



National Adult Cardiac Surgery Audit Registry Data Pre-processing

Version 10.3

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With thanks to **Graeme Hickey** for contributions to previous versions.

Summary

This report outlines the main steps taken to pre-process the National Adult Cardiac Surgery Audit (NACSA) registry data. This comprises a merger of all operative records for adult cardiac surgery: from hospital extracts to a cleaned, uniform dataset. The report is compiled directly from the pre-processing code during each cleaning implementation, and each notable modification to raw hospital data is presented. Erroneous errors are cleaned in-field but additional data pre-processing and inferences are saved to new indicator fields. The present version is up-to-date as of May 8, 2015.

Data

The latest data extract is dated 2015-05-01 and comprises all Adult Cardiac Procedures from the NACSA registry, and includes merged ONS linkage data that is available up to 2014-07-24.

The database is a single file comprised of a concatenation of two version of the NACSA databases: v3.8 and a revised v4.1.2, which took effect from April 2011.

Two methods of mapping from v3.8 to v4.1.2 are implemented: within-field mapping and between-field mapping. For within-field mapping the fields themselves have remained the same but the field options have changed between versions. These changes are highlighted under each field-heading accordingly. In contrast, for between-field mapping the fields themselves have changed. These changes are more complicated in nature and are described together in a separate section. In addition, several fields have been removed both during the transition from v3.8 to v4.1.2 and subsequently. For documentation of the up-to-date database definitions, please see:

V4.1.2 Database Definitions

www.ucl.ac.uk/nicor/audits/adultcardiac/documents/datasets/NACSAdatasetV4.1.2

Validation

The output from the pre-processing is regularly checked by reporting data summaries back to individual units for inspection. The current data is validated from 1998-01-01 to 2013-03-31, with 2013-04-01 to 2014-03-31 data due to be validated by June 2015.



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1 Changes to Previous Versions

1.1 Changes in Version 10.3

- Data for validation extended to 2014-03-31
- New hospital introduced to dataset: AHM. BMI The Alexandra Hospital
- Temporary hospital code QEP used for external QEB patients

Categorical Variables

Minor corrections to new erroneous input for cleaning:

X1.07.Gender, X1.08.Administrative.Category, X2.03.N.Previous.MIs, X3.19.Aortic.Valve.Haemodynamics, X3.23.Aortic.Valve.Explant, X3.24.Mitral.Valve.Explant, X3.25.Tricuspid.Valve.Explant, X3.43.Aortic.Valve.Procedure, X3.47.Aortic.Valve.Implant.Type

X3.47.Aortic.Valve.Implant.Type

“Bioprosthetic” mapped to “3. Biological”

Multivalue Variables

Minor corrections to new erroneous input for cleaning:

X3.37.Reason.Repeat.Tricuspid.valve.replacement, X3.82.Cardioplegia.infusion.mode, X3.95.Neuroprotection

Numerical Variables

X2.37.Height

“False” set as missing

Variable converted from string to numerical prior to cleaning

X2.38.Weight

“False” set as missing

Additional minor corrections to erroneous input cleaning

Surgeon Variables

X3.03.Responsible.Consultant.Surgeon

Updated GMC number mappings and revised cleaning algorithm

Between-Field Mapping

Minor corrections to new erroneous input for cleaning:

X3.69.1.Ao.proc.Root.Segment.Code.1, X3.71.1.Ao.proc.Ascending.Segment.Code.2, X3.73.1.Ao.proc.Arch.Segment.Code.3, X3.75.1.Ao.proc.Descending.Segment.Code.4, X3.77.1.Ao.proc.Abdominal.Segment.Code.5

X3.77.1.Ao.proc.Abdominal.Segment.Code.5

“Tube graft + separate AVR” mapped to missing



1.2 Changes in Version 10.2

- Variables for ONS linkage **LS.Status** and **LS.Date** extended to 2014-07-24
- Updated removal procedure from mismatched ONS linkage
- New hospital introduced to dataset: CBS. Spire Southampton Hospital
- New clinical definition of unstable angina (see below)

Categorical Variables

Minor corrections to new erroneous input for cleaning:

X1.08.Administrative.Category, **X3.20.Mitral.Valve.Haemodynamics**, **X3.23.Aortic.Valve.Explant**, **X3.43.Aortic.Valve.Procedure**, **X3.44.Mitral.Valve.Procedure**, **X3.45.Tricuspid.Valve.Procedure**, **X3.47.Aortic.Valve.Implant.Type**, **X3.48.Mitral.Valve.Implant.Type**, **X3.49.Tricuspid.Valve.Implant.Type**, **X3.50.Pulmonary.Valve.Implant.Type**, **X3.84.Non.cardioplegic.protection**, **X4.01.1.Deep.Sternal.wound.infection**, **X4.01.2.Deep.Sternal.wound.infection.treatment**, **X4.03.Post.Op.Dialysis**

X3.47.Aortic.Valve.Implant.Type

“Tissue” and “Biological” remapped from missing to “3. Biological”

X3.48.Mitral.Valve.Implant.Type

“Tissue” remapped from missing to “3. Biological”

Multivalue Variables

Minor corrections to new erroneous input for cleaning:

X3.90.Presentation, **X3.95.Neuroprotection**, **X4.02.New.CVA**

Surgeon Variables

Minor corrections to new erroneous input for cleaning:

X3.06.First.Operator.Grade, **X3.09.First.Assistant.Grade**

X3.03.Responsible.Consultant.Surgeon

Updated GMC number mappings

Between-Field Mapping

Minor corrections to new erroneous input for cleaning:

X2.12.1.Renal.Function.Dialysis, **X3.69.1.Ao.proc.Root.Segment.Code.1**, **X3.71.1.Ao.proc.Ascending.Segment.Code.2**, **X3.75.1.Ao.proc.Descending.Segment.Code.4**

Flags

Aortic Valve Flag

Additional mapping if **X3.69.1.Ao.proc.Root.Segment.Code.1** is “2. Tube graft + separate AVR”, “4. Root replacement with composite valve graft and coronary reimplantation (Modified Bentall or Cabroll)” or “7. Ross Procedure”

OR if **X3.71.1.Ao.proc.Ascending.Segment.Code.2** is “3. Tube graft + separate AVR”, “4. Root replacement with composite valve graft and coronary reimplantation (Modified Bentall or Cabroll)” or “7. Ross Procedure”

Pulmonary Valve Flag

Additional mapping if **X3.69.1.Ao.proc.Root.Segment.Code.1** is “7. Ross Procedure”

OR if **X3.71.1.Ao.proc.Ascending.Segment.Code.2** is “7. Ross Procedure”



Model Variables

Unstable angina field **angina** extended from definition of **X2.29.IV.Nitrates** set as "1. Yes" to:

IF **X2.29.IV.Nitrates** is "1. Yes"

AND **X2.01.Angina.Status.Pre.Surgery** is "4. Symptoms at rest or minimal activity"

AND **X2.35.Operative.Urgency** is "2. Urgent" "3. Emergency" "4. Salvage"

1.3 Changes in Version 10.1

Fields Dropped

- Fields dropped from dataset:
 - X2.15.Carotid.Bruits
 - X2.25.Left.Ventricular.End.Diastolic.Pressure
 - X2.26.Mean.Pulmonary.Artery.Wedge.Pressure
- Redundant fields:
 - X2.12.0.Unmeasured: associated field **X2.12.0.Actual.Creatinine.at.time.of.Surgery** re-mapped
 - Date: duplicate of **Creation.Date**
 - Ethnic.Group, LADProx, LADOther, RCA LCX, Grafts.present and Grafts.patent currently only recorded at one hospital
- V3.8 fields dropped after cleaning/mapping:
 - X2.12.Renal: mapped to **X2.12.0.Actual.Creatinine.at.time.of.Surgery** and **X2.12.1.Renal.Function.Dialysis**
 - X3.13.Other.thoracic.and.vascular.procedures: mapped to **X3.11.3.Major.aortic**, **X3.11.4.Cardiopulmonary.bypass** and **X3.12.Other.Cardiopulmonary.procedures**

Categorical Variables

X2.21.Extent.of.Coronary.Vessel.Disease

"1. Two vessels with >50% diameter stenosis" remapped from "1. One vessel with >50% diameter stenosis" to "2. Two vessels with >50% diameter stenosis"

X2.24.3.Category.of.AVS

"1. Moderate" remapped from "1. Mild" to "2. Moderate"

X2.29.IV.Nitrates

"2. Within one week of operation" and "2" mapped to "1. Yes"

X3.78.Cardiopulmonary.bypass

"1. No" remapped from missing to "0. No"

X3.83.Cardioplegia.timing

"2. Intermittent" remapped from "2. Continuous" to "1. Intermittent"

X3.84.Non.cardioplegic.protection

"Beating heart with perfusion" remapped from missing to "5. Beating heart without cross clamp"



Multivalue Variables

For native valve pathology variables:

- X3.27.Native.Aortic.Valve.Path
- X3.28.Native.Mitral.Valve.Path
- X3.29.Native.Tricuspid.Valve.Path
- X3.30.Native.Pulmonary.Valve.Path

"2. Degenerative inc Calcific degeneration" mapped from "7. Calcific degeneration" and "2. Degenerative"

X3.27.Native.Aortic.Valve.Path

"14 - other degenerative disease" remapped from "19. Other native valve pathology" to "2. Degenerative inc Calcific degeneration"

"13 - Annuloaortic ectasia" remapped from "19. Other native valve pathology" to "6. Annuloaortic ectasia"

For reason for repeat valve replacement variables:

- X3.35.Reason.Repeat.aortic.valve.replacement
- X3.36.Reason.Repeat.Mitral.valve.replacement
- X3.37.Reason.Repeat.Tricuspid.valve.replacement
- X3.38.Reason.Repeat.Pulmonary.valve.replacement

"5. Implanted valve failure" mapped from "5. Intrinsic valve failure"

X3.35.Reason.Repeat.aortic.valve.replacement

"6. Other" remapped from "6. Haemolysis" to "19. Other reason"

"7. Unknown" remapped from "7. Prior valve repair failure" to missing

X3.81.Cardioplegia.temperature

"2. Cold" remapped from "2. Warm" to "1. Cold"

"1. Warm" remapped from "1. Cold" to "2. Warm"

X3.82.Cardioplegia.infusion.mode

"3. Antegrade and retrograde" remapped from missing to "1. Antegrade;2. Retrograde"

X4.02.New.CVA

"0 No" remapped from missing to "0. None"

Numerical Variables

X2.38.Weight

Converted field class from integer to numerical with 1 dp

Converted field class from numerical to integer:

- X3.85.Cumulative.Bypass.time
- X3.86.Cumulative.cross.clamp.time
- X3.87.Circulatory.arrest.time

X3.86.Cumulative.cross.clamp.time

"1;2" remapped from "12" to missing



Between-Field Mapping

Renal Mapping

X2.12.0.Actual.Creatinine.at.time.of.Surgery

Minor updates to renal mappings from v3.8 field

X2.12.1.Renal.Function.Dialysis

Minor updates to renal mappings from v3.8 field

Aortic Pathologies

X3.68.1.Ao.path.Root.Segment.Code.1

Minor updates to aortic pathology mappings from v3.8 field

X3.70.1.Ao.path.Ascending.Segment.Code.2

Minor updates to aortic pathology mappings from v3.8 field

Erroneous "8" and "9" mapped to "99. Other"

Erroneous "5" mapped to missing

X3.74.1.Ao.path.Descending.Segment.Code.4

Erroneous "7" mapped to missing

X3.76.1.Ao.path.Abdominal.Segment.Code.5

"15. Intramural haematoma" mapped to "15. Intramural haematoma"

Aortic Procedures

X3.69.1.Ao.proc.Root.Segment.Code.1

Minor updates to aortic procedure mappings from v3.8 field

X3.71.1.Ao.proc.Ascending.Segment.Code.2

 Minor updates to aortic procedure mappings from v3.8 field

"Reduction aortoplasty" remapped from missing to "10. Reduction aortoplasty"

"Root replacement with preservation of native valve and coronary reimplantation" remapped from

"4. Root replacement with composite valve graft and coronary reimplantation (Modified Bentall or Cabroll)"

to "5. Root replacement with preservation of native valve and coronary reimplantation"

Patching

Major Aortic Patching

Patching no longer applied to X3.91.Aetiology since the affected hospital records are prior to the field introduction in v4.1.2. Instead, the old v3.8 aortic pathology fields are patched, and implemented prior to mapping to X3.91.Aetiology.

Post-patching Mapping

This section has been created to move the cleaning and mapping for some fields to be conducted after the patching section. The cleaning of these fields have also been reordered to ensure that fields are only mapped from other fields that themselves have already been cleaned. This was necessary as a result of the increasing inter-relatedness of between-field mappings conducted to improve the overall data validity.

Cardiac Procedures

Minor updates to cardiac procedure mappings from v3.8 field

Aortic Aetiology

Minor updates due to changes to mapping fields

Multivalued formatting updated to check for errors in field delimitations



Flags

Single Episode Flag

Minor corrections to script that misallocated cases with missing Apollo codes

Previous Operation Flag

Streamlined correction algorithm

Shortcuts

Survival data

Corrections to **time** field that amends mismatches from ONS

2 Variable Cleaning

2.1 Dates

The cleaning script converts date and date-time fields in the NACSA database to a standardized format.

The following date fields are converted to a YYYY-MM-DD format

- **Creation.Date**
- **X2.08.Date.Last.Cardiac.Operation**
- **X2.20.Date.Last.Catheterisation**
- **X3.01.Admission.Date**
- **X3.02.Procedure.Date**
- **X4.06.Discharge.Date**

For the following fields, all dates prior to 1967-01-01 (a proxy date for cardiac surgery in the UK) were set as missing:

- **X2.08.Date.Last.Cardiac.Operation**
- **X2.20.Date.Last.Catheterisation**

For field **X3.02.Procedure.Date** a separate HH:MM time field **X3.02.Procedure.Time** is also generated. For fields **Creation.Date**, **X2.08.Date.Last.Cardiac.Operation** and **X3.01.Admission.Date** the time field is removed due to the high proportion of insufficient and erroneous entries e.g. default values of 00:00 or 00:01.

2.2 Categorical Variables

Categorical variables are selected through drop-down menus and radio button controls. In principle they should be error free but due to historical data, different hospital software, ad hoc record editing and errors at the central repository, errors have inevitably emerged. For the present version (from version 10.0) all corrections are treated as variable specific. Global rules are removed and each observed permutation of error is manually inspected and categorised.

Reasons for cleaning generally fall under one or more of the following categories:

1. Erroneous entries: "n/a" "#N/A" "null" "." "Entry not found" "Not Defined" or equivalent
2. Case sensitivity or spelling e.g.
"0. No Angina" to "0. No angina" for **X2.01.Angina.Status.Pre.Surgery**
3. Text file encoding (such as occurrence of symbols) e.g.
"1. One." to "1. One" **X2.03.N.Previous.MIs**
4. Missing inputs e.g.
"3. 1-30 days" to "3. MI 1-30 days" **X2.04.Interval.between.Surgery.and.last.MI**
5. Extra inputs e.g.
"2. Current smoker within 4 weeks of surgery" to "2. Current smoker" **X2.11.Smoking.Status**
6. Repeated value encoding e.g.
"1. Stenosis;1. Stenosis" to "1. Stenosis" **X3.19.Aortic.Valve.Haemodynamics**
7. Numeric prefix omissions e.g.
"Mechanical" to "2. Mechanical" **X3.23.Aortic.Valve.Explant**

Further corrections or remappings not sufficiently captured by the above are presented for each applicable variable under the appropriate headings below.

**X1.07.Gender**

Set as missing: "0. Not known" "Unknown" "9. Not specified" "0" "1;2." "2;1."

X1.08.Administrative.Category

Set as "1. NHS": "01" "3. NHS" "5. Visitor"

Set as "2. Private": "02"

Set as missing: "3. Amenity" "4. Other" "5. Overseas" "9. Unknown" "[349]" "03"

X2.01.Angina.Status.Pre.Surgery

Set as "0. No angina": "0. CCS 0"

Set as "1. No limitation": "1. CCS 1"

Set as "2. Slight limitation of ordinary activity": "2. CCS 2"

Set as "3. Marked limitation of ordinary physical activity": "3. CCS 3"

Set as "4. Symptoms at rest or minimal activity": "4. CCS 4"

Set as missing: "[59]" "1;2" "2;3" "3;4"

X2.02.Dyspnoea.Status.Pre.Surgery

Set as "1. No limitation of physical activity": "1. NYHA 1"

Set as "2. Slight limitation of ordinary physical activity": "2. NYHA 2"

Set as "3. Marked limitation of ordinary physical activity": "3. NYHA 3"

Set as "4. Symptoms at rest or minimal activity": "4. NYHA 4"

Set as missing: "[09]" "-1." "1001" "1002"

X2.03.N.Previous.MIs

Set as missing: "[347]" "10"

X2.04.Interval.between.Surgery.and.last.MI

Set as "3. MI 1-30 days": "1. MI 1-30 days"

Set as missing: "9" "1; 5" "204_13"

Between-field cleaning: if X2.03.N.Previous.MIs == "0. None", recode missing to "0. No previous MI"

X2.05.Previous.PCI

Set as "0. No previous PCI": "No"

Set as missing: "01/01/1995" "27/12/2007" "9"

X2.09.Diabetes.Management

Set as missing: "[49]" "1002"

X2.10.Hx.of.Hypertension

Set as "9. Unknown": "Unkwn"

Set as missing: "2"

X2.11.Smoking.Status

Set as missing: "[39]"

X2.12.1.Renal.Function.Dialysis

See **Between-Field Mapping** for variable cleaning

**X2.13.Hx.of.Pulmonary.Disease**

Set as "0. No pulmonary disease: "n"

Set as "1. COAD/emphysema or Asthma": "1;1" "1;1;1" "1;2"

OR starting with "1. COAD" or "2. Asthma"

OR containing "COPD" "pneumonia" "mediastinal sarcoidosis" "sleep apnoea" "pleural calcification"
"Pulmonary oedema" "Respiratory failure type 11"

Set as missing: "9. Unknown" "[34LPs]" "0;" "1;0"

OR starting with "0. No pulmonary disease"

X2.16.Hx.of.Neurological.Dysfunction

Set as "0. No": "0. No neurological dysfunction at start of operation."

Set as "1. Yes": "1. Neurological dysfunction at start of operation."

Set as missing: "9. Unknown" "3"

X2.17.Extracardiac.arteriopathy

Set as missing: "9. Unknown" "9" "-1"

X2.18.Pre.operative.heart.rhythm

Set as "2. Complete heart block/pacing": "3. Complete heart block / paced"

Set as "3. Ventricular fibrillation or ventricular tachycardia": "2. History VT / VF in 2 weeks before surgery"

Set as missing: "1;2;4" "1;3"

X2.19.Left.Heart.Catheterisation

Set as "1. Yes": "2" "2. Previous admission" "1. This admission;2. Previous admission"

Set as missing: "3" "99"

OR starting with "0. Never"

X2.21.Extent.of.Coronary.Vessel.Disease

Set as "0. No vessel with >50% diameter stenosis": "0"

Set as "1. One vessel with >50% diameter stenosis": "1"

Set as "2. Two vessels with >50% diameter stenosis": "1. Two vessels with >50% diameter stenosis" "2"

Set as "3. Three vessels with >50% diameter stenosis": "3"

Set as missing: "[456]" "99"

OR containing "0. No vessel with >50% diameter stenosis"

For erroneous multivalued format, those containing multiple are recoded in order:

"3. Three vessels with >50% diameter stenosis"

"2. Two vessels with >50% diameter stenosis"

"1. One vessel with >50% diameter stenosis"

X2.22.Left.Main.Stem.Disease

Set as "0. No LMS disease or LMS disease <= 50% diameter stenosis": "0. 0%" "1. 1-49%"

"0. No LMS disease / LMS disease <51% diameter stenosis"

Set as "1. LMS>50% diameter stenosis": "2. 50-74%" "3. 75-94%" "4. 95-99%" "5. 100%"

Set as missing: "-1" "99"

X2.24.3.Category.of.AVS

Set as "1. Mild": "1"

Set as "2. Moderate": "1. Moderate" "2"

Set as "3. Severe": "3"

Set as missing: "[04]"

**X2.28.IV.Ejection.Fraction.Category**

Set as "1. Good (LVEF > 50%)": "1. Good (LVEF >= 50%)"

Set as "2. Fair (LVEF 30-50%)": "2. Fair (LVEF 30-49%)"

Set as missing: "[045]"

X2.29.IV.Nitrates

Set as "1. Yes": "1. Within one week of operation" "2. Within one week of operation" "2"

Set as missing: "2. Within one week of 1. Until operation" "11"

X2.30.Cardiogenic.Shock.Preop

Set as missing: "[-9]"

X2.31.IV.Inotropes

Set as missing: "9"

X2.31.IV.Inotropes

No cleaning needed

X2.35.Operative.Urgency

Set as missing: "9" "56" "65" "97" "100"

For valve haemodynamics variables:

- X3.19.Aortic.Valve.Haemodynamics
- X3.20.Mitral.Valve.Haemodynamics
- X3.21.Tricuspid.Valve.Haemodynamics
- X3.22.Pulmonary.Valve.Haemodynamics

Set as "3. Mixed": containing "3. Mixed" or both "1. Stenosis" and "2. Regurgitation"

Set as missing: "Ammallah. Dr" "3612419" "4266998" "[045]" "0;0" "11" "13" "21" "22"

X3.23.Aortic.Valve.Explant

Set as "6. Prior Repair": "6. Ring"

Set as "7. Other": "7" "Other"

Set as missing: containing "1. Native valve" and either "2. Mechanical" or "3. Biological"

See **Patching** for further variable cleaning

X3.24.Mitral.Valve.Explant

Set as "1. Native valve": "N"

Set as "4. Homograft": "4"

Set as "5. Autograft": "5"

Set as "6. Prior repair": "6. Ring" "R" "1. Native valve;6. Ring"

Set as missing: "0"

OR containing "1. Native valve" and either "2. Mechanical" or "3. Biological"

See **Patching** for further variable cleaning

X3.25.Tricuspid.Valve.Explant

Set as "3. Biological": "3. Repair with ring"

Set as "6. Ring": "6. Prior repair"

Set as missing: "0" "Autograft" "7. Inspection"

See **Patching** for further variable cleaning

**X3.26.Pulmonary.Valve.Explant**

Set as missing: "0" "Prior repair"

See **Patching** for further variable cleaning

X3.43.Aortic.Valve.Procedure

Set as "2. Repair": "2"

Set as "5. Isolated commissurotomy": "Isolated commissurotomy"

Set as missing: "0. None" "0" "11" "111"

OR containing "1. Replacement" and "2. Repair"

X3.44.Mitral.Valve.Procedure

Set as "2. Repair": "2"

Set as "5. Isolated commissurotomy": "Isolated commissurotomy"

Set as missing: "[0r]" "33"

OR containing "1. Replacement" and "2. Repair"

X3.45.Tricuspid.Valve.Procedure

Set as "2. Repair": "2"

Set as missing: "Isolated commissurotomy" "Repair with ringReplacement" "0"

OR containing "1. Replacement" and "2. Repair"

X3.46.Pulmonary.Valve.Procedure

Set as missing: "repair" "01-Jan-00" "0"

X3.47.Aortic.Valve.Implant.Type

Set as "2. Mechanical": "M" "1. Mechanical" "MechanicalBiological"

Set as "3. Biological": "B" "1. Tissue" "Pericardial" "Bioprosthesis"

Set as "4. Homograft": "H" "HomograftBiological"

Set as missing: "5. Annuloplasty" "6. Annuloplasty (ring)" "7. Annuloplasty (no ring)" "Other"

Set as missing: "[01679]" "22" "33" "333" "44"

OR containing "0. None" or "3. Biological" and either "2. Mechanical" or "5. Annuloplasty ring"

X3.48.Mitral.Valve.Implant.Type

Set as "2. Mechanical": "M" or "2. Mechanical" and "6. Annuloplasty ring"

Set as "3. Biological": "B" "1. Tissue"

Set as "6. Annuloplasty ring": "A"

Set as "7. Other": "4. Homograft" "4. Homograft; 3. Biological" "Other" "[457]"

Set as missing: "7. Annuloplasty (no ring)" "Autograft" "0. None" "Suture" "[01rR]" "66"

OR containing "6. Annuloplasty ring" or "2. Mechanical" and "3. Biological"

X3.49.Tricuspid.Valve.Implant.Type

Set as "2. Mechanical": "M"

Set as "3. Biological": "B"

Set as "4. Homograft": "H"

Set as "6. Annuloplasty ring": "5. Annuloplasty ring"

Set as "7. Other": "7. Annuloplasty (no ring)"

Set as missing: "Valve Type (T)" "Annuloplasty ringBiological" "0. None" "[015]"

OR containing "2. Mechanical" and "3. Biological"



X3.50.Pulmonary.Valve.Implant.Type

Set as "7. Other": "7" "7. Annuoplasty (no ring)"
Set as missing: "Valve Type (P)" "0. None" "[016]"

X3.78.Cardiopulmonary.bypass

Set as "0. No": "1. No" Set as missing: erroneous numerical entries

X3.79.Myocardial.Protection

Set as missing: "2"

X3.80.Cardioplegia.solution

Set as "8. Not applicable": "8"
Set as missing: "[03]" "1; 2" "2;1"

X3.83.Cardioplegia.timing

Set as "1. Intermittent": "Intermittent;Continuous" "2. Intermittent"
Set as "8. Not applicable": "8"
Set as missing: "0" "1; 2" "53"

X3.84.Non.cardioplegic.protection

Set as "5. Beating heart without cross clamp": "Beating heart + perfusion" "Beating Heart with perfusion"
Set as missing: "Cerebral perfusion" "0. Not applicable" "[06]" "99" "1;2" "1;4"
"1;5"

X4.01.1.Deep.Sternal.wound.infection

Set as "0. None": "0. No" Set as missing: "2" "8"

X4.01.2.Deep.Sternal.wound.infection.treatment

Set as missing: "[0489]" "1;2"

X4.03.Post.Op.Dialysis

Set as "0. No": "0 No > creatinine" "0 No; Trancient renal failur; full recovery"
"Chronic renal (on dialysis preop)"
Set as "1. Yes": "1 Yes cvvh" "1 Yes (cvvh)"
Set as missing: "5" "10" "99"

X4.04.Discharge.Destination

Set as missing: "3 Other ward" "5. Transferred to different Consultant" "Another dept within the trust"
"Second op" "[05789]"

X4.05.Status.at.Discharge

No cleaning needed

2.3 Multivalued Variables

Multivalued variables, as with the previous categorical variables are also selected through drop-down menus and radio button controls. However, in contrast the input allows multiple options to be selected, with each selected option delimited by ';' in the output. The cleaning process for the categorical variables is repeated for each selected option, but additionally the selected options are reordered and duplicates removed, with extra care taken to check for erroneous delimitation.

This applies to the following fields:

- X2.07.Previous.Surgical.Interventions
- X2.14.Hx.of.Neurological.Disease
- X3.35.Reason.Repeat.aortic.valve.replacement
- X3.36.Reason.Repeat.Mitral.valve.replacement
- X3.37.Reason.Repeat.Tricuspid.valve.replacement
- X3.38.Reason.Repeat.Pulmonary.valve.replacement
- X3.81.Cardioplegia.temperature
- X3.82.Cardioplegia.infusion.mode
- X3.90.Presentation
- X3.95.Neuroprotection
- X4.01.Return.to.Theatre
- X4.02.New.CVA

Further corrections or remappings beyond the core categorical variable cleaning are presented for each applicable variable under the appropriate headings below.

X2.07.Previous.Surgical.Interventions

Mapping values within-variable from V3.8 sub-set to missing: "6. Aortic surgery - descending or abdominal"
"7. Other thoracic" "8. Carotid endarterectomy" "9. Other peripheral vascular"

X2.14.Hx.of.Neurological.Disease

Set as "0. No history of neurological disease": "0. No history of Cerebrovascular disease"

Set as missing: "[4AeEnP]"

OR containing either "0. No history of Cerebrovascular disease" or "0. No history of neurological disease" and another variable

X3.27.Native.Aortic.Valve.Path

Set as "2. Degenerative inc Calcific degeneration": "2. Degenerative" "7. Calcific degeneration" "7" "14 - other degenerative disease"

Set as "6. Annuloaortic ectasia": "13 - Annuloaortic ectasia"

Set as "19. Other native valve pathology": "15 - dissection"

Set as missing: "12" "22"

See **Patching** for further variable cleaning

X3.28.Native.Mitral.Valve.Path

Set as "2. Degenerative": "2. Degenerative inc Calcific degeneration"

Set as "7. Calcific degeneration": "7"

Set as missing: "22"

See **Patching** for further variable cleaning

X3.29.Native.Tricuspid.Valve.Path

Set as "7. Calcific degeneration": "7"

See **Patching** for further variable cleaning

**X3.30.Native.Pulmonary.Valve.Path**

Set as "7. Calcific degeneration": "7"

See **Patching** for further variable cleaning

X3.35.Reason.Repeat.aortic.valve.replacement

Set as "2. Dehiscence;4. Infection": "2;4"

Set as "5. Implanted valve failure": "5. Intrinsic valve failure"

Set as "19. Other reason": "6. Other"

Set as missing: "0. Not applicable" "[0]" "7. Unknown"

X3.36.Reason.Repeat.Mitral.valve.replacement

Set as "1. Thrombosis": "1. Thrombosis"

Set as "2. Dehiscence;19. Other reason": "2;19"

Set as "4. Infection;19. Other reason": "4;19"

Set as "5. Implanted valve failure;19. Other reason": "5;19"

Set as "5. Implanted valve failure": "5. Intrinsic valve failure"

Set as missing: "0. Not applicable" "[08MRr]" "99" "1919"

X3.37.Reason.Repeat.Tricuspid.valve.replacement

Set as "5. Implanted valve failure": "5. Intrinsic valve failure"

Set as missing: "0. Not applicable" "0"

X3.38.Reason.Repeat.Pulmonary.valve.replacement

Set as "4. Infection": "4. Infection;7. Prior valve repair failure"

Set as "4. Infection;5. Implanted valve failure": "4;5"

Set as "5. Implanted valve failure": "5. Intrinsic valve failure"

Set as "5. Implanted valve failure;19. Other reason": "5;19"

Set as missing: "0. Not applicable" "7. Prior valve repair failure" "[07]"

X3.81.Cardioplegia.temperature

Set as "1. Cold": "2. Cold" "1. Cold;8. Not applicable"

Set as "2. Warm": "1. Warm" "2. Warm;8. Not applicable"

Set as "1. Cold;2. Warm": containing "1. Cold;2. Warm;8. Not applicable"

Set as "8. Not applicable": "8"

Set as missing: "[03]"

X3.82.Cardioplegia.infusion.mode

Set as "1. Antegrade": "1. Antegrade;8" "1. Antegrade;down grafts" "1. Antegrade;8. Not applicable"

Set as "1. Antegrade;2. Retrograde": "1. Antegrade;2. Retrograde;down grafts" "3. Antegrade and retrograde"

"1. Antegrade;2. Retrograde;8. Not applicable" "Antegrade and Retrog"

Set as "2. Retrograde": "2. Retrograde;down grafts" "2. Retrograde;8. Not applicable"

Set as "8. Not applicable": "8"

Set as missing: "Down grafts" "Down ostia" "[03]" "1004"

X3.90.Presentation

Standard multivalued formatting only

X3.95.Neuroprotection

Set as "1. Deep Hypothermic Circulatory Arrest": "0. None required;1. Deep Hypothermic Circulatory Arrest"

Set as missing: 2-3 digit numbers



X4.01.Return.to.Theatre

Set as "0. No re-operation necessary": "0. No re-operation required" "0. No" "0. None" "00"

Set as "1. Re-operation for bleeding or tamponade": "1. Re-operation for bleeding"

Set as "2. Re-operation for valvular problems": "2. Other (exclusive of sternal resuturing)"

Set as "4. Re-operation for other cardiac problems": "LVAD"

Set as "6. Surgery for deep sternal wound problem": "Surgery for deep sternal wound infection" "Debride"
"excision of sternal sinus"

Set as missing: containing "0. No re-operation necessary" and another variable

X4.02.New.CVA

Set as "0. None": "0. No" "0 No"

Set as "2. Permanent": "Left Sided Weakness"

Set as missing: "0;2" "99" "0 No TIA"

OR containing "0. None"

2.4 Numerical Variables

Numerical variables herein are those that are defined as either numeric or integer variables after cleaning. The cleaning has generally occurred in the direction: string -> numeric -> integer.

For fields originally stored as strings, entries with non-numerical symbols are evaluated as strings first. Methods such as character removal, imputation or parsing/evaluation are then undertaken, prior to converting the field class.

As numeric fields, some may need to be rescaled. For example, "X2.37.Height", which may be stored as m, cm or mm, requires appropriate rescaling to allow equivalent comparisons.

Converting to integers either involves variable rounding or truncation. By default rounding is applied unless the metric of interest is to be evaluated as > than a criterion. For example, "Age.at.operation" whereby > 18 is an important consideration.

Those stored as numeric values:

- X2.12.0.Actual.Creatinine.at.time.of.Surgery
- X2.24.1.Severity.of.AVS.EOA
- X2.24.2.Severity.of.AVS.Gradient
- X2.38.Weight

Those stored as integer values:

- Age.at.operation
- X2.23.PA.Systolic
- X2.27.Ejection.Fraction
- X2.36.N.Previous.Heart.Operations
- X2.37.Height
- X3.14.NGrafts
- X3.18.NValves.Repaired.Replaced
- X3.54.Aortic.valve.or.ring.size
- X3.58.Mitral.valve.or.ring.size
- X3.62.Tricuspid.valve.or.ring.size
- X3.66.Pulmonary.valve.or.ring.size
- X3.67.N.Aortic.Segments.operated.on
- X3.85.Cumulative.Bypass.time
- X3.86.Cumulative.cross.clamp.time
- X3.87.Circulatory.arrest.time

Variable cleaning is presented for each applicable variable under the appropriate headings below.



Age.at.operation

Values < -5 are increased by 100
Values <= 0 or > 105 are set as missing
Variable truncated and converted from numerical to integers

X2.12.0.Actual.Creatinine.at.time.of.Surgery

See **Between-Field Mapping** for variable cleaning

X2.23.PA.Systolic

Values containing "MM" or "<" are removed
Variable converted from string to integers
Values > 200 are set as missing
Patching: records at Morriston Hospital for procedure dates prior to 2006-04-01 are set as missing

X2.24.1.Severity.of.AVS.EOA

Values < 0.1 or > 6 are set as missing

X2.24.2.Severity.of.AVS.Gradient

See **Between-Field Mapping** for variable cleaning

X2.27.Ejection.Fraction

Values containing "-" "%" "<" or ">" are removed
Variable converted from string to integers
Values < 10 or > 99 are set as missing

X2.36.N.Previous.Heart.Operations

Variable converted from string to integers
Values > 6 are set as missing

X2.37.Height

Values of "False" set as missing
Variable converted from string to numerical
Values between > 1.4 and < 2.2 are multiplied by 100
Values between > 12000 and < 22000 are divided by 100
Variable converted from numerical to integers
Values < 107 or > 250 are set as missing

X2.38.Weight

Variable converted from string to numerical
Values < 25 or > 250 are set as missing
Variable rounded to 1 dp

X3.14.NGrafts

See **Between-Field Mapping** for variable cleaning

X3.18.NValves.Repaired.Replaced

Values > 4 are set as missing

**For valve or ring size variables:**

- X3.54.Aortic.valve.or.ring.size
- X3.58.Mitral.valve.or.ring.size
- X3.62.Tricuspid.valve.or.ring.size
- X3.66.Pulmonary.valve.or.ring.size

Values containing “-” “.” “/” “;” space or alphabetical characters are removed

Variable converted from string to integers

Values < 16 or > 40 are set as missing

X3.67.N.Aortic.Segments.operated.on

Values containing non-digit characters are removed

Variable converted from string to integers

Values < 5 are set as missing

X3.85.Cumulative.Bypass.time

Values containing “-” are removed

Values containing equations are parsed and evaluated

Variable converted from string to integer

Values > 10080 are set as missing

X3.86.Cumulative.cross.clamp.time

Set as missing: “1;2”

Variable converted from string to integer

Values < 0 or > 360 are set as missing

X3.87.Circulatory.arrest.time

Values > 240 are set as missing Variable converted from numeric to integer

2.5 Free Text Variables

Free text fields at present are only minimally cleaned, and restricted to the standardization of ‘Not specified’ options. To harmonise output, all fields have been transformed to uppercase characters. This applies to the following fields:

- X3.31.Native.Aortic.valve.other.path
- X3.32.Native.Mitral.valve.other.path
- X3.33.Native.Tricuspid.valve.other.path
- X3.34.Native.Pulmonary.valve.other.path
- X3.39.Other.Reason.for.Repeat.Aortic.Valve.Replacement
- X3.40.Other.Reason.for.Repeat.Mitral.Valve.Replacement
- X3.41.Other.Reason.for.Repeat.Tricuspid.Valve.Replacement
- X3.42.Other.Reason.for.Repeat.Pulmonary.Valve.Replacement

Cleaning of these fields is subject to review, with comprehensive mapping of options to be completed for a subsequent update.



2.6 Surgeon Data

Surgeon variables have previously been documented according to their corresponding class of variable. However, for clarity these have been split out to better highlight these fields and the cleaning implemented.

X3.03.Responsible.Consultant.Surgeon

All input recorded as surgeon names are converted to GMC numbers.

Additional remapping from initials are conducted after co-ordinating with hospitals.

Set as "0602828": "2641315"

Set as "2733526": "2733521"

Set as "2800752": "C28006752"

Set as "3136168": "3131618"

Set as "3226274": "C32262"

Set as "3246515": "32465151"

Set as "3279753": "327953"

Set as "3467822": "3431681"

Set as "4120771": "41207701"

Set as "7090362": "7030362"

Set as missing: "General Surgeon" "Other" "John Keates" "Mr Clyde Saldanha" "Prof M Thompson"
"xas" "04H04610"

X3.06.First.Operator.Grade

Set as missing: "[0468]" "36" "41" "46" "57" "70" "97" "2. Staff grade/Clinical Assistant" "4. SpR"
"6. Associate specialist"

OR seven digit numbers representing GMC numbers

Set as "9. Other": "7. Surgeon's assistant"

X3.07.First.Operator.Calman.Year

Set as missing: "0" "99" "0. Not applicable" "9. Not applicable"

OR initials representing surgeons' names

Set as "6. Year 6 and above": "6. Year 6"

X3.09.First.Assistant.Grade

Set as missing: "[48]" "36" "41" "46" "50" "57" "58" "70" "97" "99" "2. Staff grade/Clinical Assistant"

OR seven digit numbers representing GMC numbers

Set as "3. SpR": "4. SpR" "6. Associate specialist"

X3.10.First.Assistant.Calman.Year

Set as missing: "[07]" "99" "9. Not applicable"

OR initials representing surgeons' names

Set as "6. Year 6 and above": "6. Year 6"

3 Between-Field Mapping

The mapping phase of cleaning involves taking values from one or more fields and using that information to improve the utility or validity of subsequent fields. Notably, this is particularly pertinent for information contained in old v3.8 database fields that are recorded in a different format after subsequent modifications to the database. Due to the complexity of some of these mappings, associated fields are cleaned and mapped together. These are presented below under the following sections:

- **Renal Function**
- **Aortic Valve Gradient**
- **Intra-Aortic Balloon Pump**
- **Grafts**
- **Aortic Pathologies**
- **Aortic Procedures**

The specific sequence for each mapping proceeds as outlined accordingly.

3.1 Renal Function

Mapping from old v3.8 field X2.12.Renal to new v4.1.2 fields:

- X2.12.0.Actual.Creatinine.at.time.of.Surgery
- X2.12.1.Renal.Function.Dialysis

1. X2.12.1.Renal.Function.Dialysis (Cleaning)

Set as missing: “[49]” “[12];[2349]”

Set as “0. None”: “0;”

Set as “1. Dialysis for acute renal failure: onset within 6 weeks of cardiac surgery”: “1;”

Set as “2. Dialysis for chronic renal failure: onset more than 6 weeks prior to cardiac surgery”: “2;”

Set as “3. No dialysis but pre-operative acute renal failure (anuria or oliguria > 10ml/hour)”: “3;”

2. Mapping from X2.12.Renal defined as when BOTH X2.12.0.Actual.Creatinine.at.time.of.Surgery AND X2.12.1.Renal.Function.Dialysis are missing

3. X2.12.1.Renal.Function.Dialysis (Mapping)

Set as “0. None”, mapped values: “0. No renal disease” “1. Functioning transplant”

Set as “1. Dialysis for acute renal failure: onset within 6 weeks of cardiac surgery”, mapped values: “3. Dialysis for acute renal failure”

Set as “2. Dialysis for chronic renal failure: onset more than 6 weeks prior to cardiac surgery”, mapped values: “4. Dialysis for chronic renal failure”

4. X2.12.0.Actual.Creatinine.at.time.of.Surgery (Cleaning/Mapping)

Set as “80”, original and mapped values: “0. No renal disease” “1. Functioning transplant”

Set as “250”, original and mapped values: “2. Creatinine” “3. Dialysis for acute renal failure” “4. Dialysis for chronic renal failure”

3.2 Aortic Valve Gradient

Mapping from old v3.8 field X2.24.Aortic.Valve.Gradient to new v4.1.2 field:

- X2.24.2.Severity.of.AVS.Gradient

1. Mapping from X2.24.Aortic.Valve.Gradient defined as when X2.24.2.Severity.of.AVS.Gradient is missing

2. Patching: no mapping from X2.24.Aortic.Valve.Gradient entries for Papworth Hospital due to erroneous entries



3. X2.24.2.Severity.of.AVS.Gradient (Cleaning/Mapping)

Set as missing, original and mapped values: < 15 OR > 200

3.3 Intra-Aortic Balloon Pump

The intra-aortic balloon pump fields have proved to be particularly problematic, with errors evident in the transition to the new v4.1.2 fields. Consequently, the original v3.8 fields X2.33.Intra.aortic.balloon.pump.used and X2.34.Reason.for.IABP.Use are mapped to the new v4.1.2 fields, and these themselves are then mapped to a new restricted set:

- X2.33.0.Intra.aortic.balloon.pump.used
- X2.33.1.Impeller.device.used
- X2.33.2.Ventricular.assist.device.used
- X2.33.3.Other.Support.device.used
- X2.34.0.IABP.Ind
- X2.34.1.Impeller.Ind
- X2.34.2.Ventricular.Ind
- X2.34.3.Other.Ind

The original v4.1.2 fields comprised 3 sub-categories for each of the above to indicate whether the device was used pre-op, intra-op or post-op. However, erroneous options were provided that resulted in conflicting output.

X2.33.0.Intra.aortic.balloon.pump.used

Concatenate v3.8 field X2.33.Intra.aortic.balloon.pump.used and pre-op, intraop and post-op v4.1.2 fields

Clean derived concatenation according to standard multivalued procedure, with four options: "0. No"

"1. Pre-operation" "2. Intra-operation" "3. Post-operation"

Set as missing: containing "0. No" and another option

X2.33.1.Impeller.device.used

Concatenate pre-op, intraop and post-op v4.1.2 fields

Clean derived concatenation according to standard multivalued procedure, with three options:

"1. Pre-operation" "2. Intra-operation" "3. Post-operation"

X2.33.2.Ventricular.assist.device.used

Concatenate pre-op, intraop and post-op v4.1.2 fields

Clean derived concatenation according to standard multivalued procedure, with three options:

"1. Pre-operation" "2. Intra-operation" "3. Post-operation"

X2.33.3.Other.Support.device.used

Concatenate pre-op, intraop and post-op v4.1.2 fields

Clean derived concatenation according to standard multivalued procedure, with three options:

"1. Pre-operation" "2. Intra-operation" "3. Post-operation"

X2.34.0.IABP.Ind

Directly mapped from v4.1.2 field X2.34.0.1.IABP.Ind.Preop

If X2.34.0.IABP.Ind missing, mapped from v3.8 field X2.34.Reason.for.IABP.Use

X2.34.1.Impeller.Ind

Directly mapped from only v4.1.2 field X2.34.1.1.Impeller.Ind.Preop

X2.34.2.Ventricular.Ind

Directly mapped from only v4.1.2 field X2.34.2.1.Ventricular.Ind.Preop

X2.34.3.Other.Ind

Directly mapped from only v4.1.2 field X2.34.3.1.Other.Ind.Preop

3.4 Grafts

A validation mapping is conducted from v4.1.2 field X3.14.NGrafts to the v4.1.2 fields:

- X3.15.Graft.site
- X3.16.Graft.conduit
- X3.17.Graft.Anastomoses

Notably, for the mapped fields the input is multivalued but both the order and repeat entries of the same option are valid. Problematically, many of the delimiters are omitted from the output. As a consequence, a new method of cleaning is applied, whereby recognised valid entries are cleaned by reference to their position, in an iterative manner, and redelimited. The exact procedure is omitted from the document due to the length and complexity. The cleaning of this section is subject to review.

X3.14.NGrafts

Variable converted from string to integers

Values > 11 are set as missing

3.5 Aortic Pathologies

Mapping from old v3.8 fields to new v4.1.2 fields:

- X3.68.Aortic.pathology.Root to X3.68.1.Ao.path.Root.Segment.Code.1
- X3.70.Aortic.pathology.Ascending to X3.70.1.Ao.path.Ascending.Segment.Code.2
- X3.72.Aortic.pathology.Arch to X3.72.1.Ao.path.Arch.Segment.Code.3
- X3.74.Aortic.pathology.Desc to X3.74.1.Ao.path.Descending.Segment.Code.4
- X3.76.Aortic.pathology.Abd to X3.76.1.Ao.path.Abdominal.Segment.Code.5

Mapping rules for v3.8 Aortic pathology fields:

- "2. Syphilis" to "1. Aneurysm"
- If X2.35.Operative.Urgency recorded as "1. Elective"
 - "3. Dissection" to "2. Chronic Dissection"
- If X2.35.Operative.Urgency recorded as "2. Urgent" "3. Emergency" "4. Salvage"
 - "3. Dissection" to "3. Acute Dissection"
- If X2.35.Operative.Urgency is missing
 - "3. Dissection" to "99. Other"
- "4. Transection" to "4. Trauma"
- "5. Coarctation" to "99. Other"
- "6. Atheromatous" to "99. Other"
- "7. Marfan's" to "99. Other"
- "9. Mycotic" to "99. Other"
- "10. Other connective tissue disorder" to "99. Other"
- "11. Congenital" to "99. Other"
- "12. Infection - native" to "99. Other"
- "13. Infection - graft" to "99. Other"
- "99. Unknown" to "99. Other"

**X3.68.1.Ao.path.Root.Segment.Code.1**

Set as missing: “[05789]” “13”

Set as “16. Normal”: “161616”

Set as “16. Normal;99. Other”: “1699”

Set as “99. Other”: “10” “11” “9999”

If **X3.68.1.Ao.path.Root.Segment.Code.1** missing, mapped from v3.8 X3.68.Aortic.pathology.Root

Multivalue formatting

X3.70.1.Ao.path.Ascending.Segment.Code.2

Set as missing: “5” “22” “31” “33”

Set as “99. Other”: “[789]” “10” “11” “13”

If **X3.70.1.Ao.path.Ascending.Segment.Code.2** missing, mapped from v3.8 X3.70.Aortic.pathology.Ascending

Multivalue formatting

X3.72.1.Ao.path.Arch.Segment.Code.3

Set as missing: “11” “16” “16. Normal”

If **X3.72.1.Ao.path.Arch.Segment.Code.3** missing, mapped from v3.8 X3.72.Aortic.pathology.Arch

Multivalue formatting

X3.74.1.Ao.path.Descending.Segment.Code.4

Set as missing: “7” “16” “16. Normal”

Set as “99. Other”: “11”

If **X3.74.1.Ao.path.Descending.Segment.Code.4** missing, mapped from v3.8 X3.74.Aortic.pathology.Desc

Multivalue formatting

X3.76.1.Ao.path.Abdominal.Segment.Code.5

Set as missing: “16” “16. Normal”

Set as “3. Acute Dissection”: “3. Dissection”

If **X3.76.1.Ao.path.Abdominal.Segment.Code.5** missing, mapped from v3.8 X3.76.Aortic.pathology.Abd

Multivalue formatting

3.6 Aortic Procedures

Mapping from old v3.8 fields to new v4.1.2 fields:

- X3.69.Aortic.Procedure.Root to **X3.69.1.Ao.proc.Root.Segment.Code.1**
- X3.71.Aortic.Procedure.Ascending to **X3.71.1.Ao.proc.Ascending.Segment.Code.2**
- X3.73.Aortic.Procedure.Arch to **X3.73.1.Ao.proc.Arch.Segment.Code.3**
- X3.75.Aortic.Procedure.Desc to **X3.75.1.Ao.proc.Descending.Segment.Code.4**
- X3.77.Aortic.Procedure.Abd to **X3.77.1.Ao.proc.Abdominal.Segment.Code.5**

1. X3.69.1.Ao.proc.Root.Segment.Code.1 (Cleaning)

Set as “4. Root replacement with composite valve graft and coronary reimplantation (Modified Bentall or Cabroll)”: “4;”

Set as “5. Root replacement with preservation of native valve and coronary reimplantation”: “5;”

Set as “6. Homograft root replacement”: “6;”

Set as “9. Sinus of Valsalva repair”: “Sinus of Valsalva repairInterposition tube graft with/without extension into the arch” “9;”

Set as missing: “Aortic patch graft” “Interposition tube graft with/without extension into the arch”

“Tube graft + separate AVR” “Interposition tube graft with reimplantation of major vessels”

“Reduction aortoplasty” “B2040965A” “b062162” “[1238]” “10” “12” “44” “46” “99” “1;2;3;” “1;99;”

“3;99;”

**2. X3.71.1.Ao.proc.Ascending.Segment.Code.2 (Cleaning)**

Set as "1. Interposition tube graft with/without extension into the arch": "Interposition tube graft with reimplantation of major vessels" "1;"

Set as "3. Tube graft + separate AVR": "Tube graft + separate AVR" "Interposition tube graft with/without extension into the arch" "3. Tube graft + separate AVR" "3;"

Set as "4. Root replacement with composite valve graft and coronary reimplantation (Modified Bentall or Cabroll)": "4;"

Set as "5. Root replacement with preservation of native valve and coronary reimplantation": "5;"

Set as missing: "Sinus of Valsalva repair" "[02]" "99"

3. X3.71.1.Ao.proc.Ascending.Segment.Code.2 (Mapping)

If X3.71.1.Ao.proc.Ascending.Segment.Code.2 missing, map "10. Reduction aortoplasty" from X3.69.1.Ao.proc.Root.Segment.Code.1

4. X3.69.1.Ao.proc.Root.Segment.Code.1 (Mapping)

If X3.69.1.Ao.proc.Root.Segment.Code.1 missing, map "4. Root replacement with composite valve graft and coronary reimplantation (Modified Bentall or Cabroll)" "5. Root replacement with preservation of native valve and coronary reimplantation" "6. Homograft root replacement" from X3.71.1.Ao.proc.Ascending.Segment.Code.2

If X3.69.1.Ao.proc.Root.Segment.Code.1 == "10. Reduction aortoplasty", set as missing

X3.73.1.Ao.proc.Arch.Segment.Code.3

Set as "2. Interposition tube graft with reimplantation of major vessels": "Interposition tube graft with/without extension into the arch" "2;"

Set as missing: "[1345]" "99"

X3.75.1.Ao.proc.Descending.Segment.Code.4

Set as "1. Interposition tube graft": "Interposition tube graft with reimplantation of major vessels" "Interposition tube graft with/without extension into the arch" "1;"

Set as "11. Concomitant endovascular aortic procedure": "Concomitant endovascular aortic procedure" "Interposition tube graft with/without extension into the arch"

Set as missing: "Tube graft + separate AVR" "Reduction aortoplasty" "2" "4" "6" "99"

X3.77.1.Ao.proc.Abdominal.Segment.Code.5

Set as "1. Interposition tube graft": "Interposition tube graft with/without extension into the arch"

Set as missing: "Aortic patch graft" "Tube graft + separate AVR"

4 Patching

Obvious database record errors that were isolated to one particular hospital and / or one particular time period were 'patched' pending a resolution at the trust-level or central database repository. In these cases, trusts were contacted directly. In principle these patches can be removed from the cleaning scripts after confirmation of amendments at the source level. CSV files are written out for each 'patch' for review by NICOR and hospital units.

4.1 Major Aortic Patching

Affected records: "St. Thomas' Hospital" for procedure dates before "2002-12-31".

Field affected:

- X3.68.1.Ao.path.Root.Segment.Code.1
- X3.70.1.Ao.path.Ascending.Segment.Code.2
- X3.72.1.Ao.path.Arch.Segment.Code.3
- X3.74.1.Ao.path.Descending.Segment.Code.4
- X3.76.1.Ao.path.Abdominal.Segment.Code.5
- X3.69.1.Ao.proc.Root.Segment.Code.1
- X3.71.1.Ao.proc.Ascending.Segment.Code.2
- X3.73.1.Ao.proc.Arch.Segment.Code.3
- X3.75.1.Ao.proc.Descending.Segment.Code.4
- X3.77.1.Ao.proc.Abdominal.Segment.Code.5
- Old v3.8 aortic pathology fields subsequently mapped to X3.91.Aetiology

Error: all records indicate major aortic surgery (on all 5 segments). Patients are recorded as having an interposition tube graft for an aneurysm in the root, ascending, arch and descending segments, and a dissection in the abdominal segment.

Resolution: all records where X3.67.N.Aortic.Segments.operated.on was recorded as zero AND X3.13.Other.thoracic.and.vascular.procedures does not contain "1. Aortic or peripheral vascular", has the corresponding procedure and pathology fields wiped.

4.2 Native Valve Patching

Affected records: "Liverpool Heart and Chest Hospital" and "Papworth Hospital" for all procedure dates.

Fields affected:

- X3.23.Aortic.Valve.Explant
- X3.24.Mitral.Valve.Explant
- X3.25.Tricuspid.Valve.Explant
- X3.26.Pulmonary.Valve.Explant

Error: for any valve(s) having undergone a cardiac operation, the explant field of (some) valves not operated on were recorded as 'Native valve'. There was no other evidence these valves were operated on. In many cases it made it look as if patients had received quadruple valve surgery. This is likely to be a software malfunction at the base hospitals.

Notes: this only seems to affect pre-2009 data.

Affected records: "Liverpool Heart and Chest Hospital", "Papworth Hospital" and "St. Thomas' Hospital" for all procedure dates.



Fields affected:

- X3.27.Native.Aortic.Valve.Path
- X3.28.Native.Mitral.Valve.Path
- X3.29.Native.Tricuspid.Valve.Path
- X3.30.Native.Pulmonary.Valve.Path

Error: for any valve(s) having undergone a cardiac operation, the native valve pathology of the valves not operated on was recorded as '0. Native valve not present' or '19. Other valve pathology'. This is likely to be a software malfunction at the base hospital.

Notes: St. Thomas' were aware of this issue for 2008-04-01 to 2011-03-31 period after previous data validation exercises and subsequently resolved the issues. No attempt to revise previous and / or future records has been made.

Resolution: Separate patches were created for associated Aortic, Mitral, Tricuspid and Pulmonary valve fields. These flag if a valid entry is present in any of the associated fields: haemodynamics, reason for repeat replacement, procedure, implant type, prosthesis name, prosthesis model or ring size. Furthermore if uncleaned explant field is NOT missing or "1. Native valve", and if uncleaned pathology field is NOT missing, "0. Native valve not present" or "19. Other native valve pathology".

For the Explant fields at the affected hospitals, the records were set as missing if the above patch was FALSE, AND if the valve specific explant field was set as "1. Native valve"

For the Pathology fields at the affected hospitals, the records were set as missing if the above patch was FALSE, AND if the valve specific pathology field was set as "0. Native valve not present" or "19. Other native valve pathology"

5 Post-patching Mapping

This section has been created to move the cleaning and mapping for some fields to be conducted after the patching section. The cleaning of these fields have also been reordered to ensure that fields are only mapped from other fields that themselves have already been cleaned. This was necessary as a result of the increasing inter-relatedness of between-field mappings conducted to improve the overall data validity.

- **Cardiac Procedures**
- **Other Cardiac Procedures**
- **Aortic Aetiology**

5.1 Cardiac Procedures

Mapping from old v3.8 field `X3.11.Cardiac.Procedures` to fields:

- `X3.11.1.CABG`
- `X3.11.2.Valve`
- `X3.11.3.Major.aortic`

`X3.11.3.Major.aortic` requires further mapping from:

- Cleaned aortic pathology and procedure fields
- `X3.13.Other.thoracic.and.vascular.procedures`
- `X3.67.N.Aortic.segments.operated.on`

1. Mapping from `X3.11.Cardiac.Procedures` when associated fields are missing

2. `X3.11.1.CABG` (Mapping)

Set as "0. No", mapped values: "5. Valve alone" "6. Valve + other" "8. Other"

Set as "1. Yes", mapped values: "1. Yes" "1. CABG alone" "2. CABG + valve" "3. CABG + valve + other" "4. CABG + other"

3. `X3.11.2.Valve` (Mapping)

Set as "0. No", mapped values: "1. Yes" "1. CABG alone" "4. CABG + other" "8. Other"

Set as "1. Yes", mapped values: "2. CABG + valve" "3. CABG + valve + other" "5. Valve alone" "6. Valve + other"

4. `X3.11.3.Major.aortic` (Mapping)

If any aortic pathology or procedure recorded as not missing, set missing to "1. Yes"

If `X3.13.Other.thoracic.and.vascular.procedures` is missing or "1. Aortic or peripheral vascular"

AND `X3.67.N.Aortic.Segments.operated.on` > 0, set missing to "1. Yes"

Set as "0. No", mapped values: "1. Yes" "1. CABG alone" "2. CABG + valve" "3. CABG + valve + other" "4. CABG + other" "5. Valve alone" "6. Valve + other" "8. Other"

5.2 Other Cardiac Procedures

Mapping from old v3.8 field `X3.13.Other.thoracic.and.vascular.procedures` to field:

- `X3.12.Other.Cardiac.Procedures`

Requires further mapping from variables:

- `X3.11.3.Major.aortic`
- `X3.67.N.Aortic.segments.operated.on`

**1. X3.12.Other.Cardiac.Procedures (Cleaning)**

Set as "0. No other cardiac procedure performed": "0. No"

Set as "4. Pulmonary embolectomy": "4. Acute Pulmonary embolectomy"

Set as "7. Cardiac trauma;8. Epicardial pacemaker": "7;8"

Set as "7. Cardiac trauma;9. Pericardiectomy": "7;9"

Set as "12. Pulmonary thromboendarterectomy": "12. Pulmonary Thrombo-endarterectomy"

Set as missing: "20" or any text strings

2. If X3.13.Other.thoracic.and.vascular.procedures contains "2. Carotid endarterectomy"
append "17. Carotid endarterectomy" to selected multivalue options

3. If X3.13.Other.thoracic.and.vascular.procedures contains "3. Other thoracic"
append "19. Other procedure not listed above" to selected multivalue options

4. If X3.13.Other.thoracic.and.vascular.procedures contains "1. Aortic or peripheral vascular"
AND if X3.11.3.Major.aortic == "1. Yes"
AND if X3.67.N.Aortic.segments.operated.on == "1. Yes"
append "19. Other procedure not listed above" to selected multivalue options

5. Multivalue formatting

6. Subsequent mapping from old v3.8 field X3.11.Cardiac.Procedures to fields:

- X3.11.4.Cardiac.Procedures.Other

Requires further mapping from variables:

X3.11.3.Major.aortic

X3.12.Other.Cardiac.Procedures

X3.11.4.Cardiac.Procedures.Other (Mapping)

Set as "0. No": "0"

Set as "1. Yes": "1"

Set as "0. No", mapped values: "1. Yes" "1. CABG alone" "2. CABG + valve" "5. Valve alone"

Set as "1. Yes", mapped values: "3. CABG + valve + other" "4. CABG + other" "6. Valve + other"
"8. Other"

If X3.11.3.Major.aortic and X3.11.4.Cardiac.Procedures.Other are both missing

AND if X3.11.3.Major.aortic and X3.11.4.Cardiac.Procedures.Other are both "1. Yes"

AND if X3.12.Other.Cardiac.Procedures is "0. No other cardiac procedure performed" or
"16. Peripheral vascular", set as "0. No"

5.3 Aortic Aetiology

Mapping to new v4.1.2 field X3.91.Aetiology from old v3.8 fields:

- X3.68.Aortic.pathology.Root
- X3.70.Aortic.pathology.Ascending
- X3.72.Aortic.pathology.Arch
- X3.74.Aortic.pathology.Desc
- X3.76.Aortic.pathology.Abd

Requires further mapping from variables:

X2.07.Previous.Surgical.Interventions

X2.10.Hx.of.Hypertension

X3.11.3.Major.aortic



1. X3.91.Aetiology (Cleaning)

Set as "5. Other connective tissue disease": "5. Other connective tissue disorder"

Set as missing: "70" "80" "84" "86" "112" "114" "146" "181"

2. X3.91.Aetiology (Mapping Rule 1)

Mapping rules for v3.8 Aortic pathology fields:

- "6. Atheromatous" to "2. Atherosclerosis"
- "7. Marfan's" to "3. The Marfan Syndrome"
- "4. Transection" to "6. Trauma"
- "5. Coarctation" to "7. Coarctation"
- "11. Congenital" to "8. Other congenital"
- "2. Syphilis" to "9. Infection"
- "9. Mycotic" to "9. Infection"
- "13. Infection - graft" to "9. Infection"
- "10. Other connective tissue disorder" to "10. Aortitis"

3. X3.91.Aetiology (Mapping Rule 2)

If `X2.10.Hx.of.Hypertension` == "1. Treated or BP>140/90 on >1 occasion prior to admission"
AND `X3.11.3.Major.aortic` == "1. Yes", set as "1. Hypertension"

4. X3.91.Aetiology (Mapping Rule 3)

If `X2.07.Previous.Surgical.Interventions` == "5. Aortic surgery - ascending or arch",
set as "11. Previous aortic surgery"

5. Concatenate mapping rules, and map to `X3.91.Aetiology` if set as missing

6. Multivalue formatting



6 Removed records

Two sets of records were removed prior to the cleaning process: 1 record for a dummy hospital and 17474 records where either the admission, procedure or discharge date was recorded as before 1998-01-01. These were removed from the database due to the poor quality of the data prior to this time.

After the cleaning process, additional records were removed according to the following criteria:

Date Conflicts

Admission > Procedure OR Procedure > Discharge

Age Filter

Age.at.operation < 18

Non-Cardiac Procedures

Any record that is classified as isolated abdominal aortic surgery by satisfying the following conditions:

- An aortic procedure only, characterised by: `X3.11.3.Major.aortic == "1. Yes"` AND `X3.11.1.CABG == "0. No"` `X3.11.2.Valve == "0. No"` `X3.11.4.Cardiac.Procedures.Other == "0. No"`
- Operated on just one segment, characterised by: `X3.67.N.Aortic.Segments.operated.on == "1"`
- That one procedure recorded as abdominal, characterised by: `X3.77.1.Ao.proc.Abdominal.Segment.Code.5` with a recorded procedure, and missing for `X3.69.1.Ao.proc.Root.Segment.Code.1` `X3.71.1.Ao.proc.Ascending.Segment.Code.2` `X3.73.1.Ao.proc.Arch.Segment.Code.3` `X3.75.1.Ao.proc.Descending.Segment.Code.4`

Duplicate Records

1. Create two temporary variables:
 - A "tempID" variable set as the `Apollo` code, or if missing the `Artemis` code
 - A "tempOperative" variable set `X2.35.Operative.Urgency`, or if missing "1. Elective"
2. Variables re-ordered, according to hierarchy: `"X3.02.Procedure.Date"` `"Hospital"` `"Apollo"` `"X3.01.Admission.Date"` `"X4.06.Discharge.Date"`
3. Duplicates (set 1) removed if records equal on the following variables: `"Hospital"` `"X1.07.Gender"` `"tempOperative"` `"X3.11.1.CABG"` `"X3.11.2.Valve"` `"X3.02.Procedure.Date"` `"Age.at.operation"` `"tempID"`
4. Duplicates (set 2) removed if records equal on the following variables: `"Hospital"` `"X1.07.Gender"` `"tempOperative"` `"X2.36.N.Previous.Heart.Operations"` `"X3.11.1.CABG"` `"X3.11.2.Valve"` `"X3.01.Admission.Date"` `"X3.02.Procedure.Time"` `"Age.at.operation"` `"tempID"`
5. Duplicates (set 3) removed if records equal on the following variables: `"Hospital"` `"X1.07.Gender"` `"tempOperative"` `"X2.36.N.Previous.Heart.Operations"` `"X3.11.1.CABG"` `"X3.11.2.Valve"` `"X4.06.Discharge.Date"` `"X3.02.Procedure.Time"` `"Age.at.operation"` `"tempID"`

TAVI Procedures

1. TAVI procedures (set 1) removed:

If `X3.51.Aortic.implant.prosthesis.name` contains "9300TFX" "9000TFX" "SAPIEN" "TAVI" "THV" OR `X3.52.Aortic.implant.prosthesis.model` contains "9300TFX" "9000TFX" "SAPIEN" "TAVI" "THV"



2. TAVI procedures (set 2) removed:

If `X3.31.Native.Aortic.valve.other.path` contains "TRANSF" "TRANSA" AND `X3.23.Aortic.Valve.Explant` == "1. Native valve"

3. TAVI procedures (set 3) removed for King's College Hospital only:

If both `X3.51.Aortic.implant.prosthesis.name` == "PENDB" AND `X3.52.Aortic.implant.prosthesis.model` missing, OR IF `X3.31.Native.Aortic.valve.other.path` == "TAVI"

Census Data Conflicts

1. ONS records mapped to NACSA data:

Pre-cleaned ONS data is deterministically mapped to patient records by common `ParentUNID` fields

1. ONS mismatched records removed:

If `LS.Date` precedes `X3.02.Procedure.Date` and `LS.Status` is "Dead"

2. `LS.Date` and `LS.Status` set as missing:

If `LS.Date` precedes `X3.02.Procedure.Date`

Summary

1. Date Conflicts: 577 records removed
 2. Age Filter: 553 records removed
 3. Non-Cardiac Procedures: 96 records removed
 4. Duplicate Records: 5308 records removed
respectively: 5205 , 72 , 31
 5. TAVI Procedures: 208 records removed
respectively: 142 , 21 , 45
 6. Census Data Conflicts: 46 records removed
- TOTAL: 6788**

7 Generated Indicator Fields

7.1 Flags

New fields were created to provide evidence of a risk factor or patient status when multiple fields are related yet some have missing data or are in conflict with one another.

LVEFC.flag

This is an indicator of left ventricular ejection fraction category that resolves two fields:
X2.27.Ejection.Fraction and **X2.28.LV.Ejection.Fraction.Category**

Set **LVEFC.flag** equal to **X2.28.LV.Ejection.Fraction.Category** if recorded

If **X2.28.LV.Ejection.Fraction.Category** missing or "9. Not measured":

Set as "3. Poor (LVEF < 30%)" if **X2.27.Ejection.Fraction** < 30

Set as "2. Fair (LVEF 30-50%)" if **X2.27.Ejection.Fraction** > 30 and <= 50

Set as "1. Good (LVEF >50%)" if **X2.27.Ejection.Fraction** > 50

Dead.flag

This is an indicator of in-hospital mortality status that resolves two fields:

X4.04.Discharge.Destination and **X4.05.Status.at.Discharge**.

Set as TRUE if **X4.04.Discharge.Destination** is "4. Not applicable - patient deceased" AND

X4.05.Status.at.Discharge missing or "1. Dead"

Set as TRUE if **X4.05.Status.at.Discharge** is "1. Dead" AND **X4.04.Discharge.Destination** missing

Set as FALSE if **X4.04.Discharge.Destination** is "1. Home" "2. Convalescence" "3. Other hospital" AND

X4.05.Status.at.Discharge missing or "0. Alive"

Set as FALSE if **X4.05.Status.at.Discharge** is "0. Alive" AND **X4.04.Discharge.Destination** missing

Dead.flag2

This is an indicator of in-hospital mortality status that extends the first **Dead.flag** field by using ONS census data to backfill missing records.

Set **Dead.Flag2** equal to **Dead.flag** if recorded

If **Dead.flag** missing:

Set as TRUE if **LS.Status** is "Dead" AND **LS.Date** equals **X4.06.Discharge.Date**

Set as FALSE if **LS.Status** is "Alive" AND **LS.Date** more recent than **X4.06.Discharge.Date**

NB: Still 200 conflicting records

Single Episode Flag

This is an indicator of whether the record corresponds to i) the only cardiac procedure for the admission spell, or ii) the first cardiac procedure during the admission spell (i.e. where a patient had >1 cardiac procedures).

The algorithm proceeds as follows:

- The flag is initialised as TRUE for all records
- The records are ordered according to **Artemis**, **Hospital**, **X3.02.Procedure.Date**, **X3.02.Procedure.Time**, **X3.01.Admission.Date**, then **X4.06.Discharge.Date**.
- If sequential records have the same **Artemis** number and **Hospital**, set as FALSE if :
 - **X3.02.Procedure.Date** match within 2 days
 - both **X3.01.Admission.Date** and **X4.06.Discharge.Date** match within 1 day
 - either **X3.01.Admission.Date** or **X4.06.Discharge.Date** match within 1 day AND the other field cannot be evaluated due to missing data for either record



- both **X3.01.Admission.Date** and **X4.06.Discharge.Date** cannot be evaluated due to missing data for either record AND **X3.02.Procedure.Date** is less than or equal to the preceding record **X4.06.Discharge.Date**
- both **X3.01.Admission.Date** and **X4.06.Discharge.Date** cannot be evaluated due to missing data for either record AND **X3.02.Procedure.Date** is within 14 days of the preceding **X3.02.Procedure.Date** (NB. The choice of 14 is slightly arbitrary but is retained for consistency with previous versions)
- The above procedure is then repeated with the **Apollo** numbers

Previous Operation Flag

This is an indicator of whether a patient has previously undergone cardiac surgery.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are TRUE:

- **single.ep.flag** is FALSE
- **X2.07.Previous.Surgical.Interventions** contains “1. CABG”, “2. Valve”, “3. Congenital cardiac”, “4. Other cardiac” OR “5. Aortic surgery - ascending or arch”
- **X2.36.N.Previous.Heart.Operations** > 0
- **X3.35.Reason.Repeat.aortic.valve.replacement**, **X3.36.Reason.Repeat.Mitral.valve.replacement**, **X3.37.Reason.Repeat.Tricuspid.valve.replacement**, OR **X3.38.Reason.Repeat.Pulmonary.valve.replacement** contains a non-missing response
- **X3.23.Aortic.Valve.Explant** contains “2. Mechanical”, “3. Biological”, “4. Homograft” OR “5. Autograft” AND **X3.27.Native.Aortic.Valve.Path** is “0. Native valve not present” AND **X3.43.Aortic.Valve.Procedure** is “1. Replacement”
- The above is repeated for Mitral, Tricuspid and Pulmonary valves, using variables:
 - **X3.24.Mitral.Valve.Explant**, **X3.28.Native.Mitral.Valve.Path** and **X3.44.Mitral.Valve.Procedure**
 - **X3.25.Tricuspid.Valve.Explant**, **X3.29.Native.Tricuspid.Valve.Path** and **X3.45.Tricuspid.Valve.Procedure**
 - **X3.26.Pulmonary.Valve.Explant**, **X3.30.Native.Pulmonary.Valve.Path** and **X3.46.Pulmonary.Valve.Procedure**
- **X2.08.Date.Last.Cardiac.Operation** is not missing and **X3.02.Procedure.Date** is more recent than **X2.08.Date.Last.Cardiac.Operation**
- Duplicated **Artemis** numbers
- Duplicated **Apollo** numbers

First Time Cardiac Procedure

This is an indicator of whether the record corresponds to the patient’s first-ever cardiac operation. It is set as the opposite of **previous.op.flag**.

CABG Flag

This is an indicator of whether there is any evidence to suggest a CABG procedure took place.

NB. **X3.11.1.CABG** is the primary indicator used by researchers but is occasionally in conflict with CABG specific data.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are TRUE:

- **X3.11.1.CABG** is recorded as “1. Yes”
- **X3.14.NGrafts** > 0
- **X3.15.Graft.site** is not missing
- **X3.16.Graft.conduit** is not missing
- **X3.17.Graft.Anastomoses** is not missing



Aortic Valve Flag

This is an indicator of whether there is any evidence of an **aortic valve** procedure occurring.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are non-missing:

X3.19.Aortic.Valve.Haemodynamics, X3.23.Aortic.Valve.Explant, X3.27.Native.Aortic.Valve.Path, X3.35.Reason.Repeat.aortic.valve.replacement, X3.43.Aortic.Valve.Procedure, X3.47.Aortic.Valve.Implant.Type, X3.51.Aortic.implant.prosthesis.name, X3.52.Aortic.implant.prosthesis.model, OR X3.54.Aortic.valve.or.ring.size

Set as TRUE if X3.69.1.Ao.proc.Root.Segment.Code.1 is "2. Tube graft + separate AVR", "4. Root replacement with composite valve graft and coronary reimplantation (Modified Bentall or Cabroll)" or "7. Ross Procedure"

Set as TRUE if X3.71.1.Ao.proc.Ascending.Segment.Code.2 is "3. Tube graft + separate AVR", "4. Root replacement with composite valve graft and coronary reimplantation (Modified Bentall or Cabroll)" or "7. Ross Procedure"

Mitral Valve Flag

This is an indicator of whether there is any evidence of an **mitral valve** procedure occurring.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are non-missing:

X3.20.Mitral.Valve.Haemodynamics, X3.24.Mitral.Valve.Explant, X3.28.Native.Mitral.Valve.Path, X3.36.Reason.Repeat.Mitral.valve.replacement, X3.44.Mitral.Valve.Procedure, X3.48.Mitral.Valve.Implant.Type, X3.55.Mitral.implant.prosthesis.name, X3.56.Mitral.implant.prosthesis.model, OR X3.58.Mitral.valve.or.ring.size

Tricuspid Valve Flag

This is an indicator of whether there is any evidence of an **tricuspid valve** procedure occurring.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are non-missing:

X3.21.Tricuspid.Valve.Haemodynamics, X3.25.Tricuspid.Valve.Explant, X3.29.Native.Tricuspid.Valve.Path, X3.37.Reason.Repeat.Tricuspid.valve.replacement, X3.45.Tricuspid.Valve.Procedure, X3.49.Tricuspid.Valve.Implant.Type, X3.59.Tricuspid.implant.prosthesis.name, X3.60.Tricuspid.implant.prosthesis.model, OR X3.62.Tricuspid.valve.or.ring.size

Pulmonary Valve Flag

This is an indicator of whether there is any evidence of an **pulmonary valve** procedure occurring.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are non-missing:

X3.22.Pulmonary.Valve.Haemodynamics, X3.26.Pulmonary.Valve.Explant, X3.30.Native.Pulmonary.Valve.Path, X3.38.Reason.Repeat.Pulmonary.valve.replacement, X3.46.Pulmonary.Valve.Procedure, X3.50.Pulmonary.Valve.Implant.Type, X3.63.Pulmonary.implant.prosthesis.name, X3.64.Pulmonary.implant.prosthesis.model, OR X3.66.Pulmonary.valve.or.ring.size

Set as TRUE if X3.69.1.Ao.proc.Root.Segment.Code.1 is "7. Ross Procedure"

Set as TRUE if X3.71.1.Ao.proc.Ascending.Segment.Code.2 is "7. Ross Procedure"

Valve Flag

This is an indicator of whether there is any evidence to suggest a valve procedure took place.

NB. X3.11.2.Valve is the primary indicator used by researchers but is occasionally in conflict with valve specific data.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are TRUE:

- X3.11.2.Valve is recorded as "1. Yes"
- Aortic.valve.flag is TRUE



- `Mitral.valve.flag` is TRUE
- `Tricuspid.valve.flag` is TRUE
- `Pulmonary.valve.flag` is TRUE

Aortic Flag

This is an indicator of whether there is any evidence to suggest a major aortic procedure took place.

NB. `X3.11.3.Major.aortic` is the primary indicator used by researchers but is occasionally in conflict with aortic specific data.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are TRUE:

- `X3.11.3.Major.aortic` is recorded as "1. Yes"
- `X3.67.N.Aortic.Segments.operated.on` > 0
- `X3.68.1.Ao.path.Root.Segment.Code.1` is not missing
- `X3.70.1.Ao.path.Ascending.Segment.Code.2` is not missing
- `X3.72.1.Ao.path.Arch.Segment.Code.3` is not missing
- `X3.74.1.Ao.path.Descending.Segment.Code.4` is not missing
- `X3.76.1.Ao.path.Abdominal.Segment.Code.5` is not missing
- `X3.69.1.Ao.proc.Root.Segment.Code.1` is not missing
- `X3.71.1.Ao.proc.Ascending.Segment.Code.2` is not missing
- `X3.73.1.Ao.proc.Arch.Segment.Code.3` is not missing
- `X3.75.1.Ao.proc.Descending.Segment.Code.4` is not missing
- `X3.77.1.Ao.proc.Abdominal.Segment.Code.5` is not missing

Other Flag

`X3.11.4.Cardiac.Procedures.Other` and `X3.12.Other.Cardiac.Procedures` This is an indicator of whether there is any evidence to suggest any other cardiac procedure took place.

NB. `X3.11.4.Cardiac.Procedures.Other` is the primary indicator used by researchers but is occasionally in conflict with other cardiac procedure data fields.

The flag is initialised as FALSE for all records, but set as TRUE if any of the following are TRUE:

- `X3.11.4.Cardiac.Procedures.Other` is recorded as "1. Yes"
- `X3.12.Other.Cardiac.Procedures` is neither missing nor "0. No other cardiac procedure performed"

Previous MI Flag

This is an indicator of whether there is any evidence of a previous MI for the patient using fields

`X2.03.N.Previous.MIs` and `X2.04.Interval.between.Surgery.and.last.MI`

Set as TRUE if:

- `X2.03.N.Previous.MIs` is "1. One" or "2. Two or more" AND `X2.04.Interval.between.Surgery.and.last.MI` is NOT "0. No previous MI"
- `X2.03.N.Previous.MIs` is missing or "9. Unknown" AND `X2.04.Interval.between.Surgery.and.last.MI` is neither "0. No previous MI" nor missing

Set as FALSE if:

- `X2.03.N.Previous.MIs` is "0. None" AND `X2.04.Interval.between.Surgery.and.last.MI` is "0. No previous MI" or missing
- `X2.03.N.Previous.MIs` is missing or "9. Unknown" AND `X2.04.Interval.between.Surgery.and.last.MI` is "0. No previous MI"

Set as "Conflict: type 1" if:



- **X2.03.N.Previous.MIs** is “1. One” or “2. Two or more” AND **X2.04.Interval.between.Surgery.and.last.MI** is “0. No previous MI”

Set as “Conflict: type 2” if:

- **X2.03.N.Previous.MIs** is “0. None” AND **X2.04.Interval.between.Surgery.and.last.MI** is neither “0. No previous MI” nor missing

Set as missing if:

- **X2.03.N.Previous.MIs** is missing or “9. Unknown” AND **X2.04.Interval.between.Surgery.and.last.MI** is missing

7.2 Shortcuts

As part of analysing the NACSA database certain routine fields are often required. A number of common variables have been generated and appended to the database after cleaning.

Country

Each hospital is mapped to one of the following: England, Wales, Scotland, Northern Ireland and Republic of Ireland.

Geographical region

Each hospital is mapped to one of the following: The South West, South East, South Central, London, East England, West Midlands, East Midlands, North West, Yorkshire & Humber, North East, Scotland, Northern Ireland, Republic of Ireland, Wales.

Financial year

The date of the procedure is mapped to the financial year. For example, procedure dates between 2000-04-01 to 2001-03-31 would be mapped to 2000.

Post-operative length of stay (PLOS)

The post-operative length of stay associated with each record is calculated as the difference in days between **X3.02.Procedure.Date** and **X4.06.Discharge.Date**

Once evaluated it is set as missing if following conditions are TRUE:

- **plos** < 0
- **plos** < 3 AND **Dead.flag2** is FALSE AND either **CABG.flag**, **Valve.flag**, or **Aortic.flag** are TRUE

Survival data

Survival time-to-follow-up and event indicators were calculated as follows:

1. **time** set as difference between **LS.Date** and **X3.02.Procedure.Date**
2. **event** set as 1 if **LS.Status** is “Dead” and 2 if “Alive”.
3. **time** and **event** corrections if **time**, **event**, **plos** and **Dead.flag2** all not missing:
Set **time** as **plos**, if **Dead.flag2** TRUE, **LS.Status** “Dead”, **time** < **plos**
OR if **Dead.flag2** TRUE and **LS.Status** “Alive” set as **plos**
OR if **Dead.flag2** FALSE and **time** > **plos** set as **plos**
Set **event** as 1, if **Dead.flag2** TRUE
4. **time2** initially set as **time**
Mapped from **plos** if **time** missing and **Dead.flag2** not missing
5. **event2** initially set as **event**
Mapped from **Dead.flag2** if **event** missing and **plos** not missing

**Isolated CABG**

Set as TRUE if:

- `CABG.flag==TRUE & Valve.flag==FALSE & Aortic.flag==FALSE & Other.flag==FALSE`

Isolated AVR

Set as TRUE if:

- `CABG.flag==FALSE & Valve.flag==TRUE & Aortic.flag==FALSE & Other.flag==FALSE`
- `AND Aortic.valve.flag==TRUE & Mitral.valve.flag==FALSE & Tricuspid.valve.flag==FALSE & Pulmonary.valve.flag==FALSE`
- `AND X3.43.Aortic.Valve.Procedure` is "1. Replacement" or missing

Isolated AVR + CABG

Set as TRUE if:

- `CABG.flag==TRUE & Valve.flag==TRUE & Aortic.flag==FALSE & Other.flag==FALSE`
- `AND Aortic.valve.flag==TRUE & Mitral.valve.flag==FALSE & Tricuspid.valve.flag==FALSE & Pulmonary.valve.flag==FALSE`
- `AND X3.43.Aortic.Valve.Procedure` is "1. Replacement" or missing

Isolated MV surgery

Set as TRUE if:

- `CABG.flag==FALSE & Valve.flag==TRUE & Aortic.flag==FALSE`
- `AND Aortic.valve.flag==TRUE & Mitral.valve.flag==FALSE & Pulmonary.valve.flag==FALSE`
- `AND X3.12.Other.Cardiac.Procedures` is "0. No other cardiac procedure performed", "19. Other procedure not listed above", "13. AF Ablation surgery", or missing

Isolated MV surgery + CABG

Set as TRUE if:

- `CABG.flag==TRUE & Valve.flag==TRUE & Aortic.flag==FALSE`
- `AND Aortic.valve.flag==TRUE & Mitral.valve.flag==FALSE & Pulmonary.valve.flag==FALSE`
- `AND X3.12.Other.Cardiac.Procedures` is "0. No other cardiac procedure performed", "19. Other procedure not listed above", "13. AF Ablation surgery", or missing

Isolated MV repair

Set as TRUE if:

- `CABG.flag==FALSE & Valve.flag==TRUE & Aortic.flag==FALSE`
- `AND Aortic.valve.flag==TRUE & Mitral.valve.flag==FALSE & Pulmonary.valve.flag==FALSE`
- `AND X3.12.Other.Cardiac.Procedures` is "0. No other cardiac procedure performed", "19. Other procedure not listed above", "13. AF Ablation surgery", or missing
- `X3.44.Mitral.Valve.Procedure` is "2. Repair", "3. Repair with ring", or "4. Repair without ring"

Isolated MV repair + CABG

Set as TRUE if:

- `CABG.flag==TRUE & Valve.flag==TRUE & Aortic.flag==FALSE`
- `AND Aortic.valve.flag==TRUE & Mitral.valve.flag==FALSE & Pulmonary.valve.flag==FALSE`
- `AND X3.12.Other.Cardiac.Procedures` is "0. No other cardiac procedure performed", "19. Other procedure not listed above", "13. AF Ablation surgery", or missing
- `X3.44.Mitral.Valve.Procedure` is "2. Repair", "3. Repair with ring", or "4. Repair without ring"

**Isolated MVR**

Set as TRUE if:

- **CABG.flag**==FALSE & **Valve.flag**==TRUE & **Aortic.flag**==FALSE
- AND **Aortic.valve.flag**==TRUE & **Mitral.valve.flag**==FALSE & **Pulmonary.valve.flag**==FALSE
- AND **X3.12.Other.Cardiac.Procedures** is "0. No other cardiac procedure performed", "19. Other procedure not listed above", "13. AF Ablation surgery", or missing
- **X3.44.Mitral.Valve.Procedure** is "1. Replacement"

Isolated MVR + CABG

Set as TRUE if:

- **CABG.flag**==TRUE & **Valve.flag**==TRUE & **Aortic.flag**==FALSE
- AND **Aortic.valve.flag**==TRUE & **Mitral.valve.flag**==FALSE & **Pulmonary.valve.flag**==FALSE
- AND **X3.12.Other.Cardiac.Procedures** is "0. No other cardiac procedure performed", "19. Other procedure not listed above", "13. AF Ablation surgery", or missing
- **X3.44.Mitral.Valve.Procedure** is "1. Replacement"

8 Model Variables

8.1 EuroSCORE

Age (integer)

Set as 1 if `Age.at.operation` < 60

Set as $(\text{Age.at.operation} - 58)$ if `Age.at.operation` > 59

Sex (logical)

Set as 1 if `X1.07.Gender` is "2. Female"

Set as 0 if `X1.07.Gender` is "1. Male"

Chronic pulmonary disease (logical)

Set as 1 if `X2.13.Hx.of.Pulmonary.Disease` is "1. COAD/emphysema or Asthma"

Set as 0 if `X2.13.Hx.of.Pulmonary.Disease` is "0. No pulmonary disease"

Extracardiac arteriopathy (logical)

Set as 1 if `X2.17.Extracardiac.arteriopathy` is "1. Yes"

Set as 0 if `X2.17.Extracardiac.arteriopathy` is "0. No"

Neurological dysfunction disease (logical)

Set as 1 if `X2.14.Hx.of.Neurological.Disease` contains "3. CVA with residual deficit"

OR if `X2.16.Hx.of.Neurological.Dysfunction` is "1. Yes"

Set as 0 if `X2.14.Hx.of.Neurological.Disease` does NOT contain "3. CVA with residual deficit"

AND if `X2.16.Hx.of.Neurological.Dysfunction` is "0. No"

Previous cardiac surgery (logical)

Set as 1 if `previous.op.flag` is TRUE

Set as 0 if `previous.op.flag` is FALSE

Serum creatinine (factor)

Set as 1 if `X2.12.0.Actual.Creatinine.at.time.of.Surgery` > 200

Set as 0 if `X2.12.0.Actual.Creatinine.at.time.of.Surgery` ≤ 200

Active endocarditis (logical)

Set as 1 if any of the following are TRUE:

- `X3.27.Native.Aortic.Valve.Path` is "3. Active infective endocarditis"
- `X3.28.Native.Mitral.Valve.Path` is "3. Active infective endocarditis"
- `X3.29.Native.Tricuspid.Valve.Path` is "3. Active infective endocarditis"
- `X3.30.Native.Pulmonary.Valve.Path` is "3. Active infective endocarditis"
- `X3.35.Reason.Repeat.aortic.valve.replacement` is "4. Infection"
- `X3.36.Reason.Repeat.Mitral.valve.replacement` is "4. Infection"
- `X3.37.Reason.Repeat.Tricuspid.valve.replacement` is "4. Infection"
- `X3.38.Reason.Repeat.Pulmonary.valve.replacement` is "4. Infection"

Set as NA if `X3.11.2.Valve` is "1. Yes" and all the above are FALSE.

Set as 0 otherwise

Critical preoperative state (logical)

Set as 1 if any of the following are TRUE:

- X2.12.1.Renal.Function.Dialysis is "3. No dialysis but pre-operative acute renal failure (anuria or oliguria > 10ml/hour)"
- X2.18.Pre.operative.heart.rhythm is "3. Ventricular fibrillation or ventricular tachycardia"
- X2.30.Cardiogenic.Shock.Preop is "1. Yes"
- X2.31.IVInotropes is "1. Yes"
- X2.32.Ventilated.Preop is "1. Yes"
- X2.33.0.Intra.aortic.balloon.pump.used is "1. Pre-operation"
- X2.33.1.Impeller.device.used is "1. Pre-operation"
- X2.33.2.Ventricular.assist.device.used is "1. Pre-operation"
- X2.33.3.Other.Support.device.used is "1. Pre-operation"
- X2.35.Operative.Urgency is "4. Salvage"

Set as NA if `critical.preop == 0` AND two or more of the following are missing: X2.12.1.Renal.Function.Dialysis, X2.18.Pre.operative.heart.rhythm, X2.30.Cardiogenic.Shock.Preop, X2.31.IVInotropes, X2.32.Ventilated.Preop, X2.33.0.Intra.aortic.balloon.pump.used, or X2.35.Operative.Urgency

Set as 0 otherwise

Unstable angina (logical)

Set as 1 if X2.01.Angina.Status.Pre.Surgery is "4. Symptoms at rest or minimal activity" AND X2.29.IV.Nitrates is "1. Yes"

AND X2.35.Operative.Urgency is "2. Urgent" "3. Emergency" "4. Salvage"

Set as NA if X2.01.Angina.Status.Pre.Surgery is missing or "4. Symptoms at rest or minimal activity" AND X2.29.IV.Nitrates is missing

AND X2.35.Operative.Urgency is missing or "2. Urgent" "3. Emergency" "4. Salvage"

Set as 0 otherwise

LV dysfunction (logical)

LV.dysfun1:

Set as 1 if LVEFC.flag is "2. Fair (LVEF 30-50%)"

Set as 0 if LVEFC.flag is "1. Good (LVEF > 50%)", or "3. Poor (LVEF < 30%)"

LV.dysfun2:

Set as 1 if LVEFC.flag is "3. Poor (LVEF < 30%)"

Set as 0 if LVEFC.flag is "1. Good (LVEF > 50%)", or "2. Fair (LVEF 30-50%)"

Recent myocardial infarct (logical)

Set as 1 if X2.04.Interval.between.Surgery.and.last.MI is "1. MI < 6 hours", "2. MI 6-24 hours", "3. MI 1-30 days", or "4. MI 31-90 days"

Set as 0 if X2.04.Interval.between.Surgery.and.last.MI is "0. No previous MI", or "5. MI > 90 days"

Pulmonary hypertension (logical)

Set as 1 if X2.23.PA.Systolic > 60

Set as 0 if X2.23.PA.Systolic <= 60

Emergency (logical)

Set as 1 if X2.35.Operative.Urgency is "3. Emergency", or "4. Salvage"

Set as 0 if X2.35.Operative.Urgency is "1. Elective", or "2. Urgent"

Other than isolated CABG (logical)

Set as 1 if isoCABG is FALSE

Set as 0 if isoCABG is TRUE



Surgery on thoracic aorta (logical)

Set as 1 if `Aortic.flag` is TRUE

Set as 0 if `Aortic.flag` is FALSE

Post infarct septal rupture (logical)

Set as 1 if `X3.12.Other.Cardiac.Procedures` is "2. Acquired VSD"

AND `X2.04.Interval.between.Surgery.and.last.MI` is "1. MI < 6 hours", "2. MI 6-24 hours",
"3. MI 1-30 days", "4. MI 31-90 days", or "5. MI > 90 days"

Set as NA if `X3.12.Other.Cardiac.Procedures` is "2. Acquired VSD"

AND `X2.04.Interval.between.Surgery.and.last.MI` is missing

Set as NA if `X3.12.Other.Cardiac.Procedures` is missing

AND `X2.04.Interval.between.Surgery.and.last.MI` is NOT "0. No previous MI"

AND `X2.04.Interval.between.Surgery.and.last.MI` is TRUE

Otherwise set as 0