Cookbook for Regional Interoperability Detailed Design Paper #004

Patient Identity Exchange (PIX/MPI)

PRELIMINARY DRAFT

Version 2.0 – 1st March 2023

**Abstract Interoperability Cookbook Anchor Points**

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| **Section** | **Title** |
| 8 | Security |

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**Version Control**

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# Introduction

## Purpose of this Document

This document is one of a series of design papers which underpin the Abstract of a Cookbook for Regional Interoperability (the Abstract Cookbook). These papers, in their totality, describe the technical components and the standards which form the YHCR System of Systems. They are intended as a basis for developing or procuring software and so are expressed at a level of precision which is intended to avoid ambiguity but with a consequence that they are focussed to technical readers.

Design papers are anchored to topics which are discussed in the Abstract Cookbook. They are elaborations of the concepts which were first introduced by the abstract and new content is further detail rather than variations of previously established core principles.

This document (design paper 004 - “Patient Identity Exchange (PIX/MPI)”) describes a regional capability for tracking contact with patients by the participants of the YHCR. This capability involves linking a master regional demographic for a patient to local demographics held by the YHCR participants. The capability serves two purposes:

1. To allow searches for data to be targeted to data providers who have had contact with the patient.
2. To enable all variations in patient demographics and local identifiers to be surfaced by data consumers.

The capability relies on data providers registering their patient identities with the YHCR using the NHS Number as the primary identifier.

## Use of the NHS Number by the YHCR

The NHS number is the unique identifier for a patient in the YHCR. The regional FHIR aggregator (design paper 010) will only release patient identifiable data (for a definition see design paper 005 – “Identity and Access Management”) which is related to a patient with an NHS number which has been traced against the Personal Demographic Service (PDS)[[1]](#footnote-2).

This policy obliges data consumers to ascertain the NHS number for any patient for which they wish to obtain regional data. It also obliges data providers to trace NHS numbers for any patient data that they publish.

Responsibility for determining and tracing NHS numbers rests with localities However, the YHCR can facilitate local management of NHS numbers:

* by tracing NHS Numbers with PDS where a patient with an untraced NHS number is registered by a data provider with the YHCR;
* by offering patient search facilities which will allow data consumers accessing the YHCR for the purpose of direct care to search centrally held Patient FHIR resources on a defined set of demographics and receive possible matches.

## Relationship of this Document with Other Standards

The patient identity exchange is based on the [Integrating the Healthcare Enterprise](https://www.ihe.net/resources/technical_frameworks/#IT) (IHE) concept PIX.

Other relevant standards include:

* [HL7v2 version 2.4](http://www.hl7.org/implement/standards/product_brief.cfm?product_id=185).
* FHIR [Patient resource](http://www.hl7.org/fhir/stu3/patient.html).
* FHIR [Linkage resource](http://www.hl7.org/fhir/stu3/linkage.html).
* Spine Mini Services Provider ([SMSP](https://digital.nhs.uk/services/spine/spine-mini-service-provider-for-personal-demographics-service))
* NHS [Interoperability Toolkit](https://digital.nhs.uk/services/interoperability-toolkit)

## Intended Users of the This Document

This document is a reference guide for developers and operators of YHCR regional infrastructure, data providers and data consumers

# PIX/MPI Architecture

The PIX/MPI service is a regional component which is hosted and operated as part of the YHCR regional infrastructure.

## Relationship with Other Components

The service and its positioning with other regional, local, and national services is illustrated below.



The goal of the service is to manage a regional “golden-record” for a patient’s demographics which is linked to local copies of demographics. These may or may not agree with the regional golden record.

The record is persisted in the regional FHIR store as *Patient* FHIR resources. The regional *Patient* resource is synchronised with the national Patient Demographic Service (PDS) and the regional patient demographics should always reflect the demographics registered with PDS subject to short window of latency.

The PIX/MPI service creates regional *Patient* resources at the time patients are registered with the YHCR. The service is not intended to be a complete and accurate directory of the of footprint of the YHCR: patients which have not had contact with a service operated by a participant to the YHCR will not be registered with the YHCR, and conversely, patients which have moved out of the YHCR area may still have a YHCR record.

Data providers register patients with the YHCR when:

* they onboard to the YHCR using a batch upload process;
* a patient attends a service or an appointment is booked for the first time with a service operated by a provider;
* the patient record changes on the local provider administration system resulting in a new patient record being created or an NHS number being added or amended for an existing record.

## Data Structures

The data structures which are built by PIX/MPI are used by other regional infrastructure to orchestrate its interactions with data providers. In particular:

* the regional FHIR Aggregator only issues patient-centric issues queries to those data providers which have registered contact with the patient;
* the Data Availability Service (design paper 002) uses the *Patient* resource and its linkages to local patients to respond to user interface inquiring whether any non-local data is known about a patient by the YHCR;
* the regional Subscription Manager manages patient-centric subscriptions at data providers who have had contact with a patient.

The data structure which is maintained by PIX/MPI is as follows:



A single *Patient* resource is persisted in the regional FHIR store for each patient registered with the YHCR. It has a single identifier: the NHS Number and all demographic details are identical to those maintained by PDS.

*Linkages* resources are persisted in the regional FHIR store for each patient/organisation relationship. The linkage resources have one item linking it to the regional *Patient* resource and one item linking it to Patient resources for the same patient which are maintained by a local data providers.

# Publishing Patient Contact for Data Providers

Data providers should register those patients with the YHCR for which they have publishable data and a traced NHS number (with the exception of new-born babies). The YHCR offers 3 methods for registering patients:

* an HL7v2 feed;
* a RESTful service for posting a FHIR *Patient* resources;
* a batch service for uploading bulk *Patient* resources as part of the onboarding process.

## HL7v2 Service

The service accepts an HL7v2 ADT\_28 Add Person Message in an [ITK compliant](https://digital.nhs.uk/services/interoperability-toolkit) pipe-and-hat format. The IP address and port number for the service are published in the YHCR Operations Guide.

The service is secured with certificates signed by the regional certificate authority (design paper 016 – “Securing the YHCR”).

In compliance with the ITK specification the only segments which are required are:

* MSH
* EVN
* PID

Other segments, if present, are ignored. The PID segment must contain exactly one entry in the patient identifier list (PID:3). The entry must have an assigning authority of NHS and the patient identifier must conform to the NHS number format. The implication of presence of this identifier is that the NHS number has been traced by the organisation sending the message.

Other required fields comprise:

* Patient Name (PID:5) – at least the family name and a given name must be present.
* Date/Time of Birth (PID:7)

The message is acknowledged with an HL7v2 ACK. The acknowledgement code is one of:

* AA – the message was accepted, and a linkage created.
* AE – an error occurred the sending organisation should retry after a delay.
* AR – the message was rejected and the sending organisation must investigate the reason.

In the last two cases an ERR segment provides an explanation of the error or reason for rejection.

## RESTful FHIR Service

The service accepts a FHIR *Patient* resource POSTed using the HTTPS protocol. The body of the request is a single resource rendered as JSON or XML.

The service is secured with certificates signed by the regional certificate authority (design paper 016 – “Securing the YHCR”).

The resource must comply with the Care Connect *Patient* resource profile and contain the following mandatory properties:

* A logical id.
* Exactly one identifier of the system <https://fhir.nhs.uk/Id/nhs-number> with a value which conforms to the NHS number format and with an nhsNumberVerificationStatus of 01 (implying that the NHS number has been traced) or 08 (implying a new born baby yet to be traced).
* A name with given and family name parts.
* A data/time of birth.

The service responds with an HTTP response code as follows:

* 200 - the resource was accepted, and a linkage created.
* 500 – an error occurred the sending organisation should retry after a delay.
* 400 – the resource was rejected and the sending organisation must investigate the reason.

## Batch On-take

The service accepts a file containing a bundle of FHIR *Patient* resources. The file is sent to the YHCR using FTPS secured with certificates signed by the regional certificate authority (design paper 016 – “Securing the YHCR”).

The file will be uploaded to a directory whose name embeds the organisation code which was assigned to the data provider during the onboarding process (design paper 020 – “Onboarding Data Providers”).

Details of the service address, login requirements, and directory formats are published in the YHCR Operations Guide.

Requirements for the content of the *Patient* resources are as detailed in section 3.2 for the RESTful service.

The service will return a file containing a bundle of *OperationOurcome* resources. One OperationOutcome will be written for each resource in the incoming file which was not accepted by the YHCR. The *OperationOutcome* will include an expression which locates the *Patient* resources in the incoming bundle. An empty bundle signifies that all resources were accepted.

The response file will be written to a directory on the YHCR FTPS server. The filename will reference the filename of the inbound request. Organisations submitting patients for batch on-take must poll for response files and act on their content.

## Generic PIX Processing

Regardless of the method which an organisation chooses to register patients, the YHCR PIX/MPI service performs the same processing.

1. The inbound data structure is validated for content and format.
2. The presence of mandatory fields is validated.
3. The format of the NHS number is validated.
4. The regional FHIR Store is searched for a Patient resource with the registered NHS Number.
5. If a resource is found, then it is verified as matching the patient being registered (see below) and that no existing active Linkage exists for the organisation registering the patient.
6. If a resource is not found, then a Patient resource is created with an identifier being the NHS number and a nhsNumberVerificationStatus of 03 (Trace Required).
7. A *Linkage* resource is created in the FHIR store linking the regional resource to the equivalent local resources.

Linkage resources reference the local equivalent resource using an absolute path (for registration processes involving submission of a FHIR resources) or an NHS identifier and assigning organisation if the registration was performed using HL7v2.

NHS number identifier references will be overwritten by the regional FHIR Aggregator (design paper 010) with an absolute resource reference when the equivalent *Patient* FHIR resource is first seen from the assigning organisation.

### Demographic Verification Algorithm

The following algorithm is used by the NHS Spine when verifying an individual’s identity and is also used when the YHCR PIX/MPI needs to ascertain the equivalence of two patient demographic records.

1. The NHS Numbers match.
2. At least 2 out of 3 parts of the Date of Birth match (YYYY or MM or DD).
3. The first 3 characters of the Surname match.
4. The initial character of the forename match.

## Tracing with PDS

Newly created patient resources are populated with a minimal data set which is supplemented by data obtained from PDS. When the data is obtained from PDS, demographics are validated according to the algorithm detailed above and the nhsNumberVerificationStatus uplifted to 01 (Traced).

PDS access is undertaken asynchronously from the registration request and so it is possible (although unlikely) that verification fails. An operational process will be set up to follow up on failures with the organisation who registered the patient and the national PDS team. Asynchronous tracing is normally scheduled immediately except for new-borns where tracing is deferred to 6 weeks after the birth date.

Only Patients with nhsNumberVerificationStatus of 01 (traced) or 08 (new-born baby yet to be traced) are included in searches.

## Revoking a Linkage

A *Linkage* resource may be updated in the regional FHIR Store to change the active property of the resource from true to false. The operation will only be permitted to the organisation to which the *Linkage* refers. This is the only operation that is permitted on a *Linkage* resources.

Inactive linkage resources are not included by the FHIR Aggregator when determining how to distribute a search.

## Auditing

All Patient and Linkage resource create, and update operations undertaken on the regional FHIR Store are audited in accordance with design paper 009 – “Auditing”. The PIX/MPI service also audits access to its three patient registration services. The following data is audited for each patient registration:

* service type;
* organisation accessing service;
* data and type of access;
* batch file path;
* outcome;
* error code and message;
* Patient resource reference created;
* Linkage resource reference created;

## PIX and Subscriptions

There is a dependency between the PIX/MPI service, and the regional subscription manager. This is detailed by design paper 007 – “Subscriptions Infrastructure” and summarised again here for completeness.

Subscriptions to an individual patient’s or a cohort of patients’ data which are made with the regional Subscription Manager is delegated to data providers. Only those data providers who have registered their contact with the patients are notified of the subscription. When a new patient registration occurs then it is possible that pre-existing subscriptions may be under the management of the YHCR.

The subscription manager registers pre-existing subscriptions with a new organisation creating a linkage with a patient. Subscriptions are revoked when a linkage is revoked by an organisation.

# Querying Patient Resources

Design paper 005 – “Identity and Access Management” enumerates the possible reasons for access for the YHCR and determines the implications for the scope of data which can be retrieved.

If access is for the purpose of direct care, then normally a data consumer is restricted to searches for patient identifiable data where the patient being treated is the subject of the data. The rational being that direct care is targeted at an individual and access to other patients’ data is inappropriate.

# Interactions with PDS

The goal of the PIX/MPI service is to synchronize the regional demographic with PDS. Synchronisation takes place in two stages:

1. When a new *Patient* resource is created in the regional FHIR Store then it is initialised with the demographic record sourced from PDS.
2. When the demographic record changes on PDS then the YHCR is informed of the change and the regionally held *Patient* resource is updated.

## Spine Mini Services

Spine Mini Services will be used for the initial access to the PDS when a *Patient* resource is created.

The service will be accessed using the NHS Digital hosted Spine Mini Service Provider. This is a SOAP-based web service. YHCR will use the getPatientDetailsByNHSNumber action to obtain:

* Title;
* Surname;
* Given Name(s);
* Date of Birth;
* Date of Death;
* Gender;
* Address;
* Temporary Address;
* Correspondence Address;
* Home Telephone;
* Mobile Telephone;
* Email Address;
* Practise Code.

The practise code will be used to reference an *Organisation* resource created in the regional FHIR Store through an upload from ODS (design paper 013 – “Interfaces with the Organisational Data Service (ODS)”). Should the practise not be known to the YHCR then a new *Organisation* will be created using the practise name, address, and contact telephone number included in the service response.

### Spine Mini Services Adapter

The SMSP Adapter component within Interweave Exchange is responsible for performing traces against the Spine PDS service (using the SMSP endpoint), maintaining the results of those traces in the Firestore smsp-pds collection and maintaining the Patient resources in the regional store (MPI).

A successfully traced patient’s entry in this collection (keyed by NHS Number) looks like:

{

display: "Success",

gpPracticeId: "YHCR:c4444d89-6261-49c8-8e0b-182336ed988e",

gpPracticeODS: "A20047",

id: "9658218903",

lastUpdated: "2022-01-25T13:12:13.858Z",

regionalId: "YHCR:fcb3f862-b0d0-496e-a7e6-3f5f285ff4f8",

responseCode: "SMSP-0000",

status: "success",

traceDetails: {

dob: "1939-07-21",

family: "OLLEY",

given: "Arnold",

nhs: "9658218903",

},

verificationErrors: []

}

A trace can be triggered by several flows and have subtly different effects. The environment also matters as non-production envs deploy PIX in an asynchronous fashion where traces happen post registration rather then synchronously as part of registration.

***See “Appendix 2 – SMSP Trace Logic” for further details of the logic followed for all SMSP traces***

### Trace on Query

**Exchange**

All read and search interactions on Patient made to the exchange (that are not in the analytics scope) cause a trace to occur.

* This is via the pix middleware included in GET api calls. It ends up calling the linkage.trace action. Note that from this point on, the process is asynchronous so that it doesn’t hold up the query.
* The linkage.trace action then discovers the NHS Number (either directly from the query or from any patient reference in the query).

**PIX**

The PIX refresh endpoint is then called passing the NHS number. This calls the batch.trace.refresh action.

* The batch.trace service in PIX can be run in async or sync mode. The async version is obsolete and no longer used.
* The batch.trace service then obtains the patient record from the MPI and passes to the smsp.trace service with a “reason” of “refresh”
* The smsp.trace service extracts the NHS number, DoB, family and given names and POSTs those to the SMSP Trace endpoint. See SMSP Trace Logic

### Production (synchronous) Patient registration

**Exchange**

A DataProvider calls the /pix/fhir/stu3/Patient endpoint to register a patient. The flow then goes through process.register to linkage.create which calls the PIX service’s /register endpoint.

**PIX**

In production settings, the PIX api routes the register call to pix.register and then on to patient.linkage.sync.manager.register. This action calls the smsp.trace action passing the patient resource and a reason of “register-sync”.

* The smsp.trace service extracts the NHS number, DoB, family and given names and POSTs those to the SMSP Trace endpoint (/pds/v1/smsp/trace).
* The response from SMSP is examined and if in error, the error is returned to Exchange explaining that the patient cannot be registered.
* If the trace was successful but the patient has opted out or is S-Flagged, a different error is returned. This will fail the registration.
* If all is well, PIX goes ahead and creates a Linkage resource.

### Non-production (asynchronous) Patient registration

**Exchange**

A DataProvider calls the /pix/fhir/stu3/Patient endpoint to register a patient. The flow then goes through process.register to linkage.create which calls the PIX service’s /register endpoint.

**PIX**

In non-production settings, the PIX api routes the register call to pix.register and then on to patient.linkage.async.manager.register.

* The async processing starts by obtaining the trace status for the patient (smsp.getStatus action which issues a GET to the SMSP endpoint (/pds/v1/smsp/trace/:nhsNumber).
* The trace status is examined to see if the optOut flag is set (Opt Out and S-Flag ). If so, an error is thrown. This will end the process and Exchange will report the error to the DataProvider.
* If the patient hasn’t opted out, the async service will go ahead and create the Linkage resource which also has complex logic to update the Patient record in the MPI (as the SMSP service is not being used to do it as in the synchronous path)
* This logic involves trying to find the existing MPI version of the patient based on NHS numberand then verifying the demographics match the registration request. If ok, it uses the MPI version in preference to the resource passed in by the DataProvider. However, if a match is found on NHS number but the demographics differ it overwrites the MPI.

Upon completion of async registration, PIX emits a "patient.registered" event and then returns to Exchange.

* The event is picked up by the smsp.publisher service (which is disabled in production environments). This service then extracts the NHS number, DoB, family and given names and POSTs those to the SMSP Trace endpoint (/pds/v1/smsp/trace) along with a reason of “register-async”.
* The response is logged but as this is now an asynchronous branch of processing, it doesn’t affect the registration.

### Direct Trace

**Exchange**

A participant can call the /pix/fhir/stu3/Patient/$trace endpoint passing query parameters nhs-number and birthDate. The flow then goes through process.$trace to linkage.$trace which calls the PIX service’s /$trace endpoint.

**PIX**

The pix.trace action will call the smsp.trace action with reason = “trace”. If SMSP returns an error, the details are returned to Exchange as an OperationOutcome. If the trace is successful but the patient has opted out or is S-Flagged, then a standard error message is returned.

If the trace succeeds, the patient resource that will have been updated in the MPI, is returned.

## PDS Bulk Loader (Downloads)

A daily download is scheduled that receives delta files of PDS data for the region. It will then call the SMSP workload to set trace details and MPI records for all the patients in the region. Each row is either a PDS-NEW (new patient to region), PDS-AMENDED (demographics updated) or PDS-REMOVED (patient leaves region).

The SMSP service has 2 API endpoints to facilitate the bulk loader:

**POST /pds/v1/smsp/pds/:nhsNumber**

The body of the call is JSON with properties:

* ***responseCode*** (one of PDS-NEW, PDS-AMENDED, PDS-REMOVED)
* ***patient*** which is similar to a FHIR Patient but not quite. It has a single identifier, a single name, an array of address, an array of telecom, a gender and a birthDate
* ***organization*** which is similar to a FHIR Organization but not quite. It has a single identifier, a single name, an array of address and an array of telecom

When called, the SMSP will use the above details instead of the response from spine.proxy.getPatientDetailsByNHSNumber action. The staleness check is also bypassed if the details have already been supplied.

**DELETE /pds/v1/smsp/pds/:nhsNumber**

The pds.process.pdsRemove action will create/update the trace status for the supplied NHS number and set the inRegion flag to false. It will then invoke the Out of Region processing.

## Out of Region Processing (Deactivating Patients)

With the PDS Bulk Loader (Downloads) function, an exchange can now know which patient are in and out of region. This is important for IG as we don’t want to hold information on people we have no dealings with.

When it is determined that a Patient is no longer in scope for the exchange, we will strip the MPI patient down to it’s minimal set (NHS Number and DoB) and set inactive. This will cause the Exchange to reject queries against it. Additionally any demographics beyond the NHS Number and DoB are removed from the trace status.

To become inactive, a Patient must:

* be out-of-region (the trace status inRegion flag = false or missing)
* have no Linkages

So there are 2 scenarios that trigger the out of region processing:

1. The patient has no Linkages and has either never been in region or has been in region (via a PDS-NEW or PDS-AMENDED record) and then is removed via a PDS-REMOVED record
2. The patient is out of region but has Linkages and then is deregistered by the last remaining provider to have a Linkage with them.

For 1, the pds.process.pdsRemove action is called in the SMSP gateway. pdsRemove will change the trace status to set inRegion = false and then call the out of region process.

For 2, the PIX pix.deregister action is called which then calls the SMSP endpoint /pds/v1/smsp/check which forwards to the pds.process.pdsCheckRemove action. That looks up the trace status for the patient and if out of region, calls the out of region process.

### Out of Region Process

* If inRegion flag is true, end as it is valid to store the patient details.
* Set the inRegion flag to false (if not already set)
* Check if there are any Linkages for the patient
* If zero Linkages, update the MPI record to be a minimal record and set the active flag to false.
* Remove unnecessary fields from the trace status (other demographics) and update.

Note that an inactive patient does not have the Restricted flag in it’s meta. The exchange can differentiate between a Patient that is restricted (due to opt out or S-Flag) and a patient that we don’t have a legitimate reason to process.

## Opt Out and S-Flag

The exchange provides managment APIs so the Admin console can declare that a patient has opted out. This will cause the trace status against the NHS number to have an optOut flag set. Exchange then triggers a trace so that the MPI record and trace status will be made minimal.

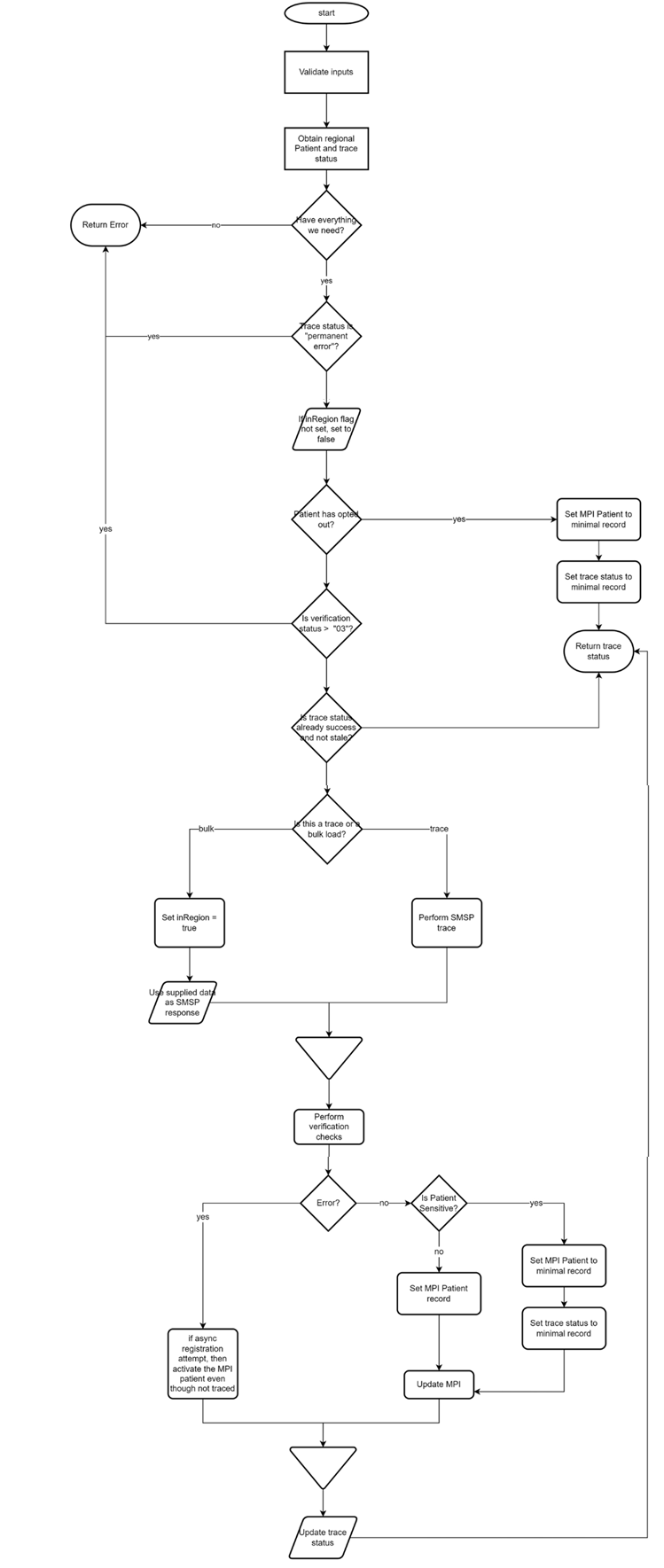
The sFlagged flag is set by the SMSP service if the traced patient has no registered GP practice, no addresses and no telecoms. This also causes the MPI record to be stripped down.

# Appendix 1 – Maturity Matrix

|  |  |  |  |  |
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# Appendix 2 – SMSP Trace Logic

In all the SMSP trace flows the SMSP Trace logic is called. This outlines that logic:



**Notes**

When the staleness check is made, if the trace status is NOT stale AND the trace is begin made because of a registration, then set the MPI patient to active if it isn’t already. There is a chance that the patient could be set to inactive (out of region with no Linkages) by the PDS Bulk loader and then a registration is made but because the trace status isn’t stale, a new trace and update won’t be made. Therefore the MPI does need to be updated to set the active flag to true.

1. There is an exception for new-born babies. [↑](#footnote-ref-2)