Crawling before running: Advanced analytics in orthopaedics research with Matlab

Focus on data quality

Corey Scholes, PhD. (Lead Consultant)
Milad Ebrahimi Beng (Hons) (Lead Engineer)
Quality in research

Musculoskeletal research

Matlab in practice

Evidence based medicine

Analytics (challenges)

Fundamentals

Data quality
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
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
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
Our role
Tools and applications

Patient registries
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
Challenges

Focus on quality
Biomedical research

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

Ku et al 2015
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

Raghupathi et al 2014
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
Research process

1. Establish the background
   - Meta research of published material

2. Identify appropriate patients
   - Retrospectively, prospectively; Conduct patient matching

3. Clinical records
   - Data extraction; coding

4. Technical analysis
   - Support detailed investigation of multiple data types; data management

5. Data quality/statistical analysis
   - Conduct detailed assessment of data quality and linkage; Conduct full-spectrum statistical analysis
Matlab in Practice

Research applications
Do we have the right patients?

Patient management systems

Research databases/systems
Have we classified patients correctly for analysis?
Example 1

PMS spreadsheet  →  Output spreadsheet

rDB spreadsheet →  Results application
Results and output

Application

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

Key Points

• Source of errors
  o Patient compliance
  o Staff compliance
  o Clinical situation
  o Human error

• Lack of automation

• Process evolution

Key Lessons

• Define inclusion/exclusion criteria

• Regular logic checks
  o Check each patient in the group

• Establish fast feedback with regular reporting
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
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
Quantitative imaging

- Quality in research
  - Patient positioning
    - Movement artefact
    - Challenging anatomy
  - Imaging sequence
    - Compile datasets
    - Labour intensive analysis
Discussion

Key Points

• Source of errors
  o Patient movement
  o Software error
  o Machine malfunction
  o 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
Conclusions and Future

Challenges and applications
Conclusions

Problems solved

• Musculoskeletal medicine and research is data rich
  o Lacking quality

• Labour intensive tasks a barrier to insights and actionable information

• Increased transparency
  o 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
Future directions

Challenges

• Countering misleading narratives
  o Poor methodology
  o 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
  o Cloud-based infrastructure

• Refine quality control and pair with emerging analytical tools
Acknowledgements

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