AIRA
AMERICAN IMMUNIZATION REGISTRY ASSOCIATION

Measures and Tests for IIS Assessment

Patient Matching – HL7

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Background and Context

The consolidation of immunization records from multiple sources is a primary function of immunization information systems (IIS).[1] To ensure complete, accurate records, consolidated in a timely way, IIS must receive data from immunizers within their catchment area (such as a state or territory) through standardized electronic reporting channels. Data messaging standards have been present in the IIS community for more than 20 years and have increasingly gained importance as electronic health record (EHR)-IIS interoperability has grown in necessity across health care. The primary standard for IIS messaging is the HL7 Version 2.5.1 Implementation Guide for Immunization Messaging, Release 1.5.[2] As data is electronically exchanged, IIS must attempt to match incoming patient records from a provider with existing records already in their IIS. Additionally, when IIS are queried for a patient's immunization records, they must accurately locate an existing IIS patient's record using the supplied query parameters. This can be challenging when the information in the query varies from the same patient's record in the IIS.

In 2016, AIRA convened the Measurement for Assessment and Certification Advisory Workgroup (MACAW) to develop and propose measures for IIS Assessment.[3] The **Patient Matching – HL7 Submission** and **Patient Matching – HL7 Query** measurable concepts within the Measurement and Improvement (M&I) Initiative focus on IIS ability to accurately match patients and merge them into a single consolidated record for later retrieval. Measures and tests are vetted with the full IIS community to ensure broad community input and agreement.

IIS Assessment Stage Details

MACAW defined the scope, measures, tests, outcomes, and testing methods for measuring IIS ability to accurately merge and match incoming patient information to existing patient information. This work has its foundations in the Functional Standards[4] document and CDC's Patient-Level Deduplication Best Practices.[5]

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[1] https://www.cdc.gov/iis/about/index.html
[2] https://www.cdc.gov/iis/technical-guidance/hl7.html
[3] https://www.immregistries.org/measurement-for-assessment-certification-advisory-workgroup
[4] https://archive.cdc.gov/#/details?url=https://www.cdc.gov/iis/functional-standards-v4-1/index.html
[5] https://www.cdc.gov/iis/technical-guidance/deduplication.html

Functional Standards

The updated IIS Functional Standards v5.0 and Operational Guidance Statements (OGS) were developed through a consensus-based process by CDC's IIS Support Branch (IISSB), with input from a variety of IIS managers and technical experts nationwide. These standards describe the core functionality an IIS should strive to achieve in support of programmatic and stakeholder immunization goals.

The following FS and OGS are applicable to Patient Matching -HL7 functionality and are included in the MACAW measures and tests defined in this document.

Measures and tests for Patient Matching are based on the following IIS Functional Standards v5.0:

Functional Standard B4.0: The IIS validates patient demographic and vaccination data.

Guidance Statement B4.1: The IIS supports the identification, prevention, and resolution of duplicate and fragmented patient demographic and vaccination data in accordance with policies and procedures.

In scope

- Test patients who likely should have matched when submitted and queried via HL7
- Limited to single field variations between two unsolicited immunization update (VXU) messages (e.g., first name and date of birth would not both change in a single test, just one or the other)
- Single field changes that include, but are not limited to beginning sounds, ending sounds, vowel sounds, typos, spelling variations, hyphenation variations, name order, and field specific changes

Out of scope

- Test patients who likely should NOT have matched when submitted or queried via HL7
- Complex scenarios such as:
    - Name change with a new address (e.g., marriage)
    - Placeholder names changed to a real name (e.g., Baby Girl to Penelope)
    - Twins with identical first names
- Multi-field changes within a single test, except for some name test cases focused on common typographical errors seen in the community (e.g., middle in first, suffix not in suffix field)

- Traditional scoring calculations for patient matching (e.g., sensitivity, specificity, F-score, positive predictive value)
- Record consolidation rules when records match (e.g., which first name to keep)

Providing best practices or standards is not a component of these measurable concepts . Please see the Patient-Level Deduplication Best Practices document created by the CDC.

Measure overview

The measures span key demographic fields used in patient matching. The fields include first name, middle name, last name, suffix, date of birth, administrative sex, mother's maiden last name, address, phone number, and email address. Each measure focuses on a specific field and a specific change to the field. For example, a middle name measure submits a full middle name in one message followed by just the middle initial in another message. No other demographic fields are modified between the two messages.

Measure outcomes

Each measure has a defined expectation. The expectations are used during testing to determine how well an IIS aligns with standards and best practices. Once each measure is executed against an IIS, the IIS is slotted into one of the following categories:

Meets: The IIS meets the expectation.

Not measured: The IIS is unable to be measured at this time.

Does not meet: The IIS does not meet the expectation.

Testing method

AIRA will submit two HL7 messages (VXU) that reflect the condition described in the measure. Each measure will be isolated to one aspect of patient matching. Following the VXUs, two queries (QBP – query by parameter message) will be sent for the patients, one for each patient represented in the VXUs. The information returned by the IIS in the two acknowledgment (ACK) and two response (RSP) messages is used to determine if the IIS has met the expectation of the measure.

Test sequencing

The Aggregate Analysis Reporting Tool (AART) exchanges data with participating IIS (preproduction environments). For a given measure, there are multiple transactions and expectations. First, AART sends a VXU containing a patient's demographics and a record of an historical dose of hepatitis A vaccine to the IIS. A few seconds later AART sends a second VXU for the same patient with demographics modified using a transformation procedure,

and a record of a historical dose of hepatitis B vaccine. In the second VXU, the patient's information, aside from a single demographic and vaccination modifications, remains the same as the first VXU. When modifying the patient's demographic information AART uses *limited* transformation possibilities that are described in more detail in Appendix D. Ideally, the IIS will consolidate the information from both VXUs into a single patient record and this patient's record will be retrieved when querying using the demographics and information from either VXU1 or VXU2.

Example of First Name Alternative Spelling VXU Test Message Content

Field	AART VXU 1	Transformation Procedure	AART VXU 2	IIS Consolidated Record
First Name	Jo**h**n	FIRST_NAME_ ALTERNATIVE_SPELLINGS	Jon	Jon or Jo**h**n
Last Name	Jones		Jones	Jones
Medical Record	1234		1234	1234
Date of Birth	20201101		20201101	20201101
Address Line 1	100 Main St.		100 Main St.	100 Main St.
Vaccine Doses	hepatitis **A**		hepatitis **B**	hepatitis A **&** B

After successfully receiving a response indicating both VXU messages were accepted the next phase begins. About five minutes after sending the VXU records,[6] AART queries the IIS for a complete immunization history using the identifiers and demographics from VXU 1. Usually within a few seconds after that, AART queries the IIS for a complete immunization history using the patient identifiers and demographics from VXU 2. For both query responses from the IIS, there is no expectation that the IIS will retain a specific set of patient identifiers or demographics. The only expectation is that the IIS will return a consolidated immunization history that includes both hepatitis A and B vaccine doses

[6] If necessary for an IIS, AART can delay these queries by more than 5 minutes. In some cases, they may be more than 1 day.

proving the VXU records were consolidated. Alternatively, IIS may respond to one query with an exact match that includes a consolidated vaccination record and the other query a single inexact match. Both submission and query test messages are sequenced in the same manner and use identical patient pairs.

Example of First Name Alternative Spelling QBP and RSP Test Message Content

Field	IIS Consolidated Record	AART QBP 1	AART QBP 2	RSP 1 – Exact Match (Z32/Z42)	RSP 2 – Inexact Match (Z31)
First Name	Jon	Jon	Jo**h**n	Jon	Jon
Last Name	Jones	Jones	Jones	Jones	Jones
Medical Record	1234	1234	1234	1234	1234
Date of Birth	20201101	20201101	20201101	20201101	20201101
Vaccine Doses	hepatitis A & B	NA	NA	hepatitis A & B	NA

Please refer to Appendix A for more information on the VXUs and QBPs and Appendix C for more information on test sequencing and measure expectations.

Assessment types
The HL7 patient matching methodology results in two assessments:

1. Patient Matching – HL7 Submission: Assesses the IIS's ability to detect that two VXU messages are for the same person

- To **meet** a measure, the IIS must consolidate the information from two VXUs into one single patient record in the IIS. Verification of the record consolidation is performed by first querying the IIS for each record and then analyzing the RSPs. At least one of the RSPs must return a single consolidated record.
- A measure outcome of **not measured** occurs if an IIS rejects either VXU. Since the IIS did not accept both messages, patient matching cannot be performed across the two VXUs.
- A measure outcome of **does not meet** occurs in all other scenarios. That is, it was able to be measured, but the IIS did not meet the requirements of the measure.

2. Patient Matching – HL7 Query: Assesses the IIS's ability to find and consolidate records when queried

- To **meet** a measure the IIS must consolidate the information from two VXUs into one single patient record in the IIS. After being queried, the IIS must return a single consolidated record for both queries. Alternatively, an IIS can return a single consolidated record for one RSP and an inexact match with one and only one patient (Z31[7] with a single patient identifier – PID – segment).
- A measure will have a measure outcome of **not measured** if an IIS rejects either VXU. Since the IIS did not accept both messages, patient matching cannot be performed across the two VXUs.
- A measure will have a measure outcome of **does not meet** in all other scenarios. That is, it was able to be measured, but the IIS did not meet the requirements to meet a measure.

Measures

Measures are organized into logical categories based on the field being tested. The fields are first name, middle name, last name, suffix, date of birth, administrative sex, mother's maiden last name, address, phone, and email address. Some limited measures test more than one field (e.g., middle name moved into first name field). Measures like these are associated with one field or the other but not both.

Measure naming conventions

Each measure has a code that is the concatenation of several pieces of information, separated with a hyphen (- ASCII code 45: hyphen-minus).

<Field of interest> - < Scenario > - < Demographic Level> - < Single v. multiple provider organizations> - <Test Variation Number>

For example, "CITY-TYPO-X-S-001" represents a measure that focuses on the patient's city with a typographical error (TYPO) in a record that includes maximum patient demographics (X), for a single organization, first variation (001). Please refer to Appendix B for more information on measure naming conventions

[7] A Z31 is a list of patient(s) where the IIS has lower confidence in the query search. The confidence in the match is locally defined. The IIS cannot return a list of multiple patients for this testing. It must be a list of one.

Field of interest

The table below provides a list of fields of interest and their corresponding codes for patient matching measures.

Field of Interest	Code
First Name	FINM
Middle Name	MDNM
Last Name	LANM
Suffix	SUFX
Mother's Maiden Last	MMLN
Date of Birth	DOBI
Administrative Sex	ASEX

Field of Interest	Code
Medical Record Number[8]	MRNU
Phone Number	PHNU
Email Address	EMLA
Street	STRE
City	CITY
ZIP Code	ZIPC
Full Address	ADDR

Scenario

Each measure evaluated a different scenario where fields of interest are modified. Below is a list of the possible scenarios that are more fully described on subsequent pages.

Test Condition	Code
Alternative End Vowels	AENV
Alternative Beginnings	ABEG
Alternative Endings	AEND
Alternative Spelling	ALTS
Alternative Vowels	ALTV
Changed	DELT
Day Shift	SHFT
Hyphen Variation	HYPV
In First Name	INFN
In Last Name	INLN

Test Condition	Code
Middle Initial	INIT
Contains Middle Name	CMNA
Nickname	NICK
Partial	PART
Repeating Consonants	REPC
Swapping fields	SWAP
Truncate	TRUN
Typographical Error	TYPO
Variation	VARI

[8] This measure will remain in Testing and Discovery for further testing and will not advance as a measure into IIS Assessment.

Demographic information completeness

Each measure could have variations in terms of patient demographic information completeness.

1. Minimum demographics, represented with "N": In general, data are populated in the HL7 v2 message for each required (R) data element (e.g., Patient Last Name PID-5.1 or Date of Birth PID-7) and patient address in a patient identifier (PID) segment. [9]
2. Maximum demographics, represented with "X": Data are populated in the HL7 v2 message for all required (R) and many required but may be empty demographic element (RE) data elements (e.g., Mother's Maiden Name PID-6 or Race PID-10) in a PID segment. A single next of kin segment is also included. [10]

Single v. multiple provider organizations

For the initial set of patient matching measures, there is only a single provider organization involved. Therefore, all measures will contain an "S." It is anticipated that multiple organizations will be used in future test cases. In such cases, measures would include "M" between the demographic level and the test scenario variation number.

Patient name measures

First name measures

Measures beginning with "FINM" are all measures which focus on the patient's first name being altered between the first and second VXU.

Measure Code[9]	Test Condition and Procedure	Description
Min Measure FINM-**ABEG**-N-S-001 Max Measure FINM-**ABEG**-X-S-001	Alternative Beginnings #1 Procedure: FIRST_NAME_ ALTERNATIVE_ BEGINNINGS	The second VXU alters the First Name field replacing its beginning sound with a similar alternative sound. VXU 1: El Dorado^**L**ucian^Wendy VXU 2: El Dorado^**J**ucian^Wendy
Min Measure		

[9] (Min) and (Max) refer to the demographic completeness of the VXU and QBP messages. A (Min) measure only supplies First name, last name, MRN, date of birth, administrative sex, and address. A (Max) measure supplies the (Min) plus middle name, mother's maiden name, race, ethnicity, phone or email, and responsible person.

FINM-**AEND**-N-S-001 Max Measure FINM-**AEND**-X-S-001	Alternative Endings #1 Procedure: FIRST_NAME_ ALTERNATIVE_ ENDINGS	The second VXU alters the First Name field by replacing its ending sound with a similar alternative sound. VXU 1: York^Meri**s**^Astra VXU 2: York^Meri**sz**^Astra
Measure Code	**Test Condition and Procedure**	**Description**
Min Measure FINM-**AENV**-N-S-001 Max Measure FINM-**AENV**-X-S-001	Alternative End Vowel Sound #1 FIRST_NAME_ ALTERNATIVE_ ENDING_VOWELS	The second VXU alters the First Name field by using different ending vowels with a similar sound. VXU 1: Sutherns^Karu**a**^Shannon VXU 2: Sutherns^Karu**ah**^Shannon
Min Measure FINM-**ALTS**-N-S-001 Max Measure FINM-**ALTS**-X-S-001	Alternative Spelling #1 FIRST_NAME_ ALTERNATIVE_ SPELLINGS	The second VXU alters the First Name field by replacing the name in the first VXU with a common alternate spelling. VXU 1: Burt^Jackson VXU 2: Burt^Jaxson
Min Measure FINM-**ALTV**-N-S-001 Max Measure FINM-**ALTV**-X-S-001	Alternative Vowels #1 FIRST_NAME_ ALTERNATIVE_ VOWELS	The second VXU alters the First Name field by using different vowels with a similar sound. VXU 1: Clay^L**o**laksi VXU 2: Clay^L**oa**laksi
Min Measure FINM-**SWAP**-N-S-001 Max Measure FINM-**SWAP**-X-S-001	Swapping fields #1	The second VXU alters the First Name field by swapping the first and last name fields. VXU 1: **Jefferson**^Shruti VXU 2: Shruti^**Jefferson**
Min Measure FINM-**SWAP**-N-S-002	Swapping fields #2	The second VXU alters the First Name field by swapping the first and last name fields.

Max Measure FINM-**SWAP**-X-S-002		VXU 1: Cindy^**Schoolcraft** VXU 2: **Schoolcraft**^Cindy

Measure Code	Test Condition and Procedure	Description
Min Measure FINM-**HYPV**-N-S-001 Max Measure FINM-**HYPV**-X-S-001	Hyphen Variation #1 FIRST_NAME_ HYPHENATE_ VARIATION	The second VXU alters the First Name field by either adding or removing a hyphen. VXU 1: Young^**Gia**^Dysthe VXU 2: Young^Gia**-Arsenio**^Dysthe

Measure Code	Test Condition and Procedure	Description
Min Measure FINM-**INFN**-N-S-001 Max Measure FINM-**INFN**-X-S-001	In First Name #1 MIDDLE_NAME_ IN_FIRST_NAME_ VARIATION	The second VXU alters the First Name field by either adding or removing the middle name from the first name field. The first VXU has a patient's first name reported in PID-5.2 (first name) and a patient's middle name in PID-5.3 (middle name). The second VXU combines first and middle names from the first VXU into PID-5.2 (first name) and no middle name is reported in PID-5.3 (middle name). VXU 1: Mason^Reiko^Rasine^ VXU 2: Mason^Reiko_Rasine^
Min Measure FINM-**INFN**-N-S-002	In First Name #2 MIDDLE_NAME_ IN_FIRST_NAME_ VARIATION	The second VXU alters the First Name field by either adding or removing the middle name from the first name field. The first VXU has a patient's first name, a space, and a second name reported in PID-5.2 (first name) - no middle name is reported in PID-5.3 (middle name). The second VXU separates the two names into PID-5.2 (first name) and PID-5.3 (middle name).

Max Measure FINM-**INFN**-X-S-002		VXU 1: Mahoning^Mikki_Estelle VXU 2: Mahoning^Mikki^Estelle

Measure Code	Test Condition and Procedure	Description
Min Measure FINM-**INFN**-N-S-003 Max Measure FINM-**INFN**-X-S-003	In First Name #3	The first VXU has a patient with a double first name reported in PID-5.2 (first name) - no middle name or initial is reported in PID-5.3 (middle name). The second VXU separates the two names into PID-5.2 (first name) and PID-5.3 (middle name). The second VXU alters PID-5.2 (first name) and PID-5.3 (middle name) by including the middle initial after the first VXU's PID-5.2 (first name). In the second VXU, PID-5.3 (middle name) is empty. VXU 1: Red Willow^Jodie^J**ohanna** VXU 2: Red Willow^Jodie J

Measure Code	Test Condition and Procedure	Description
Min Measure FINM-**REPC**-N-S-001 Max Measure FINM-**REPC**-X-S-001	Repeating Consonants #1 FIRST_NAME_ REPEATED_ CONSONANTS	The second VXU alters the First Name field by inserting repeating consonants. VXU 1: Cochise^Je**r**arda VXU 2: Cochise^Je**rr**arda

Measure Code	Test Condition and Procedure	Description
Min Measure FINM-**TYPO**-N-S-001	Typographical Error #1 FIRST_NAME_ TYPO	The second VXU alters the First Name field by randomly selecting a letter in the field and replacing it with a nearby letter on the keyboard.

Max Measure FINM-**TYPO**-X-S-001		VXU 1: Fayette^Mica**h** VXU 2: Fayette^Mica**g**
Measure Code	**Test Condition and Procedure**	**Description**
Min Measure FINM-**TYPO**-N-S-002 Max Measure FINM-**TYPO**-X-S-002	Typographical Error #2 FIRST_NAME_ TRANSPOSE	The second VXU alters the First Name field by randomly selecting two letters in a field to swap. VXU 1: Sutter^I**ri**na VXU 2: Sutter^I**ir**na
Min Measure FINM-**VARI**-N-S-001 Max Measure FINM-**VARI**-X-S-001	Variation #1 FIRST_NAME_ADD_ VARIATION	The second VXU alters the First Name field by either adding or removing spaces and single quotes. VXU 1: Seneca^Ti**r**za VXU 2: Seneca^Ti_**R**za
Min Measure FINM-**VARI**-N-S-002 Max Measure FINM-**VARI**-X-S-002	Variation #2 FIRST_NAME_ADD_ VARIATION	The second VXU alters the First Name field by either adding or removing spaces and single quotes. VXU 1: Keany^He**'R**mione VXU 2: Keany^He**R**mione

Middle name measures

Measures beginning with “MDNM” are all measures which focus on the patient’s middle name altered between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure MDNM-**ABEG**-N-S-001 Max Measure MDNM-**ABEG**-X-S-001	Alternative Beginnings #1 MIDDLE_NAME_ ALTERNATIVE_ BEGINNINGS	The second VXU alters the Middle Name field by replacing its beginning sound with a similar alternative sound. VXU 1: Saint^Elizabeth^**M**achiko VXU 2: Saint^Elizabeth^**N**achiko

Min Measure MDNM-**AEND**-N-S-001 Max Measure MDNM-**AEND**-X-S-001	Alternative Endings #1	The second VXU alters the Middle Name field by replacing its ending with an alternative. VXU 1: Turner^Coreen^Kemp VXU 2: Turner^Coreen^Kemp**ie**
Min Measure MDNM-**AENV**-N-S-001 Max Measure MDNM-**AENV**-X-S-001	Alternative End Vowels #1 MIDDLE_NAME_ ALTERNATIVE_ ENDINGS	The second VXU alters the Middle Name field by replacing its ending vowel sound with a similar vowel sound. VXU 1: Lenberg^Alani^Elo**i** VXU 2: Lenberg^Alani^Elo**y**
Min Measure MDNM-**ALTS**-N-S-001 Max Measure MDNM-**ALTS**-X-S-001	Alternative Spelling #1 MIDDLE_NAME_ ALTERNATIVE_ SPELLINGS	The second VXU alters the Middle Name field by replacing its spelling with a common alternative spelling. VXU 1: Ganron^Jeffery^**C**urt VXU 2: Ganron^Jeffery^**K**urt
Min Measure MDNM-**ALTV**-N-S-001 Max Measure MDNM-**ALTV**-X-S-001	Alternative Vowels #1 MIDDLE_NAME_ ALTERNATIVE_ VOWELS	The second VXU alters the Middle Name field by using different vowels with a similar sound. VXU 1: Dodge^Maud^Vas**i**liki VXU 2: Dodge^Maud^Vas**y**liki
Min Measure MDNM-**HYPV**-N-S-001 Max Measure MDNM-**HYPV**-X-S-001	Hyphen Variation #1 MIDDLE_NAME_ HYPHENATE_ VARIATION	The second VXU alters the Middle Name field by either adding or removing a hyphen. VXU 1: Andersson^Niju^Verena VXU 2: Andersson^Niju^Verena**-Trusha**
Min Measure MDNM-**INIT**-N-S-001	Middle Initial #1	The second VXU alters the Middle Name field by supplying the

Max Measure MDNM-**INIT**-X-S-001		inverse of the first VXU. Either a full middle name or just a middle initial. VXU 1: Omssund^Harley^**Sienna** VXU 2: Omssund^Harley^**S**
Min Measure MDNM-**INIT**-N-S-002 Max Measure MDNM-**INIT**-X-S-002	Middle Initial #2	The second VXU alters the Middle Name field by supplying the inverse of the first VXU. Either a full middle name or just a middle initial. VXU 1: Hocking^Helma^**A** VXU 2: Hocking^Helma^**Aure**
Min Measure MDNM-**REPC**-N-S-001 Max Measure MDNM-**REPC**-X-S-001	Repeating Consonants #1 MIDDLE_NAME_ REPEATED_ CONSONANTS	The second VXU alters the Middle Name field by inserting repeating consonants. VXU 1: Llano^Despina^Albi**n**ka VXU 2: Llano^Despina^Albi**nn**ka
Min Measure MDNM-**TYPO**-N-S-001 Max Measure MDNM-**TYPO**-X-S-001	Typographical Error #1 MIDDLE_NAME_ TYPO	The second VXU alters the Middle Name field by randomly selecting a letter in the field and replacing it with a nearby letter on the keyboard. VXU 1: Toale^Tierra^C**a**ryn VXU 2: Toale^Tierra^C**s**ryn
Min Measure MDNM-**TYPO**-N-S-002 Max Measure MDNM-**TYPO**-X-S-002	Typographical Error #2 MIDDLE_NAME_ TRANSPOSE	The second VXU alters the Middle Name field by randomly selecting two letters in a field to swap. VXU 1: Isdal^Sawsan^D**od**d VXU 2: Isdal^Sawsan^D**do**d
Min Measure MDNM-**VARI**-N-S-001 Max Measure	Variation #1 MIDDLE_NAME_ ADD_VARIATION	The second VXU alters the Middle Name field by either adding or removing spaces and single quotes. VXU 1: Walsh^Kimberly^Ca**n**dace

MDNM-**VARI**-X-S-001		VXU 2: Walsh^Kimberly^Ca**'N**dace
Min Measure MDNM-**VARI**-N-S-002 Max Measure MDNM-**VARI**-X-S-002	Variation #2 MIDDLE_NAME_ ADD_VARIATION	The second VXU alters the Middle Name field by either adding or removing spaces and single quotes. VXU 1: Benton^Ellice^Sa**'**Niya VXU 2: Benton^Ellice^SaNiya

Last name measures

Measures beginning with "LANM" are all measures which focus on the patient's last name altered between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure LANM-**ABEG**-N-S-001 Max Measure LANM-**ABEG**-X-S-001	Alternative Beginnings #1 LAST_NAME_ ALTERNATIVE_ BEGINNINGS	The second VXU alters the Last Name field by replacing its beginning sound with a similar alternative sound. VXU 1: **L**ind VXU 2: **J**ind
Min Measure LANM-**AEND**-N-S-001 Max Measure LANM-**AEND**-X-S-001	Alternative Endings #1 LAST_NAME_ ALTERNATIVE_ ENDINGS	The second VXU alters the Last Name field by replacing its ending sound with a similar alternative sound. VXU 1: Durbi**n** VXU 2: Durbi**m**
Min Measure LANM-**AENV**-N-S-001 Max Measure LANM-**AENV**-X-S-001	Alternative End Vowel Sound #1 LAST_NAME_ ALTERNATIVE_ ENDING_VOWELS	The second VXU alters the Last Name field by replacing its ending vowel sound with a similar vowel sound. VXU 1: Dimitri**ou** VXU 2: Dimitri**eau**

Min Measure LANM-**ALTS**-N-S-001 Max Measure LANM-**ALTS**-X-S-001	Alternative Spelling #1 LAST_NAME_ ALTERNATIVE_ SPELLINGS	The second VXU alters the Last Name field by replacing its spelling with a common alternative spelling. VXU 1: **K**lark VXU 2: **C**lark
Min Measure LANM-**ALTV**-N-S-001 Max Measure LANM-**ALTV**-X-S-001	Alternative Vowels #1 LAST_NAME_ ALTERNATIVE_ VOWELS	The second VXU alters the Last Name field by using different vowels with a similar sound. VXU 1: Hobell^D**e**rvla VXU 2: Hobell^D**ea**rvla
Measure Code	**Test Condition and Procedure**	**Description**
Min Measure LANM-**SWAP**-N-S-001 Max Measure LANM-**SWAP**-X-S-001	Swapping parts of fields #1 LAST_NAME_ HYPHENATE_ OR_SWAP	The second VXU alters the Last Name field by swapping a hyphenated last name. VXU 1: **Washington**-Davis VXU 2: Davis-**Washington**
Min Measure LANM-**HYPV**-N-S-001 Max Measure LANM-**HYPV**-X-S-001	Hyphen Variation #1 LAST_NAME_ HYPHENATE_ VARIATION	The second VXU alters the Last Name field by either adding or removing a hyphen. VXU 1: Montgomery**-**Morrow VXU 2: Montgomery Morrow
Min Measure LANM-**INLN**-N-S-001	In Last #1	The second VXU alters the Last Name field by either adding or removing the middle name from the last name field. The first VXU has a patient's middle name reported in PID-5.3 (middle name) and a patient's last name in PID-5.1 (last name). The second VXU combines middle and last names from the first VXU into PID-5.3 (last name).

Max Measure LANM-**INLN**-X-S-001		VXU 1: Pawnee^Malak^**Oksana** VXU 2: **Oksana** Pawnee^Malak
Min Measure LANM-**INLN**-N-S-002 Max Measure LANM-**INLN**-X-S-002	In Last #2	The second VXU alters the Last Name field by either adding or removing the middle name from the last name field. The second VXU properly puts the middle and last name from VXU1 into their proper locations in the PID-5 (Last Name^First Name^Middle Name). VXU 1: **Cyrena** Simpson^Kailey VXU 2: Simpson^Kailey^**Cyrena**

Measure Code	Test Condition and Procedure	Description
Min Measure LANM-**VARI**-N-S-001 Max Measure LANM-**VARI**-X-S-001	Variation #1 LAST_NAME_ PREFIX_ VARIATION	The second VXU alters the Last Name field by either adding or removing a prefix to the name (e.g., Von, De La). VXU 1: Peniston^Valeda^Avena VXU 2: **Af**_Peniston^Valeda^Avena
Min Measure LANM-**VARI**-N-S-002 Max Measure LANM-**VARI**-X-S-002	Variation #2 REMOVE_ LAST_NAME_ PREFIX	The second VXU alters the Last Name field by either adding or removing a prefix to the name (e.g., Von, De La). VXU 1: **Ab**_Carroll^Sukanya^Lyn VXU 2: Carroll^Sukanya^Lyn
Min Measure LANM-**VARI**-N-S-003 Max Measure LANM-**VARI**-X-S-003	Variation #3 LAST_NAME_ ADD_VARIATION	The second VXU alters the Last Name field by either adding or removing spaces and single quotes. VXU 1: Coryell VXU 2: **Co**_Ryell

Min Measure LANM-**VARI**-N-S-004 Max Measure LANM-**VARI**-X-S-004	Variation #4 LAST_NAME_ ADD_VARIATION	The second VXU alters the Last Name field by either adding or removing spaces and single quotes. VXU 1: Ja**'**Ckson VXU 2: JaCkson
Min Measure LANM-**REPC**-N-S-001 Max Measure LANM-**REPC**-X-S-001	Repeating Consonants #1 LAST_NAME_ REPEATED_ CONSONANTS	The second VXU alters the Last Name field by inserting repeating consonants. VXU 1: New**p**ort VXU 2: New**pp**ort

Measure Code	Test Condition and Procedure	Description
Min Measure LANM-**TYPO**-N-S-001 Max Measure LANM-**TYPO**-X-S-001	Typographical Error #1 LAST_NAME_ TYPO	The second VXU alters the Last Name field by randomly selecting a letter in the field and replacing it with a nearby letter on the keyboard. VXU 1: Wh**a**rton VXU 2: Wh**z**rton
Min Measure LANM-**TYPO**-N-S-002 Max Measure LANM-**TYPO**-X-S-002	Typographical Error #2 LAST_NAME_ TRANSPOSE	The second VXU alters the Last Name field by randomly selecting two letters in a field to swap. VXU 1: Eg**la**nd VXU 2: Eg**al**nd

Suffix measures

Measures beginning with “SUFX” are all measures which focus on the patient’s name suffix altered between the first and second VXU. Suffixes used in include: "Jr", "Junior", "Sr", "Senior", "III", "II".

Measure Code	Test Condition and Procedure	Description
Min Measure SUFX-**VARI**-N-S-001 Max Measure SUFX-**VARI**-X-S-001	Variation #1 SUFFIX_ VARIATION	The second VXU alters the Suffix field by either adding or moving the patient’s name suffix to/from the suffix, first, or last name field. VXU 1: Gelfry^Sam^Loveday^**III** VXU 2: Gelfry **III**^Sam^Loveday
Min Measure SUFX-**VARI**-N-S-002 Max Measure SUFX-**VARI**-X-S-002	Variation #2 SUFFIX_ VARIATION	The second VXU alters the Suffix field by either adding or moving the patient’s name suffix to/from the suffix, first, or last name field. VXU 1: Lake **Jr**^Marmara^Kiska VXU 2: Lake^Marmara **Jr**^Kiska

Measure Code	Test Condition and Procedure	Description
Min Measure SUFX-**VARI**-N-S-003 Max Measure SUFX-**VARI**-X-S-003	Variation #3 SUFFIX_ VARIATION	The second VXU alters the Suffix field by either adding or moving the patient’s name suffix to/from the suffix, first, or last name field. VXU 1: Garden^Madeline^Milly VXU 2: Garden^Madeline^Milly^**Sr**
Min Measure SUFX-**VARI**-N-S-004 Max Measure SUFX-**VARI**-X-S-004	Variation #4 SUFFIX_ VARIATION	The second VXU alters the Suffix field by either adding or moving the patient’s name suffix to/from the suffix, first, or last name field. VXU 1: Sac^Sorano^Scarlett^**Junior** VXU 2: Sac **Junior**^Sorano^Scarlett

Patient's mother's maiden name measures

Measures beginning with "MMLN" are all measures which focus on the patient's mother's maiden name altered between the first and second VXU. HL7 allows for a full first, middle, and last name in the Mother's Maiden Name field, however, these measures are specifically focused on the last name portion of the mother's maiden name.

Measure Code	Test Condition and Procedure	Description
Min Measure MMLN-**ABEG**-N-S-001 Max Measure MMLN-**ABEG**-X-S-001	Alternative Beginnings #1 MOTHERS_ MAIDEN_ NAME_ ALTERNATIVE_BEGINNINGS	The second VXU alters the Mothers Maiden Name field by replacing its beginning sounds with a similar alternative sound. VXU 1: Vutton VXU 2: Button
Min Measure MMLN-**AEND**-N-S-001 Max Measure MMLN-**AEND**-X-S-001	Alternative Endings #1 MOTHERS_ MAIDEN_ NAME_ ALTERNATIVE_ENDINGS	The second VXU alters the Mothers Maiden field by replacing its ending sound with a similar alternative sound. VXU 1: Rodrigue**z** VXU 2: Rodrigue**s**
Min Measure MMLN-**AENV**-N-S-001 Max Measure MMLN-**AENV**-X-S-001	Alternative End Vowels #1 MOTHERS_ MAIDEN_ NAME_ ALTERNATIVE_ENDING_ VOWELS	The second VXU alters the Mothers Maiden Name field by replacing its ending vowel sound with a similar vowel sound. VXU 1: Rile**e** VXU 2: Rile**y**
Min Measure MMLN-**ALTS**-N-S-001 Max Measure MMLN-**ALTS**-X-S-001	Alternative Spelling #1 MOTHERS_ MAIDEN_ NAME_ ALTERNATIVE_SPELLINGS	The second VXU alters the Mothers Maiden Name field by replacing its spelling with a common alternative spelling. VXU 1: M**c**donald VXU 2: M**a**cdonald
Min Measure MMLN-**ALTV**-N-S-001	Alternative Vowels #1 MOTHERS_	The second VXU alters the Mothers Maiden Name field by

Max Measure MMLN-**ALTV**-X-S-001	MAIDEN_ NAME_ ALTERNATIVE_VOWELS	using different vowels with a similar sound. VXU 1: Richm**u**nd VXU 2: Richm**o**nd
Min Measure MMLN-**HYPV**-N-S-001 Max Measure MMLN-**HYPV**-X-S-001	Hyphen Variation #1 MOTHERS_ MAIDEN_ NAME_ HYPHENATE_ VARIATION	The second VXU alters the Mothers Maiden Name field by either adding or removing a hyphen. VXU 1: Howath VXU 2: Howath**-Ellis**
Min Measure MMLN-**REPC**-N-S-001 Max Measure MMLN-**REPC**-X-S-001	Repeating Consonants #1 MOTHERS_ MAIDEN_ NAME_ REPEATED_ CONSONANTS	The second VXU alters the Mothers Maiden Name field by inserting repeating consonants. VXU 1: C**r**osby VXU 2: C**rr**osby
Min Measure MMLN-**TYPO**-N-S-001 Max Measure MMLN-**TYPO**-X-S-001	Typographical Error #1 MOTHERS_ MAIDEN_ NAME_TYPO	The second VXU alters the Mothers Maiden Name field by randomly selecting a letter in the field and replacing it with a nearby letter on the keyboard. VXU 1: Kittit**as** VXU 2: Kittit**zs**
Min Measure MMLN-**TYPO**-N-S-002 Max Measure MMLN-**TYPO**-X-S-002	Typographical Error #2 MOTHERS_ MAIDEN_ NAME_ TRANSPOSE	The second VXU alters the Mothers Maiden Name field by randomly selecting two letters in a field to swap. VXU 1: Will**ia**ms^Tara VXU 2: Will**ai**ms^Tara
Min Measure MMLN-**VARI**-N-S-001	Variation #1 MOTHERS_	The second VXU alters the Mothers Maiden Name field by

Max Measure MMLN-**VARI**-X-S-001	MAIDEN_ NAME_ADD_ VARIATION	either adding or removing spaces and single quotes. VXU 1: R**o**gers VXU 2: R**o'**Gers
Min Measure MMLN-**VARI**-N-S-002 Max Measure MMLN-**VARI**-X-S-002	Variation #2 MOTHERS_ MAIDEN_ NAME_ADD_ VARIATION	The second VXU alters the Mothers Maiden Name field by either adding or removing spaces and single quotes. VXU 1: KeyaPaha VXU 2: Keya_Paha

Date of birth measures

The measure beginning with “DOBI” is a measure that reduces the patient’s date of birth by one day.

Measure Code	Test Condition and Procedure	Description
Min Measure [None] Max Measure DOBI-**SHFT**-X-S-001	Variation #1 DATE_OF_ BIRTH_ DAY_SHIFT	The second VXU alters the Date of Birth field by moving the day of birth by one day. VXU 1: 2019-10-0**4** VXU 2: 2019-10-0**3**

Administrative sex measures

Measures beginning with “ASEX” are all measures that focus on the patient’s administrative sex (PID-8) between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure ASEX-**VARI**-N-S-001 Max Measure ASEX-**VARI**-X-S-001	Variation #1 ADMINISTRATIVE _SEX_VARIATION	The second VXU alters the administrative sex field by swapping M for F or F for M in the second VXU. VXU 1: **F** VXU 2: **M**
Min Measure ASEX-**VARI**-N-S-002 Max Measure ASEX-**VARI**-X-S-002	Variation #2 ADMINISTRATIVE _SEX_VARIATION	The second VXU alters the administrative sex field by swapping U for F or U for M in the second VXU. VXU 1: **U** VXU 2: **F**

Address measures

Address – street measures

Measures beginning with “STRE” are all measures that focus on the patient’s street component of the address field completeness between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure STRE-**ABEG**-N-S-001 Max Measure STRE-**ABEG**-X-S-001	Alternative Beginnings #1 ADDRESS_ STREET_ ALTERNATIVE_BEGINNINGS	The second VXU alters the Street field by replacing its beginning with a similar alternative. VXU 1: **1**527 Kholen Cir^^Hawks^MI^49743 VXU 2: **2**527 Kholen Cir^^Hawks^MI^49743

Measure Code	Test Condition and Procedure	Description
Min Measure STRE-**AEND**-N-S-001 Max Measure STRE-**AEND**-X-S-001	Alternative Endings #1 ADDRESS_ STREET_ ALTERNATIVE_ ENDINGS	The second VXU alters the Street field by replacing its ending sound with a similar alternative sound. VXU 1: 1015 Richmond **Ln**^^Rothbury^MI^49452 VXU 2: 1015 Richmond **Lmm**^^Rothbury^MI^49452
Min Measure STRE-**AENV**-N-S-001 Max Measure STRE-**AENV**-X-S-001	Alternative End Vowels #1 ADDRESS_ STREET_ ALTERNATIVE_ ENDING_ VOWELS	The second VXU alters the Street field by replacing its ending vowel sound with a similar vowel sound. VXU 1: 1223 Cr**ew** Ln^^Westwood^MI^49009 VXU 2: 1223 Cr**u** Ln^^Westwood^MI^49009
Min Measure STRE-**ALTS**-N-S-001 Max Measure STRE-**ALTS**-X-S-001	Alternative Spelling #1 ADDRESS_ STREET_ ALTERNATIVE_ SPELLINGS	The second VXU alters the Street field by replacing its spelling with a common alternative spelling. VXU 1: 1108 Schmi**t**t Pl^^Detroit^MI^48266 VXU 2: 1108 Schmi**d**t Pl^^Detroit^MI^48266
Min Measure STRE-**ALTV**-N-S-001 Max Measure STRE-**ALTV**-X-S-001	Alternative Vowels #1 ADDRESS_ STREET_ ALTERNATIVE_ VOWELS	The second VXU alters the Street field by using different vowels with a similar sound. VXU 1: 1374 Stelly St^^Walloon^MI^49796 VXU 2: 1374 Ste**a**lly St^^Walloon^MI^49796
Min Measure STRE-**DELT**-N-S-001	Change #1 ADDRESS_	The second VXU alters the Street field by replacing the street name with an entirely new street name .

Max Measure STRE-**DELT**-X-S-001	STREET_ CHANGE	VXU 1: 1148 **Vroeg** Cir^^Kalamazoo^MI^49002 VXU 2: 1148 **Sittard** Cir^^Kalamazoo^MI^49002
Min Measure STRE-**HYPV**-N-S-001 Max Measure STRE-**HYPV**-X-S-001	Hyphen Variation #1 ADDRESS_ STREET_ HYPHENATE_ VARIATION	The second VXU alters the Street field by either adding or removing a hyphen. VXU 1: 1186 Hartsfield Jackson Pl^^Auburn Hills^MI^48326 VXU 2: 1186 Hartsfield-Jackson Pl^^Auburn Hills^MI^48326
Min Measure STRE-**REPC**-N-S-001 Max Measure STRE-**REPC**-X-S-001	Repeating Consonants #1 ADDRESS_ STREET_ REPEATED_ CONSONANTS	The second VXU alters the Street field by inserting repeating consonants. VXU 1: 1811 Re**s**tvoorne Pl^^Flint^MI^48502 VXU 2: 1811 Re**ss**tvoorne Pl^^Flint^MI^48502
Min Measure STRE-**TYPO**-N-S-001 Max Measure STRE-**TYPO**-X-S-001	Typographical Error #1 ADDRESS_ STREET_TYPO	The second VXU alters the Street field by randomly selecting a number in the field and replacing it with a nearby number on the keyboard. VXU 1: 131**2** Alle Ln^^Sterling^MI^48314 VXU 2: 131**1** Alle Ln^^Sterling^MI^48314
Min Measure STRE-**TYPO**-N-S-002 Max Measure STRE-**TYPO**-X-S-002	Typographical Error #2 ADDRESS_ STREET_ LETTER_ TO_NUMBER	The second VXU alters the Street field by replacing a letter with a known number substitution (e.g., S -> 5). VXU 1: 1041 Ben Helder Av**e**^^Fenn^MI^49408 VXU 2: 1041 Ben Helder Av**4**^^Fenn^MI^49408

Min Measure STRE-**TYPO**-N-S-003 Max Measure STRE-**TYPO**-X-S-003	Typographical Error #3 ADDRESS_ STREET_ NUMBER_ TO_LETTER	The second VXU alters the Street field by replacing a number with a known letter substitution (e.g., 5 -> S). VXU 1: 183**6** Kutten Cir^^South Lyon^MI^48178 VXU 2: 183**t** Kutten Cir^^South Lyon^MI^48178
Min Measure STRE-**TYPO**-N-S-004 Max Measure STRE-**TYPO**-X-S-004	Typographical Error #4 ADDRESS_ STREET_ TRANSPOSE	The second VXU alters the Street field by randomly selecting two letters in a field to swap. VXU 1: 1307 Springf**ie**ld Cir^^Lakeport^MI^48059 VXU 2: 1307 Springf**ei**ld Cir^^Lakeport^MI^48059
Min Measure STRE-**VARI**-N-S-001 Max Measure STRE-**VARI**-X-S-001	Variation #1 ADDRESS_ STREET_ADD_VARIATION	The second VXU alters the Street field by either adding or removing spaces and single quotes. VXU 1: 1730_Balburg St^^Wakefield^MI^49968 VXU 2: 1730Balburg St^^Wakefield^MI^49968

Address - city measures

Measures beginning with “CITY” are all measures which focus on the patient’s address – city altered between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure CITY-**ABEG**-N-S-001 Max Measure	Alternative Beginnings #1 ADDRESS_CITY_ ALTERNATIVE_ BEGINNINGS	The second VXU alters the City field by replacing its beginning sound with a similar alternative sound. VXU 1: 1604 Wlburg Ave^^**O**tisville

CITY-**ABEG**-X-S-001		VXU 2: 1604 Wlburg Ave^^**A**tisville
Min Measure CITY-**AEND**-N-S-001 Max Measure CITY-**AEND**-X-S-001	Alternative Endings #1 ADDRESS_CITY_ ALTERNATIVE_ ENDINGS	The second VXU alters the City field by replacing its ending sound with a similar alternative sound. VXU 1: 1673 Geel Ln^^Munge**r** VXU 2: 1673 Geel Ln^^Munger**rie**
Min Measure CITY-**AENV**-N-S-001 Max Measure CITY-**AENV**-X-S-001	Alternative End Vowels #1 ADDRESS_CITY_ ALTERNATIVE_ ENDING_VOWELS	The second VXU alters the City field by using different ending vowels with a similar sound. VXU 1: 1431 Staal Ave^^Brinkl**ey**^MI^48191 VXU 2: 1431 Staal Ave^^Brinkl**y**^MI^48191
Min Measure CITY-**ALTS**-N-S-001 Max Measure CITY-**ALTS**-X-S-001	Alternative Spelling #1 ADDRESS_ CITY_ ALTERNATIVE_ SPELLINGS	The second VXU alters the City field by replacing the name in the first VXU with a common alternative spelling. VXU 1: 1345 Main St^^Albu**qu**erque^MI^49256 VXU 2: 1345 Main St^^Albu**ke**rque^MI^49256
Min Measure CITY-**ALTV**-N-S-001 Max Measure CITY-**ALTV**-X-S-001	Alternative Vowels #1 ADDRESS_CITY_ ALTERNATIVE_ VOWELS	The second VXU alters the City field by using different vowels with a similar sound. VXU 1: 1202 Het Cir^^Mik**a**do^MI^48745 VXU 2: 1202 Het Cir^^Mik**ea**do^MI^48745
Min Measure CITY-**DELT**-N-S-001 Max Measure	Change #1 ADDRESS_ CITY_CHANGE	The second VXU alters the City field by replacing the city name with an entirely new city. VXU 1: 1694 Uitgeest Pl^^**North** Star^MI^48862

CITY-**DELT**-X-S-001		VXU 2: 1694 Uitgeest Pl^^**Brighton Township**^MI^48862

Measure Code	Test Condition and Procedure	Description
Min Measure CITY-**HYPV**-N-S-001 Max Measure CITY-**HYPV**-X-S-001	Hyphen Variation #1 ADDRESS_CITY_HYPHENATE_VARIATION	The second VXU alters the City field by either adding or removing a hyphen. VXU 1: 1831 Mulpen Cir^^Lum^MI^48412 VXU 2: 1831 Mulpen Cir^^Lum**-Waterford** Township^MI^48412
Min Measure CITY-REPC-N-S-001 Max Measure CITY-REPC-X-S-001	Repeating Consonants #1 ADDRESS_CITY_REPEATED_CONSONANTS	The second VXU alters the City field by inserting repeated consonants. VXU 1: 1879 Niets Ave^^Glen**n**^MI^49416 VXU 2: 1879 Niets Ave^^Glen**nn**^MI^49416
Min Measure CITY-**TYPO**-N-S-001 Max Measure CITY-**TYPO**-X-S-001	Typographical Error #1 ADDRESS_CITY_TYPO	The second VXU alters the City field by randomly selecting a letter in the field and replacing it with a nearby letter on the keyboard. VXU 1: 1505 Oouten Ln^^C**a**pac^MI^48014 VXU 2: 1505 Oouten Ln^^C**q**pac^MI^48014
Min Measure CITY-**TYPO**-N-S-002 Max Measure CITY-**TYPO**-X-S-002	Typographical Error #2 ADDRESS_CITY_TRANSPOSE	The second VXU alters the City field by randomly selecting two letters in a field to swap. VXU 1: 1910 Apart Ln^^Sup**er**ior^MI^48198 VXU 2: 1910 Apart Ln^^Sup**re**ior^MI^48198
Min Measure CITY-**VARI**-N-S-001	Variation #1	The second VXU alters the city field by either adding or removing spaces and single quotes.

Max Measure CITY-**VARI**-X-S-001	ADDRESS_CITY_ADD_ VARIATION	VXU 1: 1445 Town Pl^^R**oc**kland^MI^49960 VXU 2: 1445 Town Pl^^R**o C**kland^MI^49960

Address - ZIP code measures

The measure beginning with "ZIPC" is a measure which adds additional detail in the patient's ZIP code between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure ZIPC-**VARI**-N-S-001 Max Measure ZIPC-**VARI**-X-S-001	Variation #1	The second VXU alters the Address field by either adding or removing the ZIP+4 from a ZIP code. VXU 1: 1596 Popik Cir^^Cedar^MI^49621____ VXU 2: 1596 Popik Cir^^Cedar^MI^49621**-7785**

Address truncation (partial address) measures

Measures beginning with "ADDR-TRUN" are all measures which focus on the patient's address fields completeness between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure ADDR-**TRUN**-N-S-001 Max Measure ADDR-**TRUN**-X-S-001	Truncate #1	The second VXU alters the Address field by removing the first line (number and street) of the address. VXU 1: **1540 Stein Ln**^^Romulus^MI^48174 VXU 2: ^^Romulus^MI^48174
Min Measure ADDR-**TRUN**-N-S-002	Truncate #2	The second VXU alters the Address field by removing the city of the address.

Max Measure ADDR-**TRUN**-X-S-002		VXU 1: 1100 Kat Cir^^**Cassopolis**^MI^49031 VXU 2: 1100 Kat Cir^^^MI^49031
Min Measure ADDR-**TRUN**-N-S-003 Max Measure ADDR-**TRUN**-X-S-003	Truncate #3	The second VXU alters the Address field by removing the state of the address. VXU 1: 1274 Kunst Pl^^Byron^**MI**^48418 VXU 2: 1274 Kunst Pl^^Byron^^48418
Min Measure ADDR-**TRUN**-N-S-004 Max Measure ADDR-**TRUN**-X-S-004	Truncate #4	The second VXU alters the Address field by removing the ZIP code of the address. VXU 1: 1693 Oden Ln^^Loch Alpine^MI^**48103** VXU 2: 1693 Oden Ln^^Loch Alpine^MI

Phone number measures

Measures beginning with “PHNU” are all measures which focus on the patient’s middle name altered between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure PHNU-**DELT**-N-S-001 Max Measure PHNU-**DELT**-X-S-001	Change #1 PHONE_CHANGE	The second VXU alters the Phone field by replacing the phone with an entirely new phone. VXU 1: 734^**5765622** VXU 2: 734^**5986348**
Min Measure PHNU-**TYPO**-N-S-001	Typographical Error #1	The second VXU alters the Phone field by randomly selecting a

Max Measure PHNU-**TYPO**-X-S-001	PHONE_TYPO	number in the field and replacing it with a nearby number on the keyboard. VXU 1: 313^7**8**53168 VXU 2: 313^7**7**53168
Min Measure PHNU-**TYPO**-N-S-002 Max Measure PHNU-**TYPO**-X-S-002	Typographical Error #2 PHONE_ TRANSPOSE	The second VXU alters the Phone field by randomly selecting two numbers in a field to swap. VXU 1: 313^46**47**149 VXU 2: 313^46**74**149

Email address measures

Measures beginning with “EMLA” are all measures which focus on the patient’s email address between the first and second VXU.

Measure Code	Test Condition and Procedure	Description
Min Measure EMLA-**ABEG**-N-S-001 Max Measure EMLA-**ABEG**-X-S-001	Alternative Beginnings #1 EMAIL_ ALTERNATIVE_BEGINNINGS	The second VXU alters the Email field by replacing its beginning sound with a similar alternative sound. VXU 1: **a**nnissa.scioto885@ventura.com VXU 2: **e**nnissa.scioto885@ventura.com
Min Measure EMLA-**AEND**-N-S-001 Max Measure EMLA-**AEND**-X-S-001	Alternative Endings #1 EMAIL_ ALTERNATIVE_ ENDINGS	The second VXU alters the Email field by replacing its ending sound with a similar alternative sound. VXU 1: cailyn.delaware883@wettiland.co**m** VXU 2: cailyn.delaware883@wettiland.co**nn**
Min Measure EMLA-**AENV**-N-S-001 Max Measure	Alternative End Vowels #1 EMAIL_ ALTERNATIVE_	The second VXU alters the Email field by using different ending vowel sound with a similar vowel sound. VXU 1: b**o**@summit.com

EMLA-**AENV**-X-S-001	ENDING_ VOWELS	VXU 2: b**oe**@summit.com
Min Measure EMLA-**ALTV**-N-S-001 Max Measure EMLA-**ALTV**-X-S-001	Alternative Vowels #1 EMAIL_ ALTERNATIVE_VOWELS	The second VXU alters the Email field by using different vowels with a similar sound. VXU 1: argenta.madis**o**n730@duval.com VXU 2: argenta.madis**oa**n730@duval.com

Measure Code	Test Condition and Procedure	Description
Min Measure EMLA-**DELT**-N-S-001 Max Measure EMLA-**DELT**-X-S-001	Change #1 EMAIL_ CHANGE	The second VXU alters the Email field by replacing the email with an entirely new email. VXU 1: penina.bryan1845@casey.com VXU 2: **euphrasia.lyon934**@**huron.**com
Min Measure EMLA-**TYPO**-N-S-001 Max Measure EMLA-**TYPO**-X-S-001	Typographical Error #1 EMAIL_TYPO	The second VXU alters the Email field by randomly selecting a letter in the field and replacing it with a nearby letter on the keyboard. VXU 1: enda.lasalle236@kjerulf.**c**om VXU 2: enda.lasalle236@kjerulf.**d**om
Min Measure EMLA-**TYPO**-N-S-002 Max Measure EMLA-**TYPO**-X-S-002	Typographical Error #2 EMAIL_ LETTER_ TO_NUMBER	The second VXU alters the Email field by replacing a letter with a known number substitution (e.g., S -> 5). VXU 1: re**r**e.wexford924@purola.com VXU 2: re**4**e.wexford924@purola.com
Min Measure EMLA-**TYPO**-N-S-003	Typographical Error #3 EMAIL_	The second VXU alters the Email field by randomly selecting two letters in a field to swap.

Max Measure EMLA-**TYPO**-X-S-003	TRANSPOSE	VXU 1: dania.menominee1166@h**am**ilton.com VXU 2: dania.menominee1166@h**ma**ilton.com
Min Measure EMLA-**HYPV**-N-S-001 Max Measure EMLA-**HYPV**-X-S-001	Hyphen Variation #1 EMAIL_ HYPHENATE_ VARIATION	The second VXU alters the Email field by either adding or removing a hyphen. VXU 1: tom.maveric@christensen.com VXU 2: tom.maveric**-gem**@christensen.com

Measure Code	Test Condition and Procedure	Description
Min Measure EMLA-**REPC**-N-S-001 Max Measure EMLA-**REPC**-X-S-001	Repeating Consonants #1 EMAIL_ REPEATED_ CONSONANTS	The second VXU alters the Email field by inserting repeating consonants. VXU 1: lon**d**on.sac115@reeves.com VXU 2: lon**dd**on.sac115@reeves.com
Min Measure EMLA-**VARI**-N-S-001 Max Measure EMLA-**VARI**-X-S-001	Variation #1 EMAIL_ADD_ VARIATION	The second VXU alters the Email field by either adding or removing spaces and single quotes. VXU 1: saroja.presqueisle1798@karle.com VXU 2: saroja**'**.presqueisle1798@karle.com

Appendix A: Testing Method Details

Each measure requires four HL7 messages: two VXU messages to create the condition in the IIS and two QBP messages to verify the outcome of the patient matching which occurred when the VXU messages were submitted.

The two VXU messages are nearly identical with only two specific changes:

1) The field under test (e.g., first name) will be altered (e.g., Chris will change to Kris)
2) The vaccination event will be changed. The first VXU will submit a hepatitis A while the second VXU will submit a hepatitis B vaccine. These will be used to confirm the IIS matched and merged the VXUs into one consolidated record.

The two QBP messages are created using demographics from the two VXU messages.

The RSPs are analyzed to determine if a single patient was created in the IIS. A Z32 (Single Patient Found) RSP which contains both the hepatitis A vaccination and hepatitis B vaccination proves the IIS matched the two VXU records and created a single consolidate record. A Z32 (Single Patient Found) RSP with only hepatitis A or the hepatitis B confirms the IIS did not merge the two patients together and created a duplicate patient.

Appendix B: Test Measure Naming Conventions

Each test has a 17-character code. The first four characters represent the field of focus (e.g., First Name, Address City, Date of Birth). The next character is a hyphen to separate the code for readability. The next four characters are the test condition (e.g., Beginning, Typo, Swap). The next character is a hyphen to separate the code for readability. The next character indicates if the measure uses minimum (N) or maximum (X) demographics. The next character is a hyphen to separate the code for readability. The next character indicates if the measure is for a single (S) or multiple (M) provider organization test scenario. The current test plan includes measures for single provider organization scenarios only, but it is anticipated this will expand to multiple provider organization scenarios in the future. The next character is a hyphen to separate the code for readability. The final three characters indicate the measure variation number.

Field of Focus		Condition		Demographic Level		Provider Organization Level		Variation
FINM	-	TYPO	-	N	-	S	-	002

First Name		Typographical Error		Minimum Demographics		Single Provider Organization		Variation

Appendix C: Test Sequencing and Expectations

To demonstrate the ability of an IIS to **consolidate** records, an IIS must meet the expectations for a submission measure described in Table 1 below. Similarly, to demonstrate successfully **searching** ability, an IIS must meet the expectations for query measures described in Table 1 below. Note that query measure outcome expectations are more rigorous.

AART – Sending System	IIS - Receiving System	Measures Expectation	
		Submission (Assesses Consolidate Ability)	**Query (Assesses Searching Ability)**
VXU A – Submission of Patient A's hepatis A vaccine dose	ACK A – Acknowledgment	Acknowledgment of successful receipt of VXU A	
VXU B – Submission of Patient B's (Revised Patient A) Demographics and a hepatitis B vaccine dose	ACK B – Acknowledgment	Acknowledgment of successful receipt of VXU B	
QBP A – Query using Patient A's demographics	RSP A – Response to QBP A	Either or both result in a consolidated vaccine record (contains both hepatitis A and B)	Both result in a consolidated record OR One results in a consolidated record and the other results in a low confidence match listing of one patient (Z31, with one PID segment)
QBP B – Query using Patient B's demographics	RSP B – Response to QBP B		

Appendix D: Transform Logic

AART uses the IIS HL7 Tester & Simple Message Mover (SMM) to modify HL7 messages to test a given scenario. For the Patient Matching measurable concept, an initial patient is created by AART and sent to the IIS in a VXU message. When generating a second VXU for the patient, the patient identifier segment is alerted by applying procedures to the base message.

Each procedure has a limited number of possible scenarios. For example, the "First Name Alternative Beginnings #1" measures rely upon the FIRST_NAME_ALTERNATIVE_ BEGINNINGS procedure. This procedure modifies the beginning of the patient's first name using a list of possibilities defined in the table below.

Full listing of ALTERNATIVE_BEGINNINGS possibilities

a -> e	d -> th	gr -> g	n -> m	sc -> c	str -> t	w -> v
b -> v	dr -> tr	h -> v	o -> a	sh -> th	sw -> w	wr -> r
bl -> l	dw -> tw	i -> e	p -> qu	sk -> c	t -> l	x -> ek
br -> r	e -> a	j -> g	pl -> l	sl -> l	th -> f	y -> w
c -> k	f -> b	k -> c	pr -> r	sn -> n	thr -> fr	z -> s
ch -> s	fl -> l	kl -> l	q -> p	sp -> p	tr -> r	
chr -> kr	fr -> th	kr -> chr	qu -> k	spl -> pl	tw -> w	
cl -> kl	g -> k	l -> j	r -> h	squ -> qu	u -> y	
cr -> kr	gl -> l	m -> n	s -> ts	st -> t	v -> w	

If we assume that initially the patient's name is "Carl," it is possible when applying the FIRST_NAME_ALTERNATIVE_BEGINNINGS procedure that the patient's modified first name could become "Karl." Given the limited scenarios defined in the procedure (above), when using the FIRST_NAME_ALTERNATIVE_BEGINNINGS procedure, a patient named "Carl" would never be transformed to "Earl" since there is no defined "c" to "e" relationship.

Note that each measure also includes a procedure that generates a unique patient that is unlikely to have been seen by the IIS before. This is the "Anonymize and Update Record" procedure. For a full listing of the procedures used in HL7 Patient Matching measurable concepts see: https://github.com/immregistries/smm-tester/wiki/MPAT-Procedures