

**IMDRF** International Medical  
Device Regulators Forum

## **Proposed Document**

### **International Medical Device Regulators Forum**

**Title:** Patient Registry: Essential Principles

**Authoring Group:** IMDRF Registry Working Group

**Date:** 2 October 2015

## Table of Contents

1.0	Introduction .....	4
2.0	Scope .....	4
3.0	Useful References .....	4
4.0	Vision for International System of Registries linked to other data sources and tools. ....	5
4.1	Vision and purpose .....	5
4.2	Definition of medical device registry .....	6
5.0	What can we learn from the existing efforts in orthopedic, vascular and cardiac fields?.....	7
5.1	Example registries .....	7
5.1.1	Orthopedic .....	7
5.1.2	Vascular.....	11
5.1.3	Cardiac .....	13
5.2	Current Major International Collaborations.....	15
5.2.1	ICOR .....	15
5.2.2	ICTVR.....	17
5.2.3	ICVR.....	17
5.3	Other Collaborations with potential to address devices .....	18
5.3.1	Vascunet.....	18
5.3.2	Cross Border Patient Registries Initiative (PARENT).....	19
5.3.3	Nordic Arthroplasty Register Association (NARA).....	19
6.0	Quality and robustness of registry data needed for regulatory decision making.....	19
6.1	Data Quality .....	19
6.2	Example Best Practices for Total Product Life Cycle (TPLC): Beyond Compliance and Transcatheter Valve Therapy (TVT) Case Study .....	21
7.0	Assuring Analysis Validity when Linking Data Sources.....	22
7.1	Key Recommendations of the IMDRF Registry Workgroup. ....	23
7.2	Registries and Unique Device Identification. ....	25
7.3	Registries and Unique Patient Identification.....	26
7.4	Registry Governance to Encourage Data Linkage. ....	27
7.5	Envisioning Linkage of Registry and Patient Reported Information. ....	28
	Appendix .....	30
	Appendix A: Unedited information provided by IMDRF representatives related to registries	
	<a href="#">[Click here to enter appendix title]</a> .....	30
	<i>Orthopedic</i> .....	30
	<i>Canadian Orthopedic Registry</i> .....	33
	<i>Vascular</i> .....	34
	<i>Cardiac</i> .....	35

## **Preface**

The document herein was produced by the International Medical Device Regulators Forum (IMDRF), a voluntary group of medical device regulators from around the world. The document has been subject to consultation throughout its development.

There are no restrictions on the reproduction, distribution or use of this document; however, incorporation of this document, in part or in whole, into any other document, or its translation into languages other than English, does not convey or represent an endorsement of any kind by the International Medical Device Regulators Forum.

## 1.0 Introduction

The International Medical Device Regulators Forum (IMDRF) Registry Working Group had been created with the purpose of developing:

- (1) Essential principles related to linkage of electronic patient, device and outcome registries and/or related data repositories or identifiers (such as UDIs), including the principles of data access, security, informatics formats, governance and other key areas related to global regulatory applications for medical device evaluation; and
- (2) Essential principles related to optimal methodologies for analysis of heterogeneous data sources applied to medical device safety, signal detection, performance and reliability.

This report focuses on the task described in (1).

## 2.0 Scope

This document provides information and guidance on:

- Registry definition and qualifiers that define the impact, value and sustainability
- Successes in building registries and international collaborations
- Data features and quality requirements for registries
- Desirable dimensions of data to assuring analysis validity when linking registries and other relevant data sources

## 3.0 Useful References

Krucoff M, Sedrakyan A, Normand ST et al. Bridging Unmet Medical Device Ecosystem Needs with Strategically Coordinated Registry Networks: An Overview of Recommendations of the National Medical Device Registry Task Force. *In press- JAMA*

Methodological guidelines and recommendations for efficient and rational governance of patient registries. The PARENT cross border PATient REGistries iNITIative. *Submitted for publication.*

Sanborn TA, Tchong JE, Anderson HV, et al. ACC/AHA/SCAI 2014 health policy statement on structured reporting for the cardiac catheterization laboratory: a report of the American College of Cardiology Clinical Quality Committee. *J Am Coll Cardiol.* 2014; 63:2591-623.

Sedrakyan A, Paxton E, Graves S, Love R, Marinac-Dabic D. National and international postmarket research and surveillance implementation: achievements of the International Consortium of Orthopaedic Registries initiative. *J Bone Joint Surg Am.* 2014 Dec 17;96 Suppl 1:1-6.

Tchong JE, Crowley J, Tomes M, Reed TL, Dudas JM, Thompson KP, Garratt KN, Drozda JP. Unique Device Identifiers for coronary stent postmarket surveillance and research: a report from the Food and Drug Administration Medical Device Epidemiology Network Unique Device Identifier Demonstration. *Am Heart J.* 2014 Oct;168(4):405-413.

Gliklich R, Dreyer N, Leavy M, eds. *Registries for Evaluating Patient Outcomes: A User's Guide.* Third Edition. Two Volumes. Agency for Healthcare Research and Quality, Rockville, MD. April 2014.

Daniel G, McClellan M, Gardina S et al. *Unique Device Identifiers (UDIs): A Roadmap for Effective Implementation.* The Brookings Institution, Washington, DC. December 2014.

Daniel G, McClellan M, Colvin H et al. Strengthening Patient Care: Building an Effective National Medical Device Surveillance System. The Brookings Institution, Washington, DC. February 2015.

Connecting Health and Care for the Nation. A Shared Nationwide Interoperability Roadmap. The Office of the National Coordinator for Health Information Technology.

Dekkers OM, von Elm E, Vandembroucke JP. How to assess the external validity of therapeutic trials: a conceptual approach. *Int J Epidemiol.* 2010 Feb;39(1):89-94

<http://www.fda.gov/MedicalDevices/Safety/ReportaProblem/default.htm#howtoreport>

<http://omop.org/CDM>

[www.strobe-statement.org](http://www.strobe-statement.org)

<http://patientregistries.eu>

[www.beyondcompliance.uk](http://www.beyondcompliance.uk)

[www.knaw.nl/en/news/publications/evaluation-of-new-technology-in-health-care-1](http://www.knaw.nl/en/news/publications/evaluation-of-new-technology-in-health-care-1)

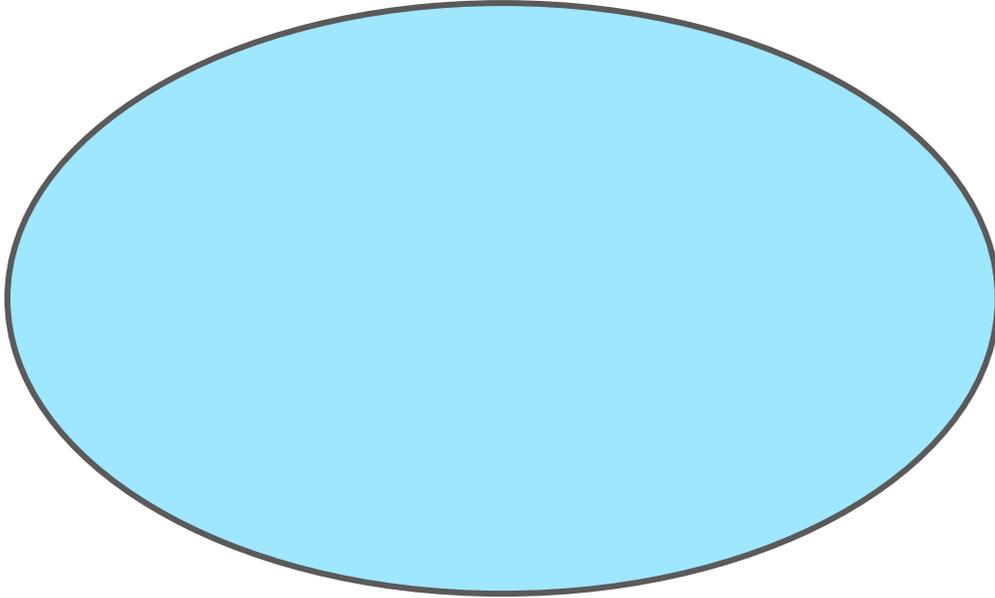
#### **4.0 Vision for International System of Registries linked to other data sources and tools.**

##### **4.1 Vision and purpose**

- I. We envision international collaboration to undertake medical device safety and performance evaluations. Strong registries and collaborative distributed data consortia are key pillars of this international collaboration.
- II. The international collaboration will harness the global strength of international experience with devices, and leverage individual country strengths in cardiac, vascular and orthopedic areas. While not all countries will contribute data to every device evaluation, all countries will benefit from the global collaborative.
- III. Worldwide, regulators will initiate early engagement with their respective registries and other data sources to (a) commence multi-stakeholder communication of their needs and (b) establish a value proposition for implementation/strengthening of device registries within existing registry systems.
- IV. The international collaboration will establish a forum and a set of priority device safety and effectiveness questions in collaboration with registry leaders and other stakeholders.
- V. The priority device questions in cardiac, vascular, orthopedic, and other clinical areas will be sufficiently broad to facilitate registry creation/collaboration but also sufficiently specific informed by international dialogue and intelligence sharing.
  - a. Priority device questions will be dynamic, changing over time as they are answered and as new questions emerge.
  - b. Continuous (e.g. semi- annual) analyses of safety issues found by registry consortia (e.g. ICOR, ICVR, ICCR) will be undertaken in order to keep stakeholders informed about consistent or changing risk posed by devices.

## 4.2 Definition of medical device registry

For the purpose of the development of the IMDRF registry essential principles document the medical device registry is defined as:



Additionally, the following qualifiers define the impact, value and sustainability of the medical device registry:

1. **DEVICE:** the registry contains sufficient information to uniquely identify the device (e.g. catalog number and manufacturer) or relevant attributes and, in the future, includes the unique device identifier.
2. **QUALITY SYSTEM:** Is part of quality assurance system or evolving into one as device technologies are diffused into practice and need continuing evaluation (including outlier identification).
3. **BENEFICIAL CHANGE:** Has established mechanisms to bring about beneficial change in health care delivery through stakeholder participation, ownership and integration into the relevant health care systems.
4. **EFFICIENCY:** the registry is embedded in the health care delivery system so that data collection occurs as part of care delivery (i.e., not overly burdensome, not highly complicated, not overly costly, etc.) and integrated with work flow of clinical teams.
5. **ACTIONABLE DATA:** The registry provides actionable information in a relevant and timely manner to decision makers.
6. **TRANSPARENCY:** the governance structure, data access, and analytical processes of the registry are transparent
7. **LINKABILITY:** information in the registry can be linked with other data sources for enhancement including adequate follow up achievement.
8. **TOTAL DEVICE LIFE-CYCLE:** The registry can serve as infrastructure for seamless integration of evidence throughout the device life cycle.

## 5.0 What can we learn from the existing efforts in orthopedic, vascular and cardiac fields?

### 5.1 Example registries

Several registries currently exist that fully or partially meet the registry definition and desirable elements. The descriptions below illustrate the strengths and limitations of these registries for regulatory process and global post-market surveillance system creation. Additional aim of this description is the encouragement of dialog between regulators and registries for establishment of value proposition for implementation/strengthening of device registry within these existing registry systems (see vision and purpose).

#### 5.1.1 Orthopedic

##### [The National Joint Registry \(NJR\) of England, Wales and Northern Ireland](#)

The National Joint Registry (NJR) was established by the Department of Health and Welsh Government in April 2003 to collect information on and to monitor the performance of joint replacement implants. Northern Ireland joined the NJR in 2013. The registry includes data on all hip, knee, ankle, elbow, and shoulder joint replacements across the National Health System (NHS) and the independent healthcare sector, and is the largest joint replacement registry in the world – currently the registry includes approximately 2 million records. The data from the NJR are used to monitor clinical outcomes data (rates of mortality) following surgery and also implant survivorship (measured as the time between procedures), at the level of hospital, surgeon and implant, tracking and linking information on primary and revision procedures.

The NJR is managed by the Health Quality Improvement Partnership (HQIP) on behalf of the Department of Health and the

Governments of Wales and Northern Ireland. Day-to-day operations of the Registry is subcontracted to Northgate Public Services, a software and outsourcing business that manages collection and reporting of the data. Since April 2014 the NJR is funded through subscriptions charged to hospitals (on a cost per procedure basis) and to industry (for data and reporting services).

The NJR reports in excess of 95% compliance nationally, and is currently undertaking Data Quality Audit to validate underlying data quality. The registry publishes an in-depth annual

---

##### [NJR of England, Wales, and Northern Ireland](#)

- **DEVICE:** Has detailed information on each device component
  - **QUALITY SYSTEM:** Is a quality assurance system: regularly monitors surgeon and device performance and has “surgeon outlier” and “implant scrutiny” groups.
  - **BENEFICIAL CHANGE:** Informs professionals, regulators and manufacturers about device use, choices and performance. Number of documented outlier devices were no longer used as a result.
  - **EFFICIENCY:** Data collection is not be embedded in the delivery of care in some delivery sites, is extensive but easy to complete. Submission is mandatory for NHS. Data capture is electronic including bar code scanning but the majority of the data are collected on paper first.
  - **ACTIONABLE DATA:** Reports back to each participating hospitals to compare against others. Device and surgeon outcome analysis is done twice yearly and is reviewed by a designated panel. Device outliers are reported to manufacturers and competent authorities.
  - **TRANSPARENCY:** Has a formal governance system overseen by a steering committee. The NJR publishes annual detailed report. Provides manufacturers, clinicians and the UK regulator has “real-time” electronic access to relevant information to conduct their own analyses.
  - **LINKABILITY:** Linkages are carried out with hospital episode statistics. UK regulator can cross-correlate NJR data on implants with manufacturer vigilance reports.
  - **TOTAL LIFE-CYCLE:** NJR can be used to collect data on joint replacement performance for both pre-market and post-market phases. It is also used to collect/analyse data for post-market clinical follow-up.
-

report in September of each year and provided regular updates about device performance to manufacturers and competent authorities and about surgeon performance to clinicians and hospitals.

---

### Canadian Orthopedic Registry

- **DEVICE:** Contains device information including both product number and lot number.
  - **QUALITY SYSTEM:** Does not perform quality assurance analysis but provides data to provincial and territorial ministries of health who may engage in quality activities.
  - **BENEFICIAL CHANGE:** Produces general annual reports and 'Analyses in Brief' on relevant clinical and administrative topics. Topics are based on CIHI's consultation with stakeholders and advisory committee.
  - **EFFICIENCY:** The data comes from surgeons, Facilities, regions and Provincial ministries of health. Reporting is mandatory in Ontario, British Columbia and Manitoba. The registry is currently transitioning from paper to electronic forms including bar code scans. In process of integration into care delivery system with major success in British Columbia.
  - **ACTIONABLE DATA:** Data is provided back upon request. Occasionally perform an analysis on component type related topics, such as 2013's Analysis in Brief on early revisions and bearing surfaces and fixation method.
  - **TRANSPARENCY:** Guided by Advisory Committee that includes representative from each province and key arthroplasty stakeholder groups. Customized data are also available upon request in a privacy appropriate manner to researchers and health system managers. The CJRR does not currently release manufacturer information to third parties but has capability to reports by manufacturer
  - **LINKABILITY:** Data is linked with the Hospital Morbidity Database (HMDB) and the Discharge Abstract Database, using patient's Health Care Number. The CJRR data can be linked to CIHI's other data holdings as well
  - **TOTAL LIFE-CYCLE:** Occasional device analyses are performed. No clinical trial infrastructure yet developed for pre-market assessments.
- 

### Canadian Joint Replacement Registry

The Canadian Joint Replacement Registry (CJRR) was launched in May 2001 by the Canadian Institute of Health Information (CIHI) as a voluntary registry and has now been mandated by some provinces. It was developed to provide a rich set of additional patient-level clinical, surgical and prosthesis information beyond what is captured in the Hospital Morbidity Database and the Discharge Abstract Database, allowing for more in-depth analysis of hip and knee replacement procedures. The CJRR is now mandated in three provinces and voluntary in others. CJRR currently covers approximately 70% of all hip and knee replacement procedures in Canada.

The CJRR produces annual reports to characterize the epidemiology of hip and knee replacement procedures (including elective and urgent cases) performed in Canada. Customized data cuts are also available upon request in a privacy appropriate manner to researchers and health system managers. As of 2012–2013, CJRR implemented a new minimum data set (MDS) based on data elements

recommended by the International Society of Arthroplasty Registries such as i) Surgeon and patients demographics, and ii) General procedure information (Type of procedure, Diagnostic grouping and Reason for revision and Prosthesis Information).

### Kaiser Permanente orthopedic registry

Kaiser Permanente (KP) is one of the largest - integrated healthcare systems in the United States with 10 million members in Southern and Northern California, Northwest, Hawaii, Colorado, Ohio, Mid-Atlantic States, and Georgia. In 2001, KP implemented the first inter-regional and the largest US population-based Total Joint Replacement Registry (TJRR). Using an integrated electronic health record (EHR), additional orthopedic (Hip fracture, Spine, Shoulder, ACL), cardiology, and vascular implant registries were also established. All surgeries are captured in

the registry. Currently there are over 150,000 cases recorded over time with more than 90% follow up.

### Australian NJR

The Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) was established in September 1999. It was implemented in a staged manner and achieved full national implementation by mid-2002 with 100% surgeon and hospital coverage. It is currently monitoring the outcome of over one million of these procedures. In 2007 it also commenced data collection on primary, revision and re-operations of shoulder, elbow, wrist, and ankle arthroplasty as well as spinal disc replacement. The AOANJRR shoulder registry is currently the largest shoulder registry globally. The AOANJRR is owned and controlled by the Australian Orthopaedic Association (AOA) and funded by government. The AOA subcontracts an academic institution to manage data collection and undertake independent analysis.

The AOANJRR Annual report is released on 1<sup>st</sup> October. It also produces almost 300 different ad hoc reports at the request of surgeons, academic institutions, researchers, government, regulatory bodies and industry each year. Over 120 outlier hip knee and shoulder prostheses have been identified and most been removed from the market. The impact of the AOANJRR in Australia and globally has been significant. It is recognized as one of the best quality arthroplasty registries globally and within Australia since its implementation there has been a major decrease in the revision burden for joint arthroplasty and increased utilization of best practice identified by the AOANJRR.

### Dutch orthopedic registry

The Dutch Arthroplasty Register (LROI) is a real-time online, digital quality arthroplasty registry in the Netherlands, initiated in 2007 by the Netherlands Orthopaedic Association. The completeness of the LROI is over 96%. All hospitals in the Netherlands participate in the registry. As of 2014 also shoulder-, ankle, elbow, wrist implants and revision surgeries are registered as well as patient reported outcomes for primary hip- and knee implants. As of August 2015, 244,108 hip implants and 186,813 knee implants are captured. Annually about 24,000 knee and 26,000 hip implants are performed in a Dutch population of 18 million. The LROI provides mirror information on a real-time web-based dashboard on the types of implants, operation

---

### Australian National Joint Registry

- **DEVICE:** Has detailed device information including attributes and major contributor to global device library.
  - **QUALITY SYSTEM:** is national/federal Quality Assurance activity. Well integrated into the health care system within Australia.
  - **BENEFICIAL CHANGE:** used extensively by Australian Therapeutics Good's Administration (TGA) and Federal Departments of Health of each state. Used for reimbursement and procurement.
  - **EFFICIENCY:** has a paper based and electronic system for data entry. The paper based system is most efficient and in each hospital dedicated registry coordinators ensures completeness and delivery of data which is monitored weekly by registry.
  - **ACTIONABLE DATA:** contracted to inform TGA about any outlier device before the annual report is published. Surgeons and hospitals receive individualized information about their outcomes compared to national average. Data updated every 6 weeks.
  - **TRANPARENCY:** The registry reports to AOA Board and publications including the annual report are reviewed by independent editorial board. The Federal Government chairs an oversight committee that includes industry and consumers. Information regarding specific products are provided to industry, researchers, and a wide range of stakeholders.
  - **LINKABILITY:** linked with major administrative data sets and a range of large cohort studies. Recently linked to cancer registries and applied to link to national drug prescription data.
  - **TOTAL LIFE-CYCLE:** Tracks every device and it's iteration in the post market area. To enhance premarket assessment it has developed the capacity to undertake clinical trials more efficiently and cost effectively.
-

techniques, and patient variables. As a result, orthopaedic departments can improve their performance by comparing their own data with national data. A second important aim of the LROI is to ensure that all joint implants are traceable at a national level. In case of a recall, all registered implants (i.e. article and lot numbers) de-encryption of the Unique Identification Number (BSN) of the patient is possible at the hospital level. In 2015, the Government of The Netherlands will also establish, according to EU regulations, a national implant registry, where all data from existing implanted medical devices will be uploaded with a unique identification code which can be traced back to the hospital. This registry is financed by a surcharge by health insurers on the hospitals DRG for hip and knee arthroplasty surgery. The registry recently had an impact on use of more evidence based implants. Overall there are about 95 different hips and 90 acetabular cups used in Netherlands.

### **Brazilian National Implants Registry**

The first approach to implement Orthopedic Registry was started by Brazilian Society of Orthopedics (SBOT) in 2007. In 2008, the SBOT initiated data collection using paper based questionnaires and faced several challenges such as data collection complexity and informatics. The SBOT contacted ANVISA (Brazilian National Health Surveillance Agency) to initiate a comprehensive registry creation. In 2010 ANVISA started a Project to develop registry. In a first step, a data collection tool with the most important questions about surgery and implant details was developed. This questionnaire was pilot tested in the electronic patient records of a public hospital specializing in Orthopedics in Porto Alegre. A larger, second pilot was conducted in 15 hospitals of Curitiba, a city of two million people. All hip and knee arthroplasty surgery data were collected in these hospitals. Based on these experiences, ANVISA is currently developing a software platform that will be implemented nationwide with possible expansion to other implants (e.g. cardiology). The new platform, called RNI (National Implants Registry), will (a) identify demographic and clinical characteristics of patients, (b) collect patient outcomes, and (c) correlate outcomes with implanted products to provide enough data to hospitals, manufactures, and surgeons for quality improvement. A pilot version will be tested in Brazilian hospitals in the second half of 2015. The RNI will be managed by ANVISA and data access will be available for different stakeholders (on a relevant level) to enable participation of different stakeholders. The entire project is a joint effort of ANVISA with different institutions such as the Health Ministry, Universities, Hospitals and professional associations.

---

### **Brazilian National Implants Registry**

**Scope:** aiming to be national and the platform to be used is in developmental stage.

→ **DEVICE:** It will have detailed device information. ANVISA is working on regulations to guarantee the appropriate labels. As part of IMDRF, the Agency will work to implement in the future UDI.

→ **QUALITY SYSTEM:** It is not a quality assurance system, but information could be used to insert data for quality systems.

→ **BENEFICIAL CHANGE:** In the future, sufficient information to guide actions and decisions to improve Health Care System is anticipated.

→ **EFFICIENCY:** It is a database that will be incorporate by public hospitals and it will be available for private hospitals. Regarding device information, a bar code/data matrix on the product labels is a request of SBOT and hospital teams in order to make data input into the system easier and avoid typing errors.

→ **ACTIONABLE DATA:** In order to achieve this, qualified data is important and some features on system to provide data validation is foreseen. Reports and alerts will be available and they are in development stage.

→ **TRANSPARENCY:** ANVISA will manage access to stakeholders with proper scope to enable participation of different stakeholders. Guidelines will be elaborated.

→ **LINKABILITY:** It will be linked with some data sources.

→ **TOTAL LIFE-CYCLE:** It is intended to use data for post market and it could be linked to some laboratory tests on products to provide information for premarket.

---

## 5.1.2 Vascular

### Vascular Quality Initiative

- **DEVICE:** Limited device information
- **QUALITY SYSTEM:** It is registered as a patient safety organization with the goal of quality improvement.
- **BENEFICIAL CHANGE:** The registry has been established by Society of vascular surgeons and is gradually engaging multiple stakeholders such as regulators and manufacturers to bring about beneficial change in improving outcomes of vascular surgery. No specific findings of the registry impact on overall outcome improvement in vascular surgery are known.
- **EFFICIENCY:** Data collection is based on web based data entry and is not yet embedded in care delivery. However, surgeons are very enthusiastically supportive within participating centers.
- **ACTIONABLE DATA:** Provides reports back to each participating sites. Each center can compare their data against other participating centers in their regional group.
- **TRANSPARENCY:** Analytic process is described. Data access is through specific requests. Regulator does not have direct access to data.
- **LINKABILITY:** Can be linked with CMS claims and potentially commercial claims to enhance the data and obtain long-term outcomes. However, all linkages have to be probabilistic as it does not have a process to share identifiable patient information with claims data owners.
- **TOTAL LIFE-CYCLE:** The registry is in a process of working with number of manufacturers to nest clinical trials.

### Vascular Quality Initiative (VQI)

The United States Vascular Quality Initiative (VQI) is the national data registry and quality improvement vehicle for the nation's largest group of physicians that provide vascular care, the Society for Vascular Surgery. It has both centralized and decentralized management as a collaborative of regional quality groups collecting and analyzing data in an effort to improve patient care. Since 2002, the VQI has collected data from its members – currently 356 hospitals and practices in 46 states with more than 1300 physicians – for outcomes analysis, benchmarking, and quality improvement. The Vascular Quality Initiative reached maturity in 2010 and has its origins in the Vascular Study Group of Northern New England. These data include more than 120 descriptive variables describing the patient's vascular conditions, the precise details of the operative procedure and devices (stents, atherectomies, endografts, filters, dialysis

access, other) utilized during the procedure, as well as detailed peri-operative and long-term outcomes. Participation and reporting is voluntary. VQI records procedures at a rate of 7,000-8,000 procedures per month and as of July, 2015, more than 215,000 procedures had been recorded. The 1-year results are reported as part of national quality improvement registry and longer follow up requires linking with claims which are started with Medicare data. The impact of the VQI is tremendous; VQI data have informed about length of stay and compliance with evidence-based therapies – since its initiation, length of hospital stay has been reduced, a much higher compliance with evidence based therapies such as use of pre-operative beta blockers, statins and use of patching after carotid procedures have been observed, and the costs of admission for certain procedures reduced.

### Australian vascular registry

The Australasian Vascular Audit (AVA) is a binational vascular audit encompassing all vascular surgery performed in Australia and New Zealand, under the auspices of the Australian and New Zealand Society for Vascular Surgery (ANZSVS). The audit involves all open and endovascular aortic procedures; open and endovascular carotid procedures; infrainguinal bypass procedures and AV fistula procedures for hemodialysis. Data collection began in January, 2010 and are used to provide risk-adjusted analysis of mortality, Stroke/death, and patency for each of these 4 index operations. Apart from these index procedures, all other vascular procedures are captured on a voluntary basis. Annual reports are produced and the audit is protected by Commonwealth

quality assurance protection legislation. Participation is compulsory in order to retain membership of the ANZSVS but the audit is available to non-members. Internal and external validation of Australian data is performed using Medicare (for private patients) and Australian Institute of Health and Welfare data (for all procedures). After 5 years, 65% of data has been captured compared with these external data sources in Australia. Follow up is limited to in-hospital stay only.

### **UK vascular registry**

The National Vascular Registry (NVR) is commissioned by the UK Government to measure the quality and outcomes of care for patients who undergo major vascular surgery in National Health System (NHS) hospitals in England and Wales. It aims to provide comparative information on the performance of NHS hospitals and thereby support local quality improvement as well as inform patients about the care delivered in the NHS. The NVR includes repair of Abdominal Aortic Aneurysm (AAA), Carotid endarterectomy, Lower limb angioplasty/stenting, Lower limb bypass, and Lower limb amputation for Peripheral Arterial Disease (PAD). The NVR was formed in January 2013 by the amalgamation of the National Vascular Database UK Carotid Interventions Audit projects.

The Clinical Effectiveness Unit of the Royal College of Surgeons of England is engaged in the analyses, in partnership with Northgate Public Services who manage the data collection system and data. The NVR is overseen by a project board chaired by a representative from the Royal College of Surgeons of England, and representatives from the Vascular Society of Great Britain and Ireland, the British Society of Interventional Radiology, HQIP and Northgate Public Services. In 2014 information for elective infrarenal Abdominal Aortic Aneurysm (AAA) repair and carotid endarterectomy procedures was made available for all UK NHS trusts that currently perform them. For English NHS trusts, the same information was published online for individual consultants, as part of NHS England's transparency initiative.

### **Japanese Registry of Endovascular Aneurysm Repair (abdominal and thoracic)**

The Japanese Registry of Endovascular Aneurysm Repair for abdominal and thoracic aneurysm was established in 2007 when the first commercial device was approved in Japan. Since then, the Japanese Committee for Stentgraft Management (JCSM) has qualified the institution and the physicians who can perform endovascular repairs of aortic aneurysms. The JCSM has run the registry which is a Web-based Data Entry System. It is mandatory for qualified physicians to enter the data for all consecutive cases into the registry. The registry contains data elements which include brief patient background data, anatomical morphology of aneurysm, procedure information, and short-term outcomes. While device information is collected, devices are not uniquely identifiable. It is also designed to collect 5-year follow-up data. The brief summary of procedure is released by Web page. Device companies are not allowed to access data of their own devices. There is no systematic approach for data audit.

### 5.1.3 Cardiac

#### [The Japan PCI](#)

J-PCI is the national data registry that was established by Japanese Association of Cardiovascular Intervention and Therapeutics (CVIT) in 2008. Since then, the J-PCI has provided benchmarking reports to the members of the society. Its primary aim is to optimize the management and outcomes of patients with cardiovascular disease by collecting and reporting data to improve the quality and safety of care through the provision of outcomes. The J-PCI also provides data for individual board certification (for interventional cardiologists) as well as for site certification system. The infrastructure is built-in on the National Clinical Database, (NCD) which is a nationwide surgical procedure registry network. In 2013, over 220,000 coronary procedures were registered from over 500 hospitals. In addition to J-PCI, J-EVT/SHD has also been developed for registration of endovascular and structural interventions.

At present, annual report is prepared by the scientific committee and distributed to professional members. The professional members include only interventional cardiologists and do not include distributors or manufacturers. The included variables are considered universal among the participating hospitals; committees of experts from multiple disciplines, reflecting both quality improvement and research priorities, identify key data elements and metrics to assess the quality of care for a specified patient population. Its format and definition is in sync with uniform electronic charting system, and could serve as a basic dataset for various clinical studies. The scientific committee of CVIT is currently working to develop real-time feedback system on short-term outcomes for each operator and sites (e.g. dashboard). Data are available upon approval by scientific committee members, and is open for use to professional members. The committee is also working towards collaborating with various manufactures to perform post-marketing survey, but this has not been formally implemented as of June 2015.

#### [The US Cath-PCI registry](#)

The NCDR® is the American College of Cardiology's suite of cardiovascular data registries helping hospitals and private practices measure and improve the quality of care they provide. The NCDR consists of five hospital based registries, one outpatient registry and two multispecialty registries. The oldest registry of the NCDR portfolio is the CathPCI (Cardiac Catheterization and Percutaneous Coronary Intervention) Registry. Created in 1998, the Cath PCI registry contains over 17,000,000 records. Approximately 95% of US hospitals participate

---

#### [The Japan PCI](#)

- **DEVICE:** It has been already functioning as a national registry.
  - **QUALITY SYSTEM:** Random auditing is performed on monthly basis.
  - **BENEFICIAL CHANGE:** It was established by domestic interventional professional society (Japanese Association of Cardiovascular Intervention and Therapeutics: CVIT)
  - **EFFICIENCY:** It reflects both quality improvement and research priorities, identify key data elements and metrics to assess the quality of care for a specified patient population.
  - **ACTIONABLE DATA:** At present, annual report is prepared by the CVIT Scientific Committee and distributed to professional members which include only interventional cardiologists and does not include distributors or manufacturers. The CVIT Scientific Committee of CVIT is currently working to develop real-time feedback system on short-term outcomes for each operator and sites (e.g. dashboard).
  - **TRANSPARENCY:** Data is available upon approval by scientific committee members, and is open for use to professional members.
  - **LINKABILITY:** Its format and definition is in sync with uniform electrical charting system such as SS-MIX, and could serve as a basic dataset for various clinical studies.
  - **TOTAL LIFE-CYCLE:** The committee is also working towards collaborating with various manufactures to perform post-marketing survey, but has not been formally implemented as of June 2015.
-

in the CathPCI registry, and worldwide a total of 1692 sites contribute data to the registry. Device-specific capture (stents) is 100% per the CathPCI database dictionary, and the CathPCI registry is positioned to incorporate UDI once UDI is available. The CathPCI registry has been extensively analyzed, with over 200 original manuscripts authored describing key analyses of the CathPCI registry. For example, The CathPCI registry, augmented by data from a subset of voluntary hospital participants, was used to demonstrate that the VasoSeal closure device was associated with a significantly higher risk of adverse outcomes after angiography than other vascular hemostasis devices.

***The US trans-catheter valve therapies (TVT) registry***

Started In early 2011 as the FDA initiated the framework in concert with the American College of Cardiology National Cardiovascular Device Registry (ACC/NCDR), Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database, industry, Center for Medicare Services (CMS), National Institutes of Health (NIH), and patients. The process is based on CMS National Coverage Decision (NCD) and the NCD defined CMS reimbursement strategy for TVT- hence creation of TVT registry. Since that time, the number of TVT procedures performed in the USA captured in the TVT Registry has increased substantially. Currently over 25,000 patient records representing virtually all patients treated in the U.S have been entered into the TVT Registry. Aortic repair service is now available in approximately 350 institutions in the U.S, and mitral repair in 75.

***The Japanese Trans-catheter Valve Therapy (TVT) Registry***

This registry was established by the Japanese Consortium of Four Academic Societies in May 2014. The database itself is managed by the National Clinical Database (NCD), which is a surgical database and provides a Web-based platform for data entry system. The registry contains data elements which includes patient background data, procedure information and short-term outcomes. It is also designed to collect 5 year follow-up data. In addition, the registry has a function that alarming e-mails are to be sent to device companies when an adverse event is input by the medical professionals. Device companies are allowed to access dataset of its own devices. Quality of data is validated through site visit (site audit).

***The Japan Adult Cardiovascular Surgery Database***

Japan Adult Cardiovascular Surgery Database (JACVSD) was established in 1999 as a registry of cardiovascular surgical procedure. It is not a device specific database but includes procedures which require the device such as prosthetic heart valve. JACVSD is Web based data entry system regarding the data of cardiovascular surgical procedure, which include patient background data, procedure information and early outcomes within 30 days after surgery. However no follow-up data is available. Device companies are not allowed to access dataset of its own devices. The quality of data is validated through site visits (site audit).

## 5.2 Current Major International Collaborations

### 5.2.1 ICOR

The International Consortium of Orthopedic Registries (ICOR) initiative was launched in 2011 to address the evidence gaps in implant safety and effectiveness ([www.icor-initiative.org](http://www.icor-initiative.org)). The inaugural conference was held on May 9-10 at the headquarters of the Food and Drug Administration in Silver Spring, Maryland. Over 70 stakeholders and more than 30 orthopedic joint registries (total joint replacement) representing 14 nations are currently part of the network.

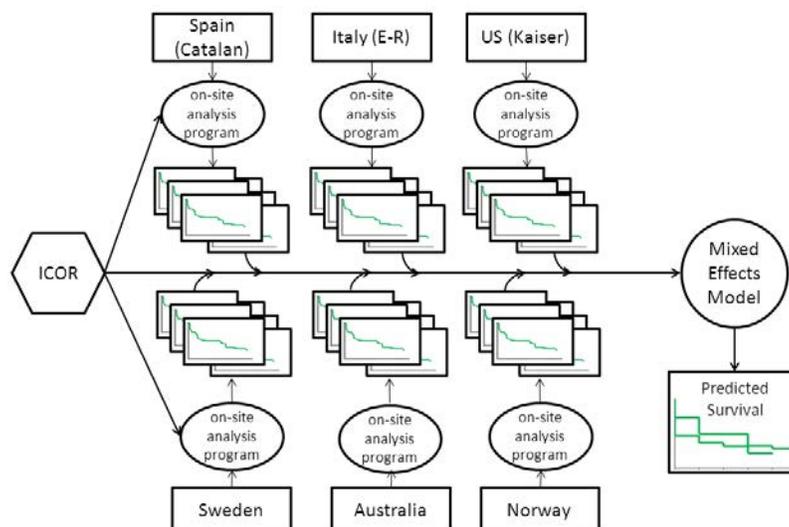


Figure 1. ICOR distributed research network & analytics

Since September 2012 the ICOR has been working on the implementation of worldwide surveillance system and meaningful use of unique devices identification in orthopedics through contract with the FDA. The ICOR focused on two goals:

1. Major demonstration projects of research and surveillance for hip and knee implants
2. Harmonization of worldwide implant data through creation of implant library

#### *Major comparative studies of hip and knee implants.*

The ICOR established a distributed data system where standardized data extraction is implemented by the ICOR coordinating center and distributed to participating registries (**Figure 1**). Each registry completes the analyses and then completely de-identified detailed data summaries that include all subgroup effects and interactions are shared with the coordinating center. The data is combined using multivariable hierarchical models. The main outcomes is all cause revision after surgery which reflects the patients experience and indicates failure of the implant as well the pain and suffering that necessitates second surgery.

#### *Multinational investigations:*

The expert consensus defines the priorities, the inclusion/exclusion criteria and a control group for all investigations. Over 30 projects are completed and published. Examples include:

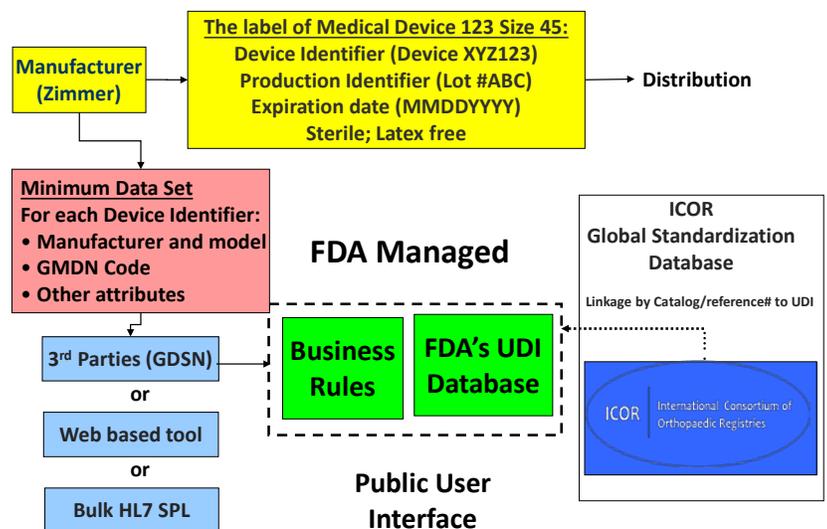
1. International comparative evaluation of knee replacement with fixed vs mobile non-posterior stabilized implants.
2. International comparative evaluation of knee replacement with fixed vs mobile posterior stabilized implants
3. International comparative evaluation of fixed cruciate retaining versus fixed posterior cruciate substituting total knee replacement.
4. Evaluation of head size on outcomes of hip replacement in a combined analysis of six international registries: focusing on metal on Highly cross-linked polyethylene bearings

5. Comparative Effectiveness of Ceramic on Ceramic Implants in Stemmed Hip Replacement: Multinational Study of Six International Registries.
6. Distributed analysis of hip implants using six National and regional registries: comparing metal on metal to metal on Highly cross-linked polyethylene bearings in uncemented Total hip arthroplasty in young patients.
7. Total hip arthroplasty risk of revision: Metal on conventional versus metal on crosslinked results from six international registries
8. Multinational Comprehensive Evaluation of Fixation Method Used in Hip Replacement: Interaction with Age in Context.

**Creating implant library for orthopedic implants: role of registries**

The creation of an orthopedic implant library and relevant nomenclature for device attributes and characteristics is the critical link with clinical and research community interested in devices from post market surveillance and research perspective when using registries. In orthopedics, large registries or networks of registries capture device information on very detailed level and can become particularly important for active surveillance and post-market evaluation. The registries can provide denominator data for adverse events related to specific implants and facilitate comparative effectiveness studies.

The FDA UDI rule mandates that manufacturers must label medical devices with a UDI code that identifies model and production characteristics. Additionally, manufacturers must provide US FDA with attributes of UDI-labeled devices to populate the Global Unique Device Identification Database (GUDID), a public hub of standardized UDI data intended to integrate with billing, inventory, and electronic (Figure 2). The ICOR contribution to this process is depicted in Figure 2 and the ICOR implant library of clinical attributes and characteristics is shown as an adjunct database to GUDID.



**Figure 2. UDI database and contribution of ICOR**

Note: GMDN, Global Medical Device Nomenclature; GDSN, Global Data Synchronization Network; HL7, Health Level 7; SPL, Structured Product Labeling

In order to monitor and evaluate total joint arthroplasty procedures, the specific devices must be accurately identified and classified. The ICOR facilitated standardized processes that enabled the development of a universal implant library that all registries could use for consistency of reporting and enhanced inter-registry collaboration. A catalogue number is assigned by a company to an implant so that it is specifically identified. The number may be numeric, alpha numeric, or a combination of both, and, specific for a particular implant size or configuration. Any change to the design of an implant necessitates a change in the catalogue number. The ICOR identified that the combinations of manufacturer name and catalogue number leads to unique identification of most 99% of products. As the UDI becomes available the registries will also link implant characteristics to UDI.

### **5.2.2 ICTVR**

Building from the success of ICOR In May 2013, the FDA and the MDEpiNet's Science and Infrastructure Center initiated the creation of the International Consortium of Cardiovascular Registries (ICCR) as a pioneering effort focusing on implantable valves and transcatheter valve technology. As surgical treatment options for valve disease are replaced by newer, less invasive procedures such as transcatheter valve replacement, questions about specific device performance, safety, and effectiveness remain unanswered in real-world settings. The ICTVR established a collaborative global network among transcatheter valve registries to conduct analytical projects within this consortium. The governance model and research projects build from the experience gained from ICOR. The registries participating in this network will identify gaps in evidence, harmonize relevant data and create innovative methodologies to analyze data in a distributed way. The ICTVR aims include:

1. To develop a multi-national distributive TAVR research network, including a governance structure whose leadership will oversee the creation of new methodological approaches for research and the establishment of public-private partnerships to address stakeholder's needs and sustainability.
2. To align the TAVR registry rare endpoint and other key variable definitions that support distributive research by reviewing current data fields in registries; summarizing, defining, and prioritizing data elements in order to reach consensus on those definitions among registry leads around the world.
3. To conduct analytic ICTVR projects using distributive research methods through the description of the variation in international practice patterns, the evaluation of the association between specific patient and procedural characteristics and rare procedure-related adverse outcomes, and determine the association between specific device attributes and in-hospital and mid-term outcomes.

### **5.2.3 ICVR**

The mission of the International Consortium of Vascular Registries (ICVR) is to provide a collaborative platform through which registries and other stakeholders around the world can share data to improve vascular health care. The ICVR was launched in November 2014 at Cornell University as another collaboration of FDA and the MDEpiNet's Science and Infrastructure Center with participation of over 12 national registries, manufacturers and other stakeholders. The goal is to more rapidly generate evidence through worldwide registries related to vascular devices and procedures. An important component is working with manufacturers and

regulators to improve the safety and effectiveness of vascular devices, to define optimal patient and pathology selection for devices, and to identify potential device problems as soon as possible.

In order to create this collaborative platform, the ICVR is leveraging existing national registries, including the Society for Vascular Surgery Vascular Quality Initiative (VQI) and a history of collaboration in Vascunet, a “sub-committee of the European Society of Vascular Surgery which aims to increase knowledge and understanding of vascular disease, and to promote excellence in vascular surgery, by means of international vascular audit”. The primary focus of ICVR is related to vascular device evaluation and several prospective projects are launched including a registry of infrarenal AAA treatment, pararenal AAA treatment, and TEVAR treatment of aortic dissection. There are two main work streams developed simultaneously: (1) registry of EVAR devices used for treatment of AAAs. The registry will involve long term (up to 5 year) follow-up of limited outcomes (death, re-intervention), and would be compared with open surgical treatment during the same time period, (2) analytic projects to understand international variation in device use in different patient subgroups using existing data. Combine the information whenever relevant using distributed analysis methodology

### **5.3 Other Collaborations with potential to address devices**

#### **5.3.1 Vascunet**

Vascunet is a sub-committee of the European Society of Vascular Surgery which aims to increase knowledge and understanding of vascular disease, and to promote excellence in vascular surgery, by means of international vascular audit. The Vascunet Committee currently includes members from UK, Denmark, Sweden, Germany, Switzerland, Australia, New Zealand, Hungary, Finland, Norway, Italy, Netherlands and Spain, but other countries are welcome to join the group. Vascunet began in 1997 at the ESVS annual meeting in Lisbon. It was agreed that there should be a common European minimal dataset for vascular registries and an organising committee was convened to organise a session at the meeting for presentation of national vascular registries. In 2006 in Prague a common European dataset was defined and funding was agreed by the ESVS to allow the production of an international comparison report. In Madrid 2007 the first Vascunet Database Report was published on aortic aneurysm repair. This report demonstrated that international data merging was possible and acted as a stimulus for further national registries to become involved. In Nice 2008 the second Vascunet Database report was published, concentrating on AAA repair and carotid surgery. There is a reported on data from 10 Registries, 8 national and 2 regional. Over 100,000 cases were submitted and outcome data helped provide a better benchmark for AAA mortality and combined stroke and death in carotid surgery. As an example, the report highlighted a high mortality rate following elective AAA repair in the UK when compared with other countries which lead to a national quality improvement programme development in the UK. Since 2009 the Vascunet group has published 8 original articles.

### 5.3.2 Cross Border Patient Registries Initiative (PARENT)

PARENT is a Joint Action supported by the EU-Commission. The overall objective of the PARENT Joint Action is to support the EU Member States in developing comparable and interoperable patient registries in fields of identified importance (e.g. chronic diseases, medical technology) with the aim to rationalize the development and governance of patient registries, thus enabling analyses of secondary data for public health and research purposes in cross-border settings.

Further information is available at the website <http://patientregistries.eu/>

Additional to the focus on methodology by setting up guidelines and a comprehensive literature review on the topic PARENT created a database to provide web service to obtain reliable and up-to-date information about patient registry metadata (Register of Registries). The tool will provide a search function in order to identify potentially relevant data providers in Europe on a specific topic

### 5.3.3 Nordic Arthroplasty Register Association (NARA)

The Nordic Arthroplasty Register Association (NARA) was established in 2007 by Sweden, Norway, and Denmark with the main target to further improve Nordic implant surgery research. By conducting multinational registry studies it is possible to obtain high number of patients. A NARA minimal dataset was created to contain data that all registries could deliver. After Finland joined NARA in 2010, the total population of the countries involved is 25.5 million. Selection and transformation of the respective data sets and de-identification of the patients, including deletion of the national civil registration numbers, are performed within national registers of each country. NARA aims to perform analyses of the patient demographics of the participating countries, outcomes of joint replacement operations in general, results of specific implant types and surgical methods, as well as tries to construct a standardized “case-mix indicator” to be used in comparisons. NARA aims at preventing large scale use of unproven implants.

## 6.0 Quality and robustness of registry data needed for regulatory decision making.

### 6.1 Data Quality

#### Measuring Data Quality –

To support its use in regulatory decision making, the quality and robustness of registry data used must be understood. The extent to which the data must achieve certain parameters (i.e. must have 95% or more case ascertainment) will depend upon the use of the data. However, before a regulatory authority is able to make any decision based upon registry data, the authority will require assessment of the registry data across a number of features:

- **Coverage** – Completeness of participation for targeted data collection (e.g. Out of targeted 100 hospitals providing care how many participate and what percent of cases are recorded within registry). This can be measured by comparing registry data with a

verified external data source, to assess the extent to which all records are recorded within the registry. The independent external data source should have 100% coverage of collected data. Examples may be the use of insurance reimbursement data on medical procedures, if insurance covers 100% of all procedures in a country.

- **Completeness** - the extent to which data items used within analysis are consistently captured within the registry. Mandatory fields will be populated in all cases (where electronic data capture is used). Optional fields, or paper-based capture will reduce the proportion of cases for which a data item is recorded. For example, if capturing details of the device is not mandatory this will significantly reduce the extent to which a regulator is able to draw conclusions from the data.
- **Accuracy** – the extent to which data recorded in the registry is an accurate reflection of the healthcare event – i.e. correct patient age, correct device, correct procedure type is recorded etc. Assessment of the accuracy may be difficult to measure but as with case ascertainment is reliant upon validation against external data sources, or completion of external audit and review to compare registry data with local records.
- **Integrity** – for regulatory use, it is essential that medical devices are uniquely identified within the registry, and that the unique identifiers are consistently recorded – such that all procedures using a device can be identified and analyzed.
- **Reliability** – the extent to which a data element is consistent. For example, if the New York Heart Association Functional Class differs by informant for the same patient, the data element would be considered unreliable.

Variable definition, data completeness and endpoint definition of registry data have a direct impact on outcome. Requirements for data quality and accepted endpoints of registry data can be considered at three different hierarchical aggregation levels. These levels are closely interlinked and cannot be considered independent. The hierarchy goes from an overall global level (i.e. national or regional or healthcare system level) to a hospital level and finally to a case record level (i.e. medical device and patient level). The criteria for these different levels are:

### **A. National or regional or system layer**

#### General Features

1. Representation Index (the aim of data registration should be all inclusive, if the choice is to sample data, the registry has to prove the external validity of the data set (i.e. a good representativeness of case mix of hospitals))
2. Completeness of collected data

### **B. Hospital layer**

#### General Features

1. Representation Index (define characteristics of patient pathology captured (e.g. inclusion and exclusion criteria of patients))
2. Completeness of collected data

### **C. Case (Patient / Medical Device)**

#### General Features

1. Define patient characteristics
  - a. Diagnosis
  - b. Case mix of patients (i.e. comorbidity affecting performance)
  - c. Treatment indication and process
2. Completeness of collected data (i.e. percentage of missing data )
3. Succinctly defined and accepted endpoint and other variables (e.g. including identification of medical devices)
4. Validity of data set for devices
  - a. Unique Medical device identification (i.e. catalog/article and lot numbers and in future UDI)

The PARENT - <http://patientregistries.eu> has a key general guidance to determine if data within the registry (population) differs from the target population with respect to characteristics that influence the outcome variable(s) of interest. Large number of patients available in the registry and statistical power issues are valuable but external and internal validity of the registry can not be ignored. In some instances, when all inclusive registry is unrealistic random sampling of hospitals/patients is a reasonable strategy for registry development. However, the sample should be large enough to capture the universe different medical devices and have sufficient power for safety and effectiveness assessments. In these instances it is critically important to ensure very high follow up of over 80% through direct contact with patients or robust systems of data linkage.

In addition to principles discussed above it is important to adhere to STROBE criteria ([www.strobe-statement.org](http://www.strobe-statement.org)) for methodological quality and minimum requirements.

#### **6.2 Example Best Practices for Total Product Life Cycle (TPLC): Beyond Compliance and Transcatheter Valve Therapy (TVT) Case Study**

For emerging registries important issues are to identify „best practices“ for collaboration between the regulatory authority and registry boards (e.g. NJR, Netherlands Implant Registry). Different models of registry may exist; (1) registry might be owned by the government (e.g. NJR), (2) professional societies (orthopaedics, cardiology etc), (3) independent entities (e.g. Swedish Knee etc). In all models, requirements for collaborations between regulators and healthcare professionals as well as manufacturers should be defined. Good collaboration between regulators, registries and manufacturers is beneficial for all involved parties and most importantly, the patient and also the „future“ patient will benefit the most. In this respect the UK „Beyond Compliance“ ([www.beyondcompliance.uk](http://www.beyondcompliance.uk)) initiative is a good example of the advantages of collaboration between registries, manufacturers and orthopedic surgeons to stimulate innovation in presence of optimal patient safety. Ultimately „Beyond Compliance“ can become a bridge between pre-market and post-market as total life cycle evaluation (TPLC) for the medical device and related medical procedure.

In USA, the FDA in concert with the American College of Cardiology National Cardiovascular Device Registry (ACC/NCDR) and Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database, other medical societies, industry partners, Center for Medicare Services (CMS),

National Institutes of Health (NIH), and patients collaboratively built the Transcatheter Valve Therapies (TVT) Registry. The registry application spans from being the platform for National Coverage Decision (NCD) for TVT devices (<https://www.ncdr.com/TVT/Home/Default.aspx>), to being the data sources for comprehensive, registry-based surveillance, replacing traditional “one off” post-approval studies FDA would traditionally require at the time of device approval. The registry is monitoring the diffusion of technology and also able to nest clinical trials of new devices for pre-market processes. The TVT registry is one of several ongoing initiatives to establish national and international registries for specific high-impact treatments and disease states that may serve as models to accelerate the evolution towards a modern electronic clinical and device evaluation infrastructure. Building on FDA-spearheaded development of the International Consortium of Orthopedic Registries (ICOR) via the Medical Device Epidemiology Network Initiative (MDEpiNet), FDA leads the development of the International Consortium of Cardiovascular Registries (ICCR) in the TAVR space. FDA continues to promote and support the development of international efforts under its plan to strengthen postmarket surveillance for medical devices.

## 7.0 Assuring Analysis Validity when Linking Data Sources

Evaluation of the total product lifecycle of medical devices is best accomplished using the totality of the evidence. The information framework that potentially contributes data to medical device evaluation includes and sometimes extends beyond the scope of registries. All parts of this information framework must act in synchrony to assure the validity of analyses derived from the data. The information framework includes the following desirable dimensions:

1. Controlled vocabularies. The use of standardized data elements that accomplish syntactic and semantic interoperability of the data among computer systems is a requisite condition. This includes standardized data elements representing clinical, technical, procedural, and administrative concepts, along with the structured documents thereof to transport data from one system to another.
2. Structured and semi-structured data capture at the point of care. The dialogue to develop clinical documentation processes that capture registry data via the processes of care should be viewed as a registry responsibility. This includes specifying information that should be collected as data, integrating clinical workflows with the process of data acquisition, utilizing all members of the healthcare team in capturing data, transitioning from a paper-based paradigm of transaction-based reports to an informatics-based paradigm that enables “collect once, use many times”, and even recommending that a common data model be used as the architecture in the respective IT systems.
3. Data quality assurance and supplementation. The capture of additional data not accomplished through routine healthcare processes, along with the pre-submission assessment and “cleaning” of the data, is an important step to addressing data quality limitations of data collected via routine clinical processes, particularly when that data will be analyzed for evaluating quality assessment, process improvement, and outcomes determinations.

4. Data packaging and upload of data to registries. The submission of “clean”, packaged data per registry schemas often requires some degree of conversion from clinical representations health record and ancillary systems to formats consistent with the technical requirements of the recipient registries.
5. Registry informatics. Registries are uniquely positioned to serve as the data hub providing a systematic, all-inclusive perspective of device performance. Key to registry activities is having a *common data model* for the information framework. Of specific note: the common data model explicitly requires unique identification of patients as single individuals wherever included in a registry, and also requires identification of devices on a detailed level, particularly with respect to longitudinal follow-up and outcomes assessment.
6. Analytics. Whether individual data are aggregated into a physical or virtual (distributed data) environment for analyses, or data are kept separate and analyses conducted via a distributed analysis model, the linking of the resulting analyses, coupled with advanced analytics and information visualization, promises to be a good solution particularly for high priority, high cost, high utilization, and otherwise high interest areas. In order for analytics to provide correct interpretations of the data, the preceding components of the information framework must all be in place and contributing appropriately to the device innovation ecosystem.
7. Reproducibility. Because of the sequential steps required to extract data from registries, the use of a flexible system to produce dynamic reports is critical. For example, systems such as *SWeave* or *knitr* enhance reproducibility of findings by generating a file that includes narrative and analysis, graphics, code, and the results of computations.

While the above describes the information framework for device data, there are additional aspects including governance and management, ownership and stewardship, usability and optimization, privacy and security, and implementation and operations that are described elsewhere in this document and in other guidance (see useful references). The focus of subsections **7.1-7.5** is data principles and best practices to enable national, regional, health care enterprise, society, and other registries, combined with additional data sources, to be integrated into a “system of systems”. It is envisioned that this “system of systems” will provide the largest platform for accelerating the delivery and availability of high quality device information for purposes of device innovation and surveillance.

## **7.1 Key Recommendations of the IMDRF Registry Workgroup.**

Table 1 describes desiderata (characteristics and properties) of registries that assure analysis validity, spanning the dimensions of the information framework described in Section 7.0 of this Chapter. The recommendations in Table 1 represent desirable characteristics of registries to contribute to a global “system of systems”. Adherence to these criteria enables a registry to act as a node in a data network, including the receipt of data of patients in the registry, the compilation

and forwarding of key data to an analysis center, and the linkage of data across sources external to the registry. These criteria also position a registry to participate as an analysis contributor in a distributed analysis network. In the distributed analysis model, data remain in their respective secure environments, rather than being consolidated into one database. An analysis coordinating center develops computer code so that each registry can evaluate the query within the confines of the registry computational systems, returning the aggregate results to the analysis coordinating center. Finally, these same desiderata are principles and best practices that position registries to act as the core of embedded observational and randomized controlled clinical trials.

Data sources that should be considered as candidates for linking with registry data include the following. Procedure documentation captured at the time of device implant, particularly when accomplished using a structured reporting approach, typically includes a wealth of clinical, technical, operator, device and administrative data. By linking to unique device identifiers key attributes filed as part of regulatory processes can be downloaded from reference databases (e.g., FDA GUDID database). Additional data necessary for analyses that are not filed in regulatory systems can also be expected to be available in supplemental reference database systems (ICOR library). Unique device identification also permits improved linkage of data across disparate sources when using regulatory reporting systems such as US FDA MedWatch. (<http://www.fda.gov/MedicalDevices/Safety/ReportaProblem/default.htm#howtoreport>).

Other potential sources of data include clinical and billing documentation captured during routine transactions of healthcare, particularly the electronic health record, healthcare claims and other payer data, and medication prescription databases. Linkage across registries, particularly between registries focused primarily on devices and those focused on longitudinal follow-up of disease (e.g., American College of Cardiology National Cardiovascular Data Registry (ACC NCDR) CathPCI registry for cardiac catheterization and the ACC NCDR PINNACLE registry for the follow-up of coronary artery disease and other cardiovascular disease), or even across registry classes (cardiology linked to oncology) should also be considered.

Table 1. Five key registry desiderata to assure cross-registry analysis validity

	<b>Component</b>	<b>Desirable Characteristics</b>
1.	Use of controlled vocabularies (standardized data dictionaries)	<p>Predefined standard data elements, preferably characterized per the ISO/IEC 11179 metadata standard (<a href="http://metadata-standards.org/11179">http://metadata-standards.org/11179</a>)</p> <p>Inclusive of all classes of data in the registry (patient demographics, clinical characteristics, procedure details, operator information, device data, clinical outcomes, administrative information)</p> <p>Baseline clinical characteristics and definitions consistent across jurisdictions (e.g., published as a clinical data standard in the medical literature, or a published registry data dictionary)</p> <p>Specific attention to the use of consistent and standardized clinical outcome definitions across jurisdictions, both short-term and long-term</p> <p>Demonstrated syntactic and semantic interoperability via standard data exchange mechanisms (e.g., source data available in an HL7 Fast Healthcare Interoperable Resource)</p>

## IMDRF/Registry WG (PD1)/N33R1

2.	Use of a common data model (e.g., Observational Medical Outcomes Partnership Common Data Model, at: <a href="http://omop.org/CDM">http://omop.org/CDM</a> )	Standardized organization, format and content of observational data, at a minimum organizing person, conditions, drug, device, procedure and visit information in discrete tables, rather than a transaction-oriented organization of the data
		Enables use of standardized applications, tools and methods to be applied to the data
		Explicit requirement of unique patient identification at the individual patient level, specifically managing the patient as a single entity throughout the registry and enabling deterministic matching across data streams external to the registry
		Facilitates the linking of long-term observational information to the individual patient
3.	Inclusion of device-related performance and device outcomes information	Registry specification to require prompting at the point of care for device-related information whenever a device is implanted, adjusted / altered, or explanted
		Data collection embedded in clinical device structured reporting processes (e.g., US Veteran Administration Clinical Assessment, Reporting, and Tracking System for Cardiac Catheterization Laboratories program [CART CL – at: <a href="http://www.hsrd.research.va.gov/for_managers/stories/cart-cl.cfm">http://www.hsrd.research.va.gov/for_managers/stories/cart-cl.cfm</a> ], US FDA Automated Adverse Event Reporting Systems [ASTER-D – at: <a href="http://www.fda.gov/downloads/MedicalDevices/NewsEvents/WorkshopsConferences/UCM320557.pdf">http://www.fda.gov/downloads/MedicalDevices/NewsEvents/WorkshopsConferences/UCM320557.pdf</a> ]
4.	Implementation of a data quality plan for the evaluation and assurance of the quality and provenance of the data	Inclusive of components of monitoring, auditing, and validation
		Consistent with the requirements of regulatory bodies to accept and processes registry data
5.	Governance that anticipates the conduct of analyses across different types of analysis frameworks	Parsimonious approach to identifying the volume and variety of data to be collected, to be based primarily on anticipated analyses
		Registry capacity to function as the analysis center, wherein analyses are conducted of data managed primarily or solely within the registry
		Registry positioned to participate in a distributed data environment, wherein analyses are conducted at an analysis center of source data that is linked (via patient and / or device identifiers) across different data sources
		Registry positioned to participate in a distributed analysis environment, wherein an analysis center requests a derived analytic output to be aggregated with those of other data centers (e.g., US FDA Sentinel Initiative – at: <a href="http://www.fda.gov/Safety/FDASentinelInitiative/ucm2007250.htm">http://www.fda.gov/Safety/FDASentinelInitiative/ucm2007250.htm</a> )

### 7.2 Registries and Unique Device Identification.

The IMDRF Registry Workgroup recommends the inclusion of unique device identification. Specifically, registries should incorporate unique device identification such as the Unique Device Identifier (IMDRF UDI Guidance [www.imdrf.org/docs/imdrf/final/technical/imdrf-tech-131209-udi-guidance-140901.pdf](http://www.imdrf.org/docs/imdrf/final/technical/imdrf-tech-131209-udi-guidance-140901.pdf) ). Registries should preferably capture also production identifier of the

device. The production identifier is a conditional, variable portion that can include information such as the lot number, serial number, date of manufacture, and expiration date. Together, the data comprising the information at the device identification level and the production identification level comprise the unique device identifier. The assignment of Unique Device Identifiers (UDI) to many types of medical devices is now specified in regulation or is being introduced in a number of countries / regions, based upon IMDRF guidance. The generic concept of the UDI is that it is a unique attribute value assigned to each and every medical device subject to UDI regulation. The assignment of the UDI value is centrally managed at the international level by organizations such as GS1, HIBCC and ICCBBA and the process can be streamlined by the use of data synchronisation systems such as the GS1 Global Data Synchronization Network (GDSN) - see

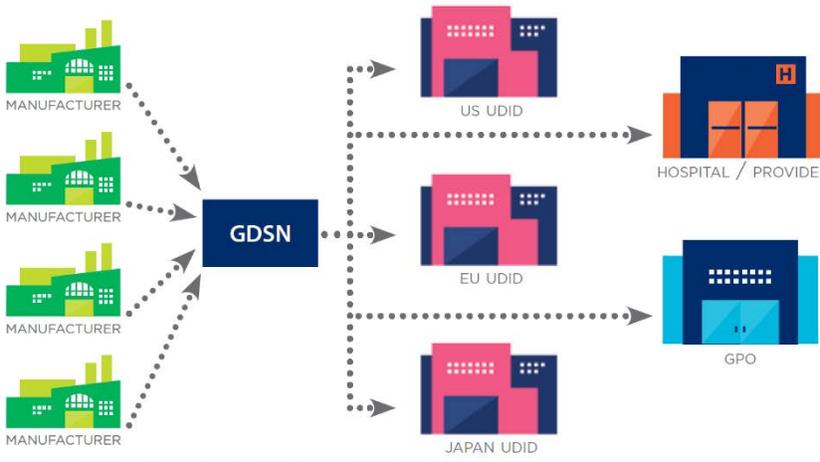


Figure 3. Populating jurisdiction-specific UDI databases

<http://www.gs1.org/gdsn> - to enable trading partners to globally share trusted product data. Depending on the requirements and regulations of individual jurisdictions, this single point of authoritative data can then be used to populate jurisdiction-specific UDI database systems. (Figure 3). Registries are in a unique position to promote the implementation of unique device identification. Inclusion of device identification in procedure documentation links clinical data with the device, and forwarding of the data to registries creates the opportunity for population-level analyses that provide an all-inclusive perspective. Device identifiers will soon serve as the foundation of device implant lists in electronic health records and allow patients to better understand their devices via patient portals and personal health records. Given that unique device identifiers are long strings of (human-readable) alphanumeric characters, manual transcription of device identifiers can be expected to be error prone, necessitating their electronic management via bar code scanners and electronic data transfer to reduce errors associated with human transcription.

**7.3 Registries and Unique Patient Identification.**

Matching of patients across data sources can be either deterministic or probabilistic. In deterministic matching, either unique identifiers for each record are compared to determine the presence of a match, or an exact match of a selected set of fields is used for linking of patient data between data sources. Unique identifiers can include national IDs, system IDs, or another value type that is uniquely associated with one, and only one patient. Deterministic matching is not completely reliable for several reasons, including the frequent situation where no single identifier provides a reliable match between records from two data sources, and because unique patient identifiers themselves are not 100% reliably associated with one and only one individual. In addition, the very presence of a unique patient identifier in databases has been a concern of some from the perspective of patient privacy. This is where probabilistic matching may be of

utility. In probabilistic matching, several field values are compared between two records and each field is assigned a weight that indicates how closely the two field values match. The sum of the weights of the individual fields indicates the strength of the match between records from different data sources, with a specific strength of match selected as representing a valid linkage.

Even with the inherent limitations of both deterministic and probabilistic matching, the IMDRF Registry Workgroup recommends that where available a country (or region) specific unique patient identifier be associated with every record in a registry, as this is a foundational enabler of deterministic matching across multiple data sources that use the same unique patient identifier. In lieu of a unique patient identifier, a sufficient amount of patient-level protected health information (e.g., surname, first name, date of birth, date of procedure, postal code, sex) sufficient to accomplish high performance probabilistic matching is to be included in each registry.

A technical approach to record matching that reduces exposure and transfer of protected health information while accomplishing deterministic matching is the application of one-way hash algorithms that assign a unique identifier via the hash without exposing the protected health information from which the hash is derived. Provided that the data sources all use the same hashing algorithm, linkage of records can occur that result in transfer of minimum datasets for analytic purposes by using the hash as the linkage index. Whatever the technical approach, a modest amount of protected, patient-identifiable data must be maintained internal to registries to enable registries to contribute to a longitudinal picture of patient and device outcomes that fully inform the device evaluation ecosystem.

#### **7.4 Registry Governance to Encourage Data Linkage.**

The critical role of registry governance in facilitating the participation and contribution of registries to a medical device evaluation “system of systems” cannot be over-emphasized. Registries should anticipate, and therefore have in place, policies and principles for handling data relevant to device evaluation. The dimensions that must be encompassed include policies and processes for assuring data transparency and integrity while maintaining provenance and traceability; processes for the review, acceptance, and control of data release; and processes for the review, acceptance, and control of data analysis requests.

Specific to data release, regulatory requirements for review of source data must be anticipated. A plan for device-specific safety data reporting to regulatory agencies, both at the individual report level and at the aggregate level should be in place. Manufacturers also have specific responsibilities for the reporting of device-related issues and may require relevant information. Even issues related to patent protection must be considered in the plan for management and control of data and its potential release to outside parties.

Coincident with data linkage, appropriate policies, processes, and information technologies are required to assure appropriate degrees of privacy (and security) of the data within the larger framework of device evaluation. As applicable law and regulation varies from jurisdiction to jurisdiction, the approach to data linkage and the degree of de-identification of protected health

information should obviously consider the legal environment of the local jurisdiction. There are several legal issues concerning registry operation, data protection, and data re-use. At the international level, aggregation of analyses – where the data are completely de-identified – may ultimately prove to be the common denominator approach that permits the findings of a “system of systems” to inform medical device evaluation and decision making. Finally, the publication of findings in the medical literature, particularly where patient consent for same may not have been obtained *a priori*, must be handled using an approach where there is minimal risk to patient privacy.

### **7.5 Envisioning Linkage of Registry and Patient Reported Information.**

While currently in its infancy, patient reported information is poised to greatly contribute to our understanding of device performance and outcomes. Multiple sources, including implanted devices, external monitoring, social media, mobile apps, periodic surveys, directly reported information, and other approaches have the potential for providing signals (both beneficial and detrimental) about device performance. The movement from traditional healthcare models of transactional care to a nearly continuous flow of information will undoubtedly require advancements in analytics to filter relevant, high value signals from the torrent of data potentially provided by patients and patient monitoring systems. While admittedly a forward-looking perspective, the IMDRF Registry Workgroup recommends that registries begin the process of incorporating or otherwise linking to patient reported information.



## Appendix

### Appendix A: Unedited information provided by IMDRF representatives related to registries [Click here to enter appendix title]

The following qualifiers define the impact, value and sustainability of the registry:

1. **DEVICE:** Has sufficient device information and, in future, unique device identification.
2. **QUALITY SYSTEM:** Is part of quality assurance system or evolving into one as device technologies get adopted and need continuing evaluation (including outlier identification).
3. **BENEFICIAL CHANGE:** Has established mechanisms to bring about beneficial change in health care delivery through stakeholder participation, ownership and integration into the relevant health care systems.
4. **EFFICIENCY:** Is embedded in the care delivery system. Hence, it is efficiently run: data is collected as part of care delivery (i.e., not overly burdensome, not highly complicated, not overly costly, etc.) and integrated with work flow of clinical teams.
5. **ACTIONABLE DATA:** Provides actionable information in a relevant and timely manner to decision makers.
6. **TRANSPARENCY:** the governance structure, data access and analytic processes are transparent).
7. **LINKABILITY:** Can be linked with other data sources for enhancement including adequate follow up achievement.
8. **TOTAL LIFE-CYCLE:** Can serve as infrastructure for seamless total product life cycle integration.

#### Orthopedic

#### **The National Joint Registry (NJR) of England, Wales and Northern Ireland**

Scope: it is aiming to be national and reached that level

1. **DEVICE:** Has detailed device information
2. **QUALITY SYSTEM:** Is a quality assurance system. For example The NJR analyses information on surgeon and implant performance on a regular basis and this activity is overseen by the NJR's "surgeon outlier" and "implant scrutiny" groups.
3. **BENEFICIAL CHANGE:** British Orthopedic Association, Government including MHRA, manufacturers are part of the collaboration and the NJR informs healthcare professionals, regulators and medical device manufacturers about patterns of usage, clinical practice choices and device performance which are used by these groups in decision making. There are number of example of beneficial change such as discontinued use of many documented outlier devices
4. **EFFICIENCY:** The data collection forms are not extensive and easy to complete. It is unclear if data collection is embedded in the delivery of care. Submission of relevant data to the NJR is mandatory for hospitals within the National Health Service and is also done by most private healthcare providers. Submission of data is electronic (via a web-based portal) and allows bar code scanning for device identifier information. The majority of submitters do not however collect the data electronically at the time of the procedure - they collect it on paper and transcribe it at a later time.
5. **ACTIONABLE DATA:** Provides reports back to each participating sites. Each center can compare their data against other participating national centers. Device and surgeon performance analysis is carried out twice yearly and is reviewed by a designated panel. Device outliers that are identified are reported to manufacturers and competent authority for further investigation / action as necessary.
6. **TRANSPARENCY:** There is a formal registry governance system which is overseen by a steering committee (lay chair). The NJR publishes detailed reports on an annual basis. It also gives "real-time" electronic access to relevant / appropriate information to manufacturers, clinicians and the MHRA so that they carry out their own analyses.
7. **LINKABILITY:** Linkages are carried out with hospital episode statistics. MHRA can cross-correlate NJR data on implants with manufacturer vigilance reports.
8. **TOTAL LIFE-CYCLE:** NJR can be used to collect data on joint replacement performance for both pre-market and post-market phases. It is also used to collect/analyse data for post-market clinical follow-up.

Australian NJR

1. **DEVICE:** The AOANJRR is able to identify each component used in a joint replacement procedure by both catalogue and lot number. In addition it has an extensive list of attributes associated with each catalogue number which are continually being verified against government databases and with individual companies. The AOANJRR already uniquely identifies each individual component but it is also in a position to rapidly integrate the use of a unique device identifier as required. To assist with this the AOANJRR has been the principal registry supporting and developing a global arthroplasty product catalogue in combination with other registries and industry. The purpose of this catalogue is to provide a resource to all registries globally and assist with the introduction of the unique device identifier.
2. **QUALITY SYSTEM:** The AOANJRR is one of the few organizations listed by the Australian Federal Government as a Federal Quality Assurance activity. Over the years it has become increasingly integrated into the health care system within Australia. One example of this is the use of AOANJRR data by the Australian regulator (The Therapeutic Goods Administration (TGA)). In 2007 it established a mechanism to review, assess and make recommendations on devices identified by the AOANJRR as having a higher than anticipated rate of revision.
3. **BENEFICIAL CHANGE:** In addition to the Therapeutic Goods Administration use of registry data AOANJRR data is also used by the Departments of Health federally and within each state. This includes device information relevant to appropriate reimbursement for both new and established devices as well as assisting in state health authority procurement contracts. Access to up to date data for individual surgeons companies and regulators has already been mentioned. In addition the AOANJRR provides specific reports requested on a wide range of topics to researchers and other stakeholders.
4. **EFFICIENCY:** The AOANJRR offer both a paper based and electronic systems for data entry. The paper based system is the preferred data entry with Australia. The collection of the identified minimum data set requires less than a minute to complete and all hospitals also used the collected data to inform and record the procedure within their own patient information systems. In each hospital there is an identified registry coordinator who has the responsibility of ensuring completeness of data and timely delivery to the AOANJRR. This is monitored by the AOANJRR on a weekly basis. The AOANJRR eases the burden on hospitals by offering a centralized data entry service. The utilization of a skilled data entry work force also has considerable benefits with maintaining data quality.
5. **ACTIONABLE DATA:** The AOANJRR is required under contract to provide information to the TGA with information on any device identified as having a higher than anticipated rate of revision. Each year the TGA receives this information before it is published in the Annual report. In addition the TGA along with other national regulators through their secure internet access to the AOANJRR database has the ability to access data which is updated daily and is accurate to within 6 weeks of the access date. This information is available for all arthroplasty devices used within Australia. All other relevant stakeholders including government, patients, surgeons, hospitals and industry are provided with extensive publically available and specific stakeholder information. There is also the capacity for each of these stakeholders to request specific reports on topics of interest.
6. **TRANSPARENCY:** The governance structures of the AOANJRR are designed to maximize transparency and accountability. The AOANJRR reports directly to the AOA Board through a variety of special committees involved in both policy and day to day activities. Publications are reviewed by an independent editorial board. The AOANJRR Annual Report is reviewed by an independent panel of orthopedic surgeons prior to its release to the AOA Board for final approval. The Australian Federal Government chairs an oversight committee which has extensive industry and consumer representation. Further accountability is established by provision of stakeholder specific information to surgeons, hospitals and industry so that they can assess the nature and quality of the data.
7. **LINKABILITY:** The AOANJRR has an extensive linkage program of data with other major administrative data sets as well as a range of large cohort studies within Australia. The linkage to administrative data sets includes separation data from each state, national death index, and more recently cancer registries with each state. The AOANJRR has also recently made application to be linked with the national pharmaceutical prescription data every patient recorded in the registry. The linkage to the large cohort studies have led to many publications looking at a wide range of factors that contribute to the outcome of joint replacement as well as the etiology of severe arthritis in particular osteoarthritis.
8. **TOTAL LIFE-CYCLE:** The AOANJRR specifically in the post market area is able to track each device and any iteration of that device through its entire development cycle. The AOANJRR has established that

few if any of the new arthroplasty devices are being introduced into the market are performing better than previously available devices. In order to enhance premarket assessment the AOANJRR has recently developed the capacity to undertake clinical trials. Using the independently established registry infrastructure to implement, and coordinate data collection and analysis means that these trials can be undertaken in a more effective accountable and cost effective manner. An effective premarket assessment program for arthroplasty devices will significantly reduce the number of poorly performed devices reaching the market.

**Kaiser Permanente Orthopedic Registry**

1. **DEVICE:** As an integrated system, the KP registries are able to capture device information for each case, including manufacturer, implant type, description, reference number, and lot number. The EHR currently captures Global Trade Item Numbers and is also designed to capture unique device identifiers as they become available. In addition to the implant descriptive information, the registries maintain reference libraries with clinical implant characteristics not captured in the Global Unique Device Identifier Database (GUDID), for evaluation of implants by class or type.
2. **QUALITY SYSTEM:** The registries enhance patient safety and improve quality by providing a variety of clinical decision tools such as risk calculators, quality reports, risk-adjusted medical center reports, summaries of surgeon data, and infection control reports to registry stakeholders. The registries are used to immediately identify patients with recalled devices, evaluate new and established device technology, and identify outlier implants. Surveillance methodology has been developed for the registries to monitor medical device performance for detection of early failures among poorly performing implants. This detection system uses statistical algorithms to flag devices (or device constructs) with higher-than-expected failure rates.
3. **BENEFICIAL CHANGE:** Critical to registry success is surgeon leadership and engagement; each medical center has a surgeon champion who provides feedback on registry initiatives and disseminates registry findings. Tools for providers include risk-adjusted medical center reports, quarterly quality scorecards, statistical process control charts, reports on outlier implants and centers, surgeon profile reports, and interactive Web-based reports. The registries contribute to cost-effectiveness initiatives through collaboration with contracting groups and confirming adherence to device formulary guidelines. Research studies based on registry data have directly influenced clinical best practices.
4. **EFFICIENCY:** The implant registries track all KP members undergoing elective primary and revision implant surgery-using an innovative observational method that collects uniform data at the point of care. The core of the data collection is the use of standardized operative documentation forms which contain key data elements such as patient demographics, implant characteristics, surgical techniques, and clinical outcomes.
5. **ACTIONABLE DATA:** Actionable information for best practices and quality improvement is provided to clinicians through physician and administrator meetings, registry website, site visits, newsletters, e-mails, webinars, annual reports, and regional/national conference presentations. Evidence-based findings of risk factors for post-operative complications, hospital re-admissions, and revision surgeries are disseminated internally and published in peer-reviewed journals.
6. **TRANSPARENCY:** There is formal registry governance from an inter-regional oversight committee composed of senior physician and administrative leaders. The KP registries have published on methodologies for data collection, data quality assurance, and the algorithms used for identifying outcomes. Analytical methods range from simple descriptive statistics to multivariable analyses (e.g., regression, survival analyses). Data imputation, propensity scores analysis, and sensitivity analysis are also applied to identify risk factors, clinical best practices and device comparative effectiveness.
7. **LINKABILITY:** The registries leverage existing administrative databases and the EHR for data collection and validation. In addition, our registries integrate data from external sources, such as the National Cardiovascular Data Registry. In addition to standardized registry data collection, all registries rely on the EHR, administrative data, and other specific databases (for example, Geographically Enriched Member Sociodemographics, Diabetes Registry, Cancer Registry, pharmacy) within the system to capture demographics, comorbidities, anthropometric measures, surgical procedure detail, and implant information. Using the same available databases, the registry staff developed algorithms for identification of monitored outcomes. For all registries, additional elements such as length of stay, postoperative utilization

(readmissions), mortality, and membership termination are obtained from the institution's administrative claims and membership and mortality files.

8. **TOTAL LIFE-CYCLE:** In collaboration with technology assessment, contracting, and information dissemination groups within KP, the registries serve an important role in the infrastructure for total product life cycle integration. The registries identify best performing implants and evaluate claims of expensive new technology, and provide feedback to contracting and clinicians. These findings influence clinical practice, resulting in improved surgical outcomes and prevent implantation of devices with higher than expected adverse event rates.

### Dutch Orthopedic Registry

Scope: National

1. **DEVICE:** Has detailed device information (lot and article number) and encrypted patient data
2. **QUALITY SYSTEM:** Is a quality assurance system with real-time dashboard information of the local practice compared to the national level for those specific variables. The system is based on self-control and self-reflection of individual surgeon groups and their quality key performance indicators (e.g., reason for revision, survival analysis, PROMS etc).
3. **BENEFICIAL CHANGE:** The LROI is a separate foundation, the board of the Netherlands Orthopaedic Association (NOV) governs the LROI with head office employees (see above). The LROI annually informs healthcare professionals, regulators and medical device manufacturers about patterns of usage, clinical practice choices and device performance which are used by these groups in decision making, by publishing annual reports in both Dutch and English. These reports are available to the public in a digital form at [www.LROI.nl](http://www.LROI.nl). There are already examples of beneficial change such as discontinued use of documented outlier devices (i.e. metal-on-metal hip stopped within 1 year).
4. **EFFICIENCY:** The data collection forms are comprehensive and cover (if on paper) 1 A4 (front and back) and easy to complete. Dataforms are embedded in the delivery of care. Submission of data to LROI is not (yet) mandatory for hospitals, nevertheless peer pressure is big and participation in the LROI is a quality indicator from the Medical Inspection General and are requested by the insurance companies for contracts. Therefore completeness is 100% for all hospitals and 98% for all implanted primary hip- and knee implants (published Steenbergen et al 2015). Submission of data to the central data base is electronic (via a web-based portal). Lot number and article code number are typed in manually, barcode scanning will be available 2016.
5. **ACTIONABLE DATA:** The database and the software are developed at the Leiden University Medical Center, department of statistics (which runs over 70 national and European registries, ProMise). Patient data are encrypted via TTP (third trusted party)
6. **TRANSPARENCY:** The LROI head office provides reports back to each participating sites. Each center can real-time compare their data against other participating national centers on a dash board. There is a formal registry governance system.
7. **LINKABILITY:** Linkage with the Netherlands Implant Database from the ministry of Health is planned to start in 2015. The Governance structure of this NID is discussed at this moment. Patient data will not be available in this NID, due to strict privacy laws in The Netherlands
8. **TOTAL LIFE-CYCLE:** LROI data can be used to collect data on joint replacement performance for both pre-market and post-market phases. It is also used to collect/analyse data for post-market clinical follow-up and thus track and trace of implants.

### Canadian Orthopedic Registry

1. **DEVICE:** The CJRR contains device information including both product number and lot number.
2. **QUALITY SYSTEM:** The CJRR does not perform quality assurance analysis itself, however CJRR data is regularly provided to provincial and territorial ministries of health, who may use it for quality improvement and quality assurance activities. The CJRR will occasionally perform an analysis on component type related topics, such as 2013's Analysis in Brief on early revisions and bearing surfaces, and includes some analyses such as fixation method in the CJRR Annual Report.
3. **BENEFICIAL CHANGE:** The CJRR produces general annual reports which are used by provinces with the objective of improving the quality of care and clinical outcomes for joint replacement recipients. The CJRR also produces Analyses in Brief on relevant clinical and administrative topics. Topics are selected

based on CIHI's consultation with its stakeholders and with input from the CJRR Advisory Committee members.

4. **EFFICIENCY:** The data collected come from various sources, namely: i) Orthopedic surgeons, ii) Facilities, iii) Health regions and iv) Provincial ministries of health. Currently, CJRR reporting is mandatory in Ontario, British Columbia and Manitoba. Participation is voluntary in other provinces and territories.

In April 2013, CJRR ended submission by paper form and supported data providers to transition to either the electronic files or the online data entry tool method. Product information can also be scanned. The CJRR has aligned data collection with the International Society of Arthroplasty Registers (ISAR) minimum dataset to increase efficiency. These initiatives have all reduced the burden of data collection for data submitters. Depending on the data submission method chosen, collection of data may be integrated in the care delivery system. British Columbia in particular has modified their operating room booking system to collect the required information, with barcodes entered at point-of-care in the OR.

For the other data providers, the predominant method is to enter the data after the point of care, either in conjunction with the Discharge Abstract Database (DAD) abstract coding or entered into a vendor interface or online through the web-tool.

5. **ACTIONABLE DATA:** Data is provided to data submitters, ministries and the media on request. Third parties make formal requests to the CJRR for data for health research and analysis. The CJRR releases an Annual Report, Analysis in Brief reports, and collaborates with researchers on scientific journal articles and presentations at relevant conferences. Topics for these analyses are selected based on CIHI's consultation with stakeholders in each province and with input from the CJRR Advisory Committee (which is comprised of clinicians, health system decision makers and other stakeholders from across Canada).
6. **TRANSPARENCY:** CJRR is guided by an Advisory Committee comprised of a provincial representative from each province, and a representative from other key arthroplasty stakeholder groups. The Advisory Committee formally meets twice a year, and communicates throughout the year as needed. CJRR produces annual reports to characterize the epidemiology of hip and knee replacement procedures (including elective and urgent cases) performed in Canada. Customized data cuts are also available upon request in a privacy appropriate manner to researchers and health system managers.
7. **LINKABILITY:** Data collected is integrated with the Hospital Morbidity Database (HMDB) and the Discharge Abstract Database, using patient's Health Care Number. CJRR data can be linked to CIHI's other data holdings as well to enable integrated analysis of data from across health care sectors.
8. **TOTAL LIFE-CYCLE:** The CJRR does not currently release manufacturer information for records in the registry to third parties; however CJRR does have the capability to report by manufacturer. The CJRR will occasionally perform an analysis on component type related topics, such as 2013's Analysis in Brief on early revisions and bearing surfaces, and includes some analyses on fixation method in the CJRR Annual Report.

### Vascular

#### Vascular Quality Initiative (VQI)

Scope: it is aiming to be national but did not reach that level yet

1. **DEVICE:** Limited device information
2. **QUALITY SYSTEM:** It is registered as a patient safety organization with the goal of quality improvement.
3. **BENEFICIAL CHANGE:** The registry has been established by Society of vascular surgeons and is gradually engaging multiple stakeholders such as regulators and manufacturers to bring about beneficial change in improving outcomes of vascular surgery. No specific findings of the registry impact on overall outcome improvement in vascular surgery are known.
4. **EFFICIENCY:** Data collection is based on web based data entry and is not yet embedded in care delivery. However, surgeons are very enthusiastically supportive within participating centers.
5. **ACTIONABLE DATA:** Provides reports back to each participating sites. Each center can compare their data against other participating centers in their regional group.

6. **TRANPARENCY:** Analytic process is described. Data access is through specific requests. Regulator does not have direct access to data.
7. **LINKABILITY:** Can be linked with CMS claims and potentially commercial claims to enhance the data and obtain long-term outcomes. However, all linkages have to be probabilistic as it does not have a process to share identifiable patient information with claims data owners.
8. **TOTAL LIFE-CYCLE:** The registry is in a process of working with number of manufacturers to nest clinical trials.

#### Australian Vascular Registry

1. **DEVICE:** There is limited device information for peripheral arterial endovascular procedures but device name and configuration is captured for carotid, aortic, infrainguinal bypass and thoracic prostheses.
2. **QUALITY SYSTEM:** It is a quality assurance activity with outlier identification.
3. **BENEFICIAL CHANGE:** There is an algorithm for dealing with outliers, involving scrutiny of the clinical details by an elected committee which has the power to restrict performance of specific procedures pending retraining if appropriate.
4. **EFFICIENCY:** It is an accepted part of clinical care by means of a web-based interface and is used for unit and personal audit. There is the ability to compare individual or hospital performance in real time with the peer group.
5. **ACTIONABLE DATA:** Data is analyzed annually.
6. **TRANPARENCY:** Processes are transparent and all data access is available to the individual or unit as a printable report to assess procedural or complication data. The AVA has a Chairman of the audit committee, overseeing the process. An administrator provides 24/7 access to a helpdesk and assistance with data entry if required. An elected audit monitoring committee of 4 wise souls is responsible for clinical scrutiny of outliers in a manner that provides natural justice to participants. Data analysis is transparent and methods are explained annually in the report.
7. **LINKABILITY:** There is no data linkage at present due to privacy legislation restrictions. Only hospital discharge outcomes are collected presently.
8. **TOTAL LIFE-CYCLE:** There is the ability in the application to piggy-back modules for additional data entry fields as well as follow up data.

#### Japanese Registry of Endovascular Aneurysm Repair (abdominal and thoracic)

Scope: It is aiming for national registry, but does not reach that level.

1. **DEVICE:** It contains device information which is device identifiable at the attribute level
2. **QUALITY SYSTEM:** There is no data assurance system for validation at present.
3. **BENEFICIAL CHANGE:** Registry has been established by JCSM in collaboration with device manufactures. A brief summary of the data has been released.
4. **EFFICIENCY:** Data collection is based on Web based data entry and is not yet embedded in care delivery.
5. **ACTIONABLE DATA:** The results of data analysis has not been provided sufficiently
6. **TRANPARENCY:** There is a steering committee for managing the registry. The method of data utilization is under discussion.
7. **LINKABILITY:** It does not have a process to share registered data with individual patient information.
8. **TOTAL LIFE-CYCLE:** It is anticipated to utilize for pre-approval and post-approval benefit/risk evaluation in future.

#### Cardiac

##### US Cath-PCI registry

1. **DEVICE:** Captures unique device identification.
2. **QUALITY SYSTEM:** Already part of a quality assurance system – used to evaluate AUC compliance (e.g., publication by Patel M. et al. ), returns information to the provider and institution regarding device usage, complication rates (e.g., acute kidney injury, mortality, length of stay), and other performance improvement opportunities. There are sufficient numbers to accomplish risk adjustment in several

dimensions. The availability of data for performance assessment compared with other institutions provides the perspective needed to understand local performance.

3. **BENEFICIAL CHANGE:** Beneficial change – stakeholders are primarily institutions (contractual) and individual clinicians. Participation is voluntary, and in the US is nearly universal. ACC Interventional Council (representing professional members) has ownership.
4. **EFFICIENCY:** Embedded in the health care delivery system – multiple CVIS and EHR vendors are qualified to send data to the ACC, and as part of the ACC Unified Model and Transmission Specification (UMTS) project, data can be sent via direct data transfer. This is a key area for structured reporting initiative of the ACC/AHA/SCAI (Structured Reporting Health Policy Statement). Several IHE (Integrating the Healthcare Environment) profiles address data standardization and interoperability. However, most institutions enter data via separate (double) data entry.
5. **ACTIONABLE DATA:** Provides actionable information – quarterly reports, and summary administrative reports are returned to the institution and provider specifically addressing performance improvement.
6. **TRANPARENCY:** Governance structure – ACC Interventional Council is the primary owner / steward, NCDR Management Board provides overall governance – but this is not open to the public currently. Public reporting of CathPCI data is currently voluntary, discussions underway to release information for public reporting (in lieu of federal reporting initiatives).
7. **LINKABILITY:** Data integration – internal to ACC only – Symphony (commercial vendor with payer data) is providing the mechanism to integrate health care claims data; information model does not support cross-registry data interoperability (yet)
8. **TOTAL LIFE-CYCLE:** Infrastructure for nesting trials – already demonstrated via the SafePCI study, the additional data needed to accomplish SafePCI was marginal compared with the infrastructure already present via the CathPCI registry.

### Japanese Trans-catheter Valve Therapy (TVT) Registry

Scope: it is aiming to be a national registry

1. **DEVICE:** It has detailed device information which includes unique device identification
2. **QUALITY SYSTEM:** The data is validated through site visit (site audit) which is organized by the National Clinical Database. Identification of outlier is possible if it is requested by the steering committee of Consortium.
3. **BENEFICIAL CHANGE:** Japanese TVT Registry was established by Japanese Consortium of Four Academic Societies in collaboration with PMDA and a manufacturer of TVT device first approved in Japan. It was used as all case surveillance and adverse event report.
4. **EFFICIENCY:** Data collection is conducted with web based data entry, but is not yet embedded in care delivery. Sustained data entry to the registry is mandatory for maintaining the institutional qualification of TAVR procedure.
5. **ACTIONABLE DATA:** The method to report the outcome of individual institution has been under discussion.
6. **TRANPARENCY:** There is a steering committee for overseeing the overall management of registry. The rule of data utilization for academic or regulatory purpose and annual evaluation method has been under discussion.
7. **LINKABILITY:** Linkages with US TVT registry can be done because more than 90% of data elements are coincided.
8. **TOTAL LIFE-CYCLE:** Multiple manufacturers are participating in the registry, which enable to compare the different generation of products and potentially serve for total product life cycle

### Japan PCI

Scope: It is aiming to be national and reached that level

1. **DEVICE:** It has been already functioning as a national registry.
2. **QUALITY SYSTEM:** Random auditing is performed on monthly basis.
3. **BENEFICIAL CHANGE:** It was established by domestic interventional professional society (Japanese Association of Cardiovascular Intervention and Therapeutics: CVIT)
4. **EFFICIENCY:** It reflects both quality improvement and research priorities; identify key data elements and metrics to assess the quality of care for a specified patient population.

5. **ACTIONABLE DATA:** At present, annual report is prepared by the CVIT Scientific Committee and distributed to professional members which include only interventional cardiologists and does not include distributors or manufacturers. The CVIT Scientific Committee of CVIT is currently working to develop real-time feedback system on short-term outcomes for each operator and sites (eg. dashboard).
6. **TRANPARENCY:** Data is available upon approval by scientific committee members, and is open for use to professional members.
7. **LINKABILITY:** Its format and definition is in sync with uniform electrical charting system such as SS-MIX, and could serve as a basic dataset for various clinical studies.
8. **TOTAL LIFE-CYCLE:** The committee is also working towards collaborating with various manufactures to perform post-marketing survey, but has not been formally implemented as of June 2015.

### Japan Adult Cardiovascular Surgery Database

Scope: It has been already functioning as a national registry.

1. **DEVICE:** It has detailed device information which includes unique device identification
2. **QUALITY SYSTEM:** The data is validated through site visit (site audit) which is organized by JACVSD. Identification of outlier has been done for improving the quality of surgical outcome in the particular institution.
3. **BENEFICIAL CHANGE:** JACVSD was established and was led by The Consortium of Japanese Association for Thoracic Surgery and Japanese Society of Cardiovascular Surgery.
4. **EFFICIENCY:** Data collection is conducted by web based data entry system, but is not yet embedded in care delivery. The information of cases registered in JACVDS has been used for qualification of Japanese Board of Surgery and Japanese Board of Cardiovascular Surgery
5. **ACTIONABLE DATA:** The results of data analysis have been released periodically. Risk calculator (Japan score) is available for surgeons.
6. **TRANPARENCY:** There is a steering committee for overseeing the overall management of registry. The rule of data utilization for academic or regulatory purpose and annual evaluation method have been constructed so that multiple papers were published utilizing the data.
7. **LINKABILITY:** Linkages with claim data or other data source has not been constructed.
8. **TOTAL LIFE-CYCLE:** The surgical outcome of descending thoracic aneurysm was used as a control for developing devices for thoracic endovascular aneurysm repair.