two views for each vaccination event must exist. One view is the best record (reported "as is"), which is used for clinical purposes. The other view is a single consolidated record that aggregates all available information. This second view is used for both clinical and public health purposes. Providers enrolled in the IIS should be able to see and use both views.

SELECTING THE BEST RECORD

Selecting the best record among potential duplicates requires assigning each record a Confidence Level and examining a set of variables for their presence or completeness. The best record is selected by applying Principles and Business Rules to the variables using a Sequential Approach.

Variables, Principles, and Business Rules Used in Selecting the Best Record

The following variables, Principles and Business Rules should be examined and applied when selecting the best record. Each variable has been assigned a level of importance that will be used when applying the Business Rules. IIS staff may add variables to the list as they deem necessary for their specific IIS.

VARIABLES	
	Vaccine – Type: Low importance **Vaccine –** Trade Name: Low importance **Vaccine –** Lot Number: Medium Importance **Confidence Level (derived variable):** High importance **Combo Vaccine (derived variable):** Medium importance

PRINCIPLES	
P10	The degree of confidence in the data should be taken into consideration.
P15	Business Rules should be applied completely, in a specified sequence.

BUSINESS RULES	
BR20	The record with the highest level of confidence should be selected.
BR21	The record with more complete data should be selected. For example, if the more important variables are present in one record compared to another, the one with the more important variables should be selected.

BUSINESS RULES (Continued)	
BR22	The record with more specific data should be selected. For example, if one record has a more specific Vaccine – Type of Hib-PRP-T, it should be selected over a record with a Vaccine – Type of Hib-unspecified.
BR23	The record that represents a combo vaccine should be selected.
BR24	The existing record should be selected over the incoming record.
BR25	Records with an earlier or later date should be selected consistently within a particular IIS. This rule should be applied only if application of Business Rules BR20 through BR24 has not resulted in selection of a best record. Also, selection of the record with earlier or later date in some cases can affect the clinical status of the vaccine series and lead to the extra-immunization or under-immunization of a patient. Extra-immunization is preferred over under-immunization.

Assigning a Confidence Level to a Record

A record's values for the following attributes of the Vaccination Event Submission data element provide information needed to assign the record a confidence level in the accuracy of the data.

Attributes of the Vaccination Event Submission data element:

- *Method:* How the record was submitted to the IIS—either via an electronic interface such as HL7 or an IIS-specific user interface.
- *Documentation Type:* The type of record that documents the data, which may be clinical, billing/claims or transcribed.
- *Record Source Type:* The individual or entity that submitted the record—a Primary Submitter (Administered) or a Secondary Submitter (Historical).

Understanding the Record Source Type Attribute

Record Source Type is directly impacted by whether the submitter claims to have administered the vaccination. If so, then the submitter is a Primary Submitter. If not, then the submitter is a Secondary Submitter. A record from a Primary Submitter always has a higher confidence level than one from a Secondary Submitter.

Some examples further illustrate how to determine the value for Record Source Type. If a provider administers a vaccination and then submits the record, the provider is a Primary Submitter and the Record Source Type is *Administered.* Similarly, if a health care plan reports the vaccinations its providers administer, the health care plan is a Primary Submitter and the Record Source Type is also *Administered.* However, if a health care plan reports vaccination data with no claims that they administered the vaccination, then the health care plan is a Secondary Submitter and the Record Source Type is *Historical.*

All records with a Records Source Type of *Administered* provide IIS staff with a High (H) confidence level in the data, while a Records Source Type of Historical can only range from a Medium (M) to Low (L) confidence level.

The following table shows how a record's confidence level is determined based on attributes for the Vaccination Event Submission data element.

Determining Confidence Level

	METHOD		DOCUMENTATION TYPE			RECORD SOURCE TYPE		
SUBMITTER	Electronic Interface	IIS-specific UI	Clinical	Billings/ Claims	Transcribed	Historical	Administered	Confidence Level for Record
Primary		X	X				X	**H+**
Primary	X		X				X	**H**
Primary	X			X			X	**H-**
Secondary		N/A	N/A	N/A	N/A	X		**M to L**

Confidence Level Scenarios

The following scenarios show how the decision-making table for assigning confidence levels is applied.

Scenario 1

A provider submits a clinical vaccination record directly through the IIS user interface.

Confidence Level: H+. In this case, IIS staff have the highest confidence in the data because the Method is an IIS-specific User Interface, the Documentation Type is *Clinical* and the Record Source Type is *Administered.*

Scenario 2

A health care plan submitted a billings/claim record as a Primary Submitter and used an HL7 electronic interface.

Confidence Level: H-. In this scenario, IIS staff would have less confidence in a record's data because the Method is *Electronic Interface,* the Documentation Type is Billings/Claim and the Record Source Type is *Administered.*

The first scenario has an H+ confidence level compared to the H- of the second scenario because billing/claims data is lower quality than a clinical electronic medical record (EMR) and data entry through an electronic interface results in potentially lower quality data than data entered directly into the IIS.

Sequential Approach to Selecting the Best Record

In the Sequential Approach, Business Rules BR20 through BR25 are applied in order, resulting in the selection of the best record. Because the examples of applying the sequential approach are lengthy, they could not be included in this mini-guide. For examples of applying the Sequential Approach (and the Weights-based Approach) for selecting the best record, review pages 66 – 71 of the original best practice guidelines.

Weights-based Approach to Selecting the Best Record

In this approach, the presence or absence of certain variables is assigned a weighted value. The aggregated sum of the weights is used to select the best record or confirm the outcome of the Sequential Approach to selecting the best record.

In the weights-based approach, a weight is assigned to each of the following:

- Confidence level of a record (H+, H, H-, M, L, or Unknown). A record with H+ would be assigned the highest value, while a record with Unknown would receive the lowest value). This weight may be further adjusted using a multiplier that indicates the degree of confidence in the submitter. The submitter "profile-related multiplier" ranges from 0 to 1 in value.
- Absence or presence of a value for Vaccine – Trade Name. Higher weight assigned if present, lower if absent.
- Absence or presence of a value for Vaccine – Type. Lower weight assigned if absent, and if present, this is further divided into Specific or Non-specific, with Specific Vaccine – Type assigned the highest weight.
- Absence or presence of Vaccine – Lot Number. Higher weight assigned if present, lower if absent.
- Absence or Presence of a Combo Vaccine, with a higher weight assigned if the Vaccine in the record is a combo vaccine.

Just as in the Evaluation phase, an aggregated score is computed for each record. In the Resolution phase, however, selecting the best record is much easier—it's simply the record with the higher aggregated score. If both records have the same aggregated score, then the first record is selected.

PRINCIPLES AND BUSINESS RULES USED IN CREATING A CONSOLIDATED RECORD

In this step, the best record is used as a base to which information is added using a Sequential Approach according to the following Principles and Business rules. The result is a consolidated record with the best values for each variable in the immunization record.

PRINCIPLES	
P18	A consolidated record at the vaccination level that merges all available information from duplicate records and other sources should be created.

BUSINESS RULES	
BR30	If both records have the same information for a variable, then that information should be used in the consolidated record.
BR31	Known information should be used instead of unknown. In other words, if the best record lacks a value for a variable, but a duplicate record contains a value for that variable, the value from the duplicate record should be used in the consolidated record.
BR32	If duplicate records have different information for a variable, then information from the record with a higher level of confidence in the data should be incorporated into the consolidated record.
BR33	If duplicate records have different information for a variable, the more specific information should be incorporated into the consolidated record.

Manual Review for Don't Know Determinations

If the Evaluation phase results in a *don't know* determination, then IIS staff must manually examine the records to determine whether they represent the same immunization event. In this Manual Review process, the staff may identify and use a new variable that helps make the determination or call the submitter to double check a record's validity. The Manual Review process is time-consuming, and in many cases may not result in a resolution. For example, calling a submitting provider may not clear up the issue. To reduce the volume of potential duplicate records sent for Manual Review, IIS staff could take one or more recommended actions. Any records not resolved during the Manual Review should be considered to differ and should be maintained as is in the IIS.

USE AN ALGORITHM TO IDENTIFY CLINICALLY SIGNIFICANT DUPLICATES

An IIS algorithm may be applied that determines if an immunization is invalid due to minimum interval or age violations. This determination helps the IIS:

- Review only potentially duplicate immunizations that belong to a series that is not complete and up to date (UTD). Since the algorithm discounts duplicate immunizations if a vaccination series is not UTD, then IIS staff should examine the series to see if one of the two duplicate immunizations is truly a duplicate and is not a mistyped immunization.
- Review potentially duplicate immunizations that can affect other doses in the group. For example, if "a" is selected, it would invalidate the next dose, whereas if "b" is selected it would not. In this instance, it is important to know which immunization was really given. This approach would probably involve additional programming for the IIS, but may be worthwhile if an IIS has a large database, numerous submitting providers and processes thousands of immunizations daily.

IDENTIFY SYSTEMATIC DUPLICATES

During manual review, staff may be able to identify patterns of duplicates. For example, a specific source always sends their immunizations as of the date they were ordered and not the date they were given. In such cases, a program may be written to automatically resolve the numerous duplicate records at once.

NARROW THE RANGE OF POTENTIAL DUPLICATES EXAMINED

If the automated de-duplication model uses the weights-based approach for evaluation, then review only a narrow range of probabilities—those just below the merge/deduplicate threshold. For example, if the automated program declares records that match above 90 percent to be duplicates and records that match below 70 percent as non-duplicates, then the IIS may decide to review matches between 85 percent and 90 percent rather than the full 70 percent to 90 percent range. However, if the automated de-duplication model used the sequential approach, you could narrow the date range window to obtain fewer possible duplicates.

INCLUDE ADDITIONAL VARIABLES IN AUTOMATED ALGORITHMS

During manual review, reviewers may discover that certain key aspects of the immunization events are systematic and clear enough to help with de-duplication. In such cases, the IIS should consider incorporating them into the automated de-duplication system to reduce the number of records sent to Manual Review.

Critical Vaccination Level De-duplication Practices for IIS

The implementation of the best practices in this mini-guide enable IIS to develop automated algorithms that will identify potential duplicate records for vaccination events, determine which of these are indeed duplicates, identify and select the best record among duplicates and create a view of a consolidated record. The results ensure the application of a consistent, logical approach to de-duplication. Doing so ultimately prevents under- and over-immunization of patients by having an up-to-date, accurate immunization record.

Learn More About Vaccine Level De-duplication in IIS

This mini-guide provides guidelines for vaccination level de-duplication that many IIS programs can use to develop automated de-duplication algorithms. For more in-depth, technical information related to these best practices, download the original best practice guidelines from the AIRA web site:

http://www.immregistries.org/pdf/AIRA_BP_guide_Vaccine_DeDup_120706.pdf.

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Immunization Information Systems for a New Era

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