Crawling before running: Advanced analytics in orthopaedics research with Matlab

Focus on data quality

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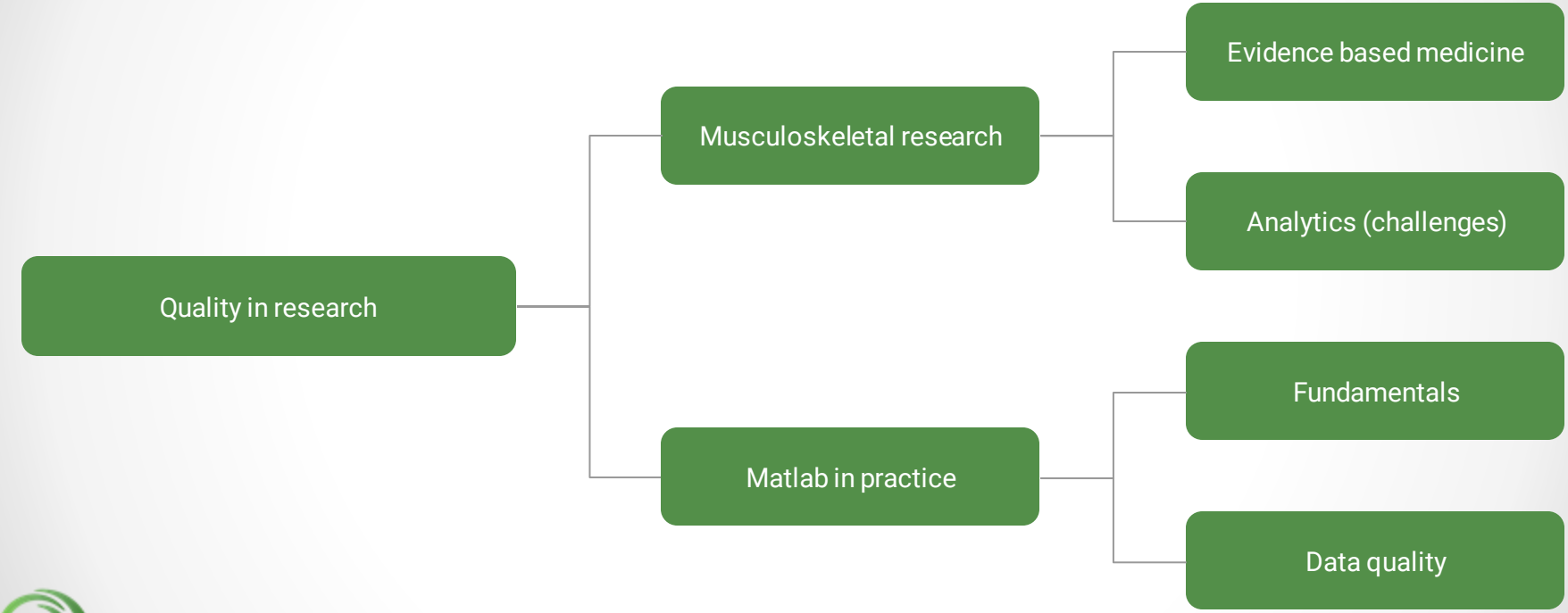
Outline



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Orthopaedic and musculoskeletal conditions

- Encompasses trauma, acute injury and chronic disease
  - Road traffic accident
  - Workplace injury
  - Sports injury
  - Osteoarthritis, tendinopathy, osteopenia

- Nearly every person affected by a musculoskeletal condition at least once in their life

- Social cost of osteoarthritis alone 0.25 - 0.5% of GDP (Puig-Junoy et al 2015)
  - ~$60billion/annum in Australia

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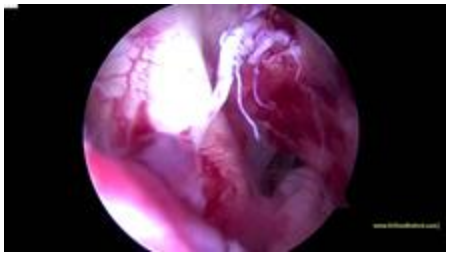
Orthopaedic treatments

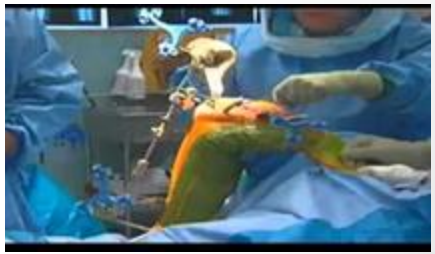
- Effective diagnosis of injury or chronic diseases
- Spectrum of treatment options from non-invasive to very invasive
- Considerations of patient preference, cost, clinical benefit and nature of the condition
- Often applied in combination
  - Ambiguity in best treatment for a specific patient

Soft tissue repair

Exercise therapy



Stem cell injection



Total joint replacement

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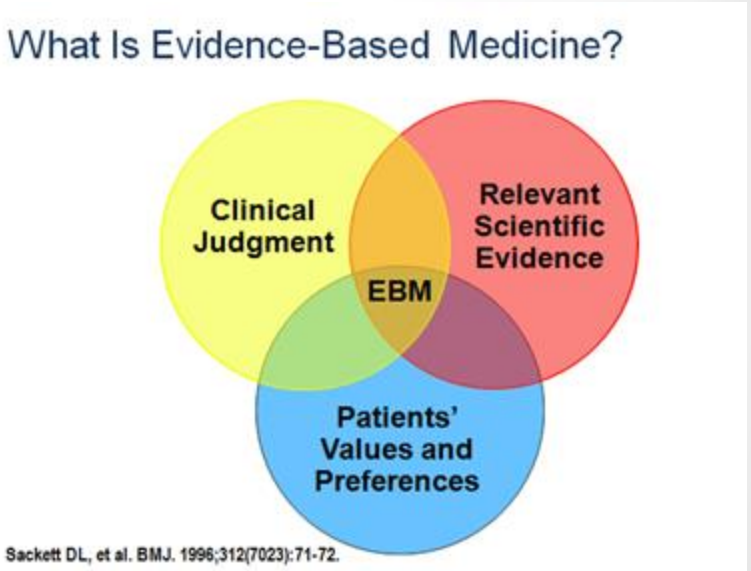
Evidence based medicine

- Attempts to replace folklore, tradition and theoretical reasoning

- Scientific evidence
  - Trials
  - Studies
  - Analyses
  - Systematic reviews
  - Meta-analyses
  - Consensus and practice guidelines

- Patient-centred
  - Expectations
  - Self-reported outcomes



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Our role

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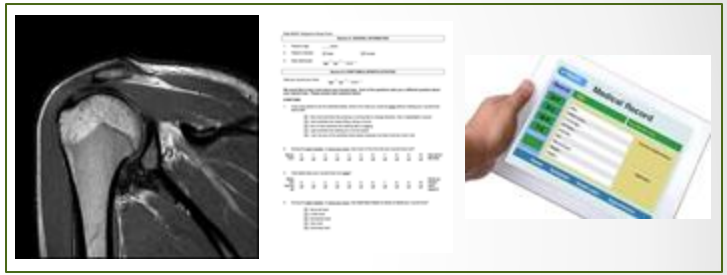
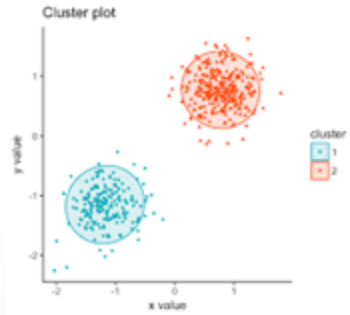
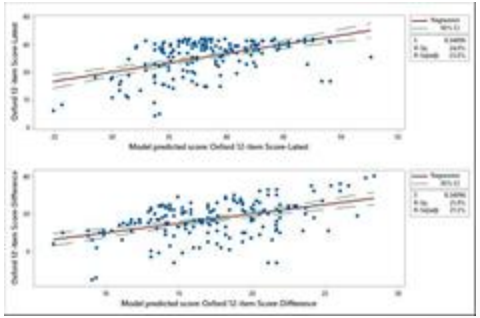
PubMed

Tools and applications

Patient registries







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Analytics

- Underpins evidence generation in EBM
- Required to inform shared-decision making between clinician and patient
- Analytics alone ≠ insight or practice change
- Integration within clinical practice

Figure 1. A continuous learning healthcare system.

Lee and Yoon 2017

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Challenges

Focus on quality

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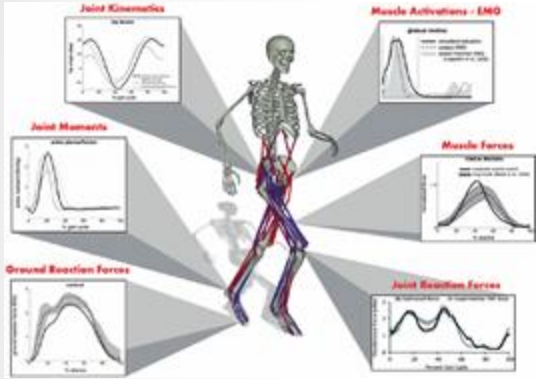
Biomedical research



Ku et al 2015

- Generate relevant scientific evidence for use in clinical practice
- Total global investment of $240billion in health related research and development (Rottingen et al 2015)
- Most clinical research is not useful
  - Replication
  - Insufficient design
  - Inadequate planning
  - Biased methods/interpretation

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Analytics and big data

- Petabytes of health data collected daily by myriad of health providers and associated organisations
  - Government departments
  - Hospital
  - Insurance
  - Device industry
  - Private practice providers
  - Not-for-profit organisations

- 4 V's (Raghupathi et al 2014)
  - Volume
  - Velocity
  - Variety
  - **Veracity**

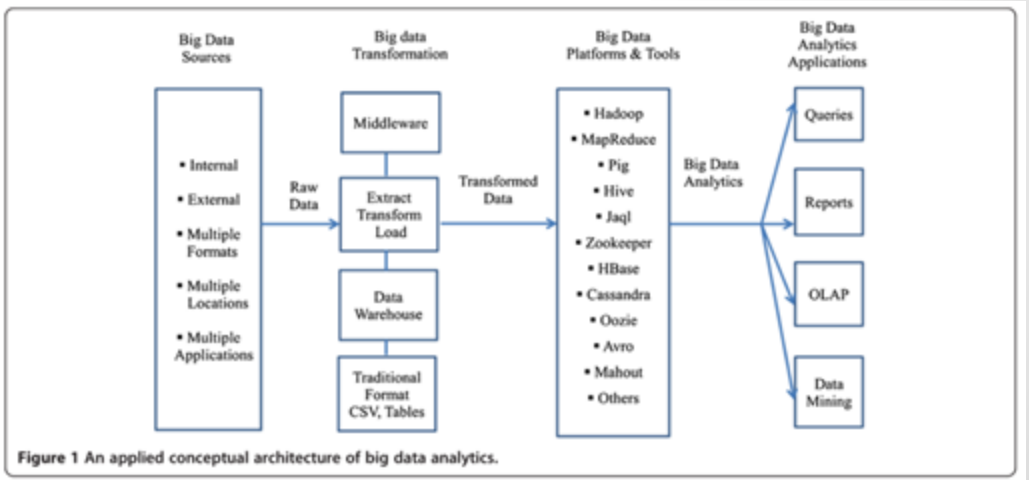

Figure 1 An applied conceptual architecture of big data analytics.

Raghupathi et al 2014

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Data quality

Fundamentals

1. Do we have *all* the relevant patients for analysis?
2. Have they been classified correctly?
3. Do we have complete and accurate data?

Logistics

1. Interoperability of software
2. Data in silos
   a. Definitions
   b. Culture
3. Time and labour requirement to build datasets

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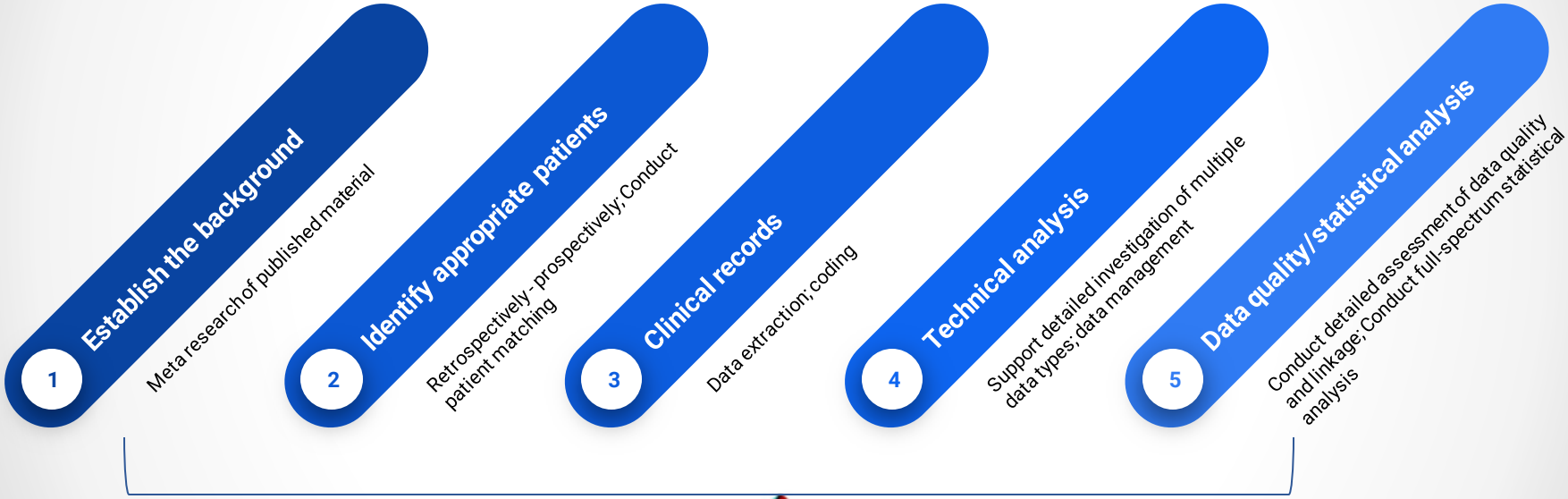
Research process



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MATLAB

Matlab in Practice

Research applications

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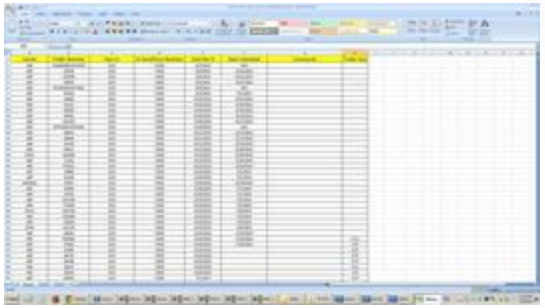
Do we have the right patients?

Patient management systems



Research databases/systems

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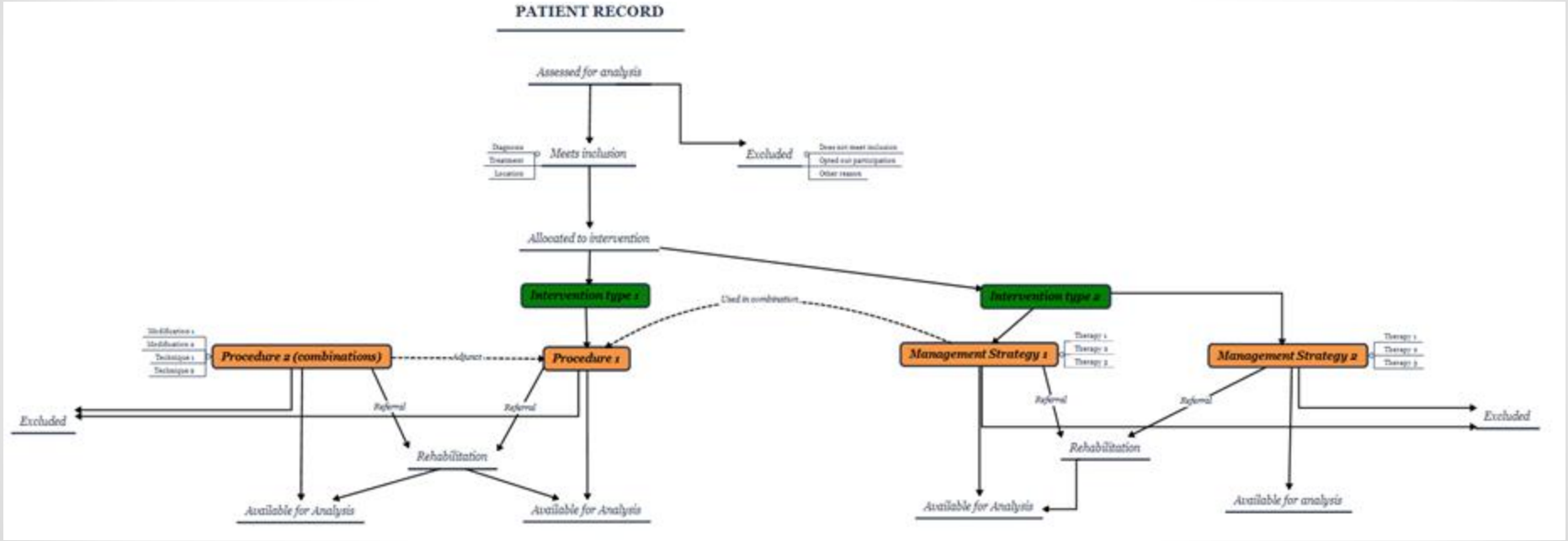
Have we classified patients correctly for analysis?



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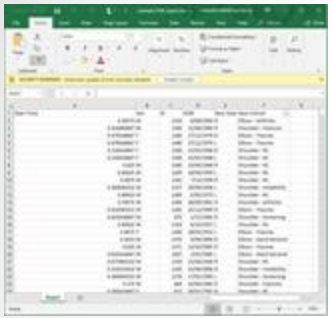
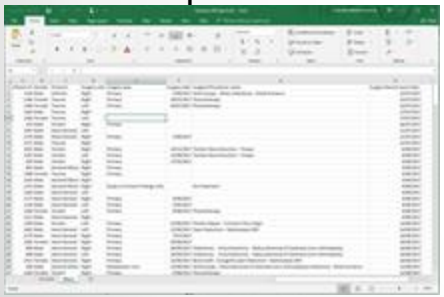
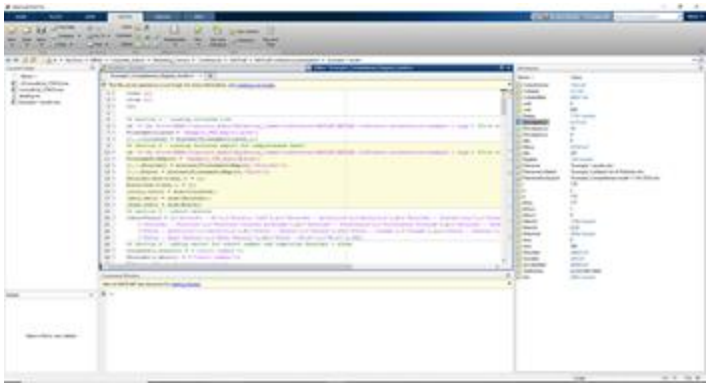
Example 1

PMS spreadsheet

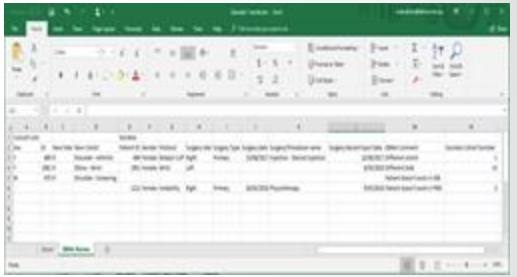


rDB spreadsheet





Output spreadsheet



Results application

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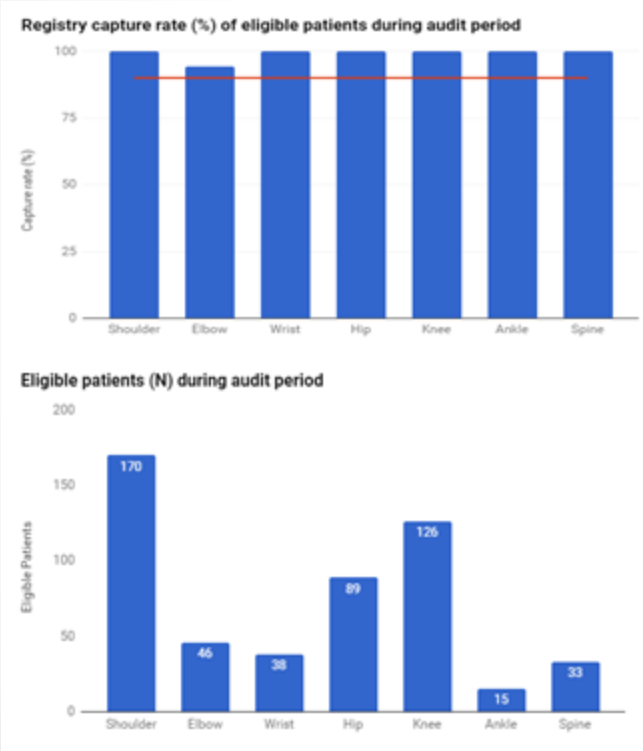
Results and output



Application

- Regular reporting to stakeholders
- Actionable information to iterate processes
- Constant communication with
  - Collecting
  - Interpreting
  - Decision-makers

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Discussion

Key Points

- Source of errors
  - Patient compliance
  - Staff compliance
  - Clinical situation
  - Human error
- Lack of automation
- Process evolution

Key Lessons

- Define inclusion/exclusion criteria
- Regular logic checks
  - Check each patient in the group
- Establish fast feedback with regular reporting

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Musculoskeletal imaging

Magnetic resonance imaging

Key points

- Non-invasive method for visualization of anatomy
- Stimulates water molecules in tissues using strong magnetic fields
- Modification of key parameters alter contrast, sharpness and quantitative information

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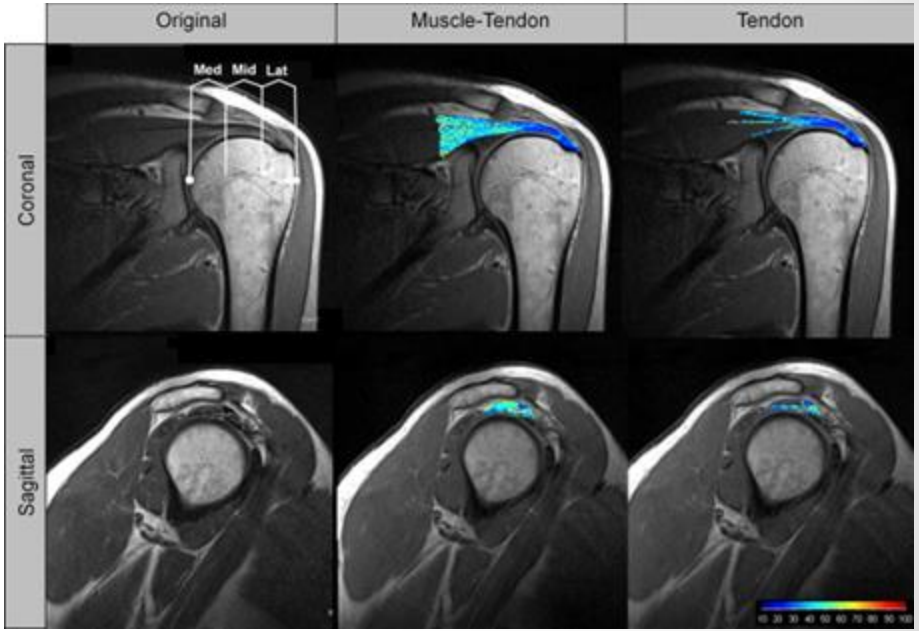
Do we have accurate data for analysis?

Imaging analysis

- Musculoskeletal medicine utilises diverse data
- Imaging data is large, complex and vulnerable to poor quality
- Quality issues can be invisible until too late
  - Analysis at scale

Quantitative mapping



Anz et al 2014

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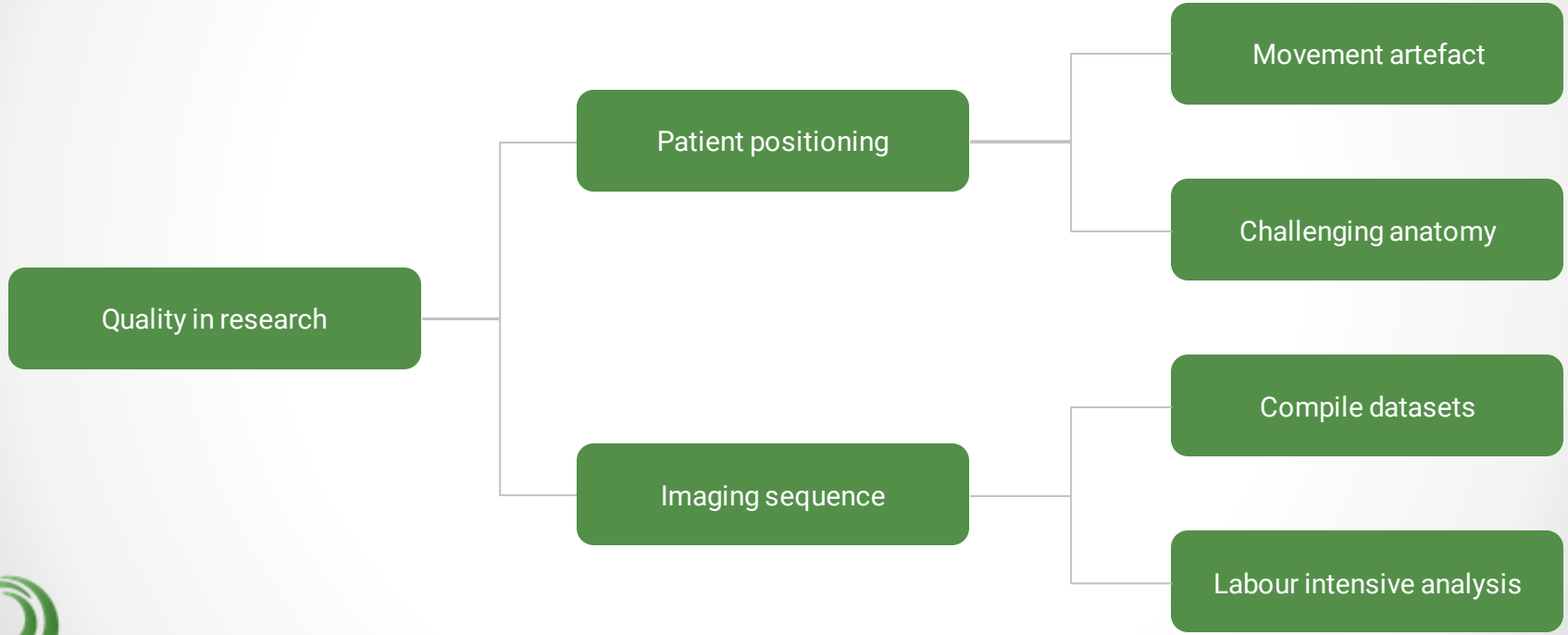
Quantitative imaging



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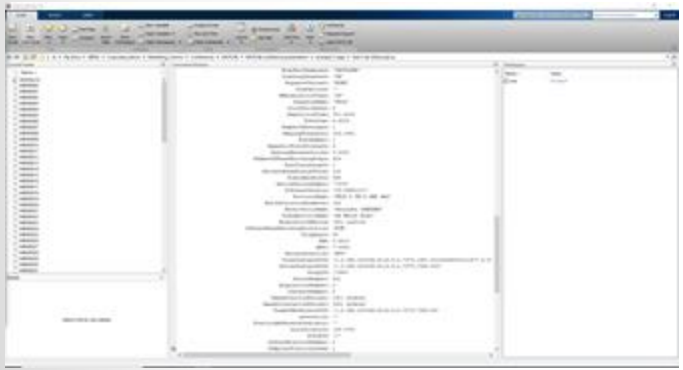
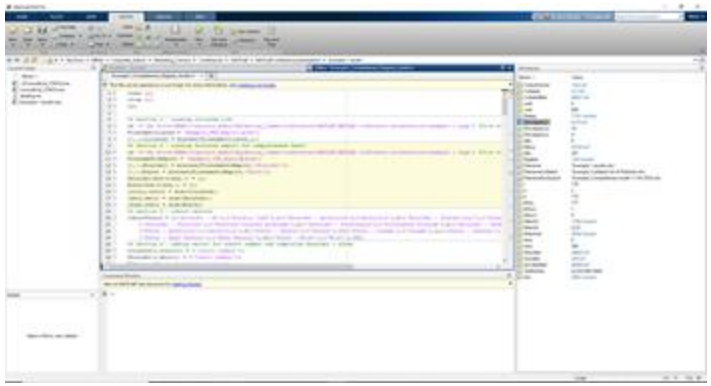
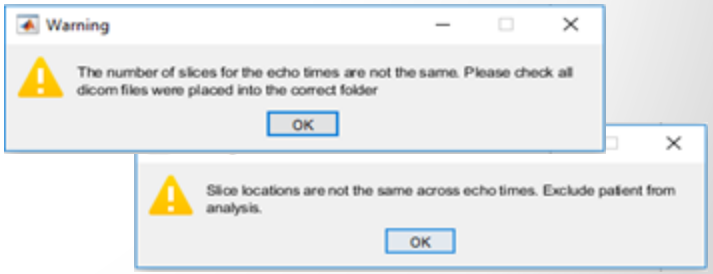
Example 2

Dicom metadata





Output



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Discussion

Key Points

- Source of errors
  - Patient movement
  - Software error
  - Machine malfunction
  - Calibration error
- Lack of automation
- Scale vs quality

Key Lessons

- Clear understanding of sequence and analysis requirements
- Communication with radiography personnel
- Establish solid understanding of latest advances/literature

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Conclusions and Future

Challenges and applications

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Conclusions

Problems solved

- Musculoskeletal medicine and research is data rich
  - Lacking quality
- Labour intensive tasks a barrier to insights and actionable information
- Increased transparency
  - Automation

Key Lessons

- The ability to apply ‘big data’ techniques remains limited
- Poor quality is contributing to imprecise findings within the literature
- More work is required to improve data quality across a range of areas

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Future directions

Challenges

- Countering misleading narratives
  - Poor methodology
  - Lack of quality control
- Disconnect between available treatments/technology and knowledge base
- Time taken to produce quality evidence in EBM

Applications and use

- Distributed deployment of tools
- Broader access to contributors and stakeholders
  - Cloud-based infrastructure
- Refine quality control and pair with emerging analytical tools

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Acknowledgements

- Staff and students
- Clinical partners
- Patients and participants
- Mathworks

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