Time to Event Analysis of Arthroplasty Registry Data

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ABSTRACT

Background: Arthroplasty registry data are traditionally analysed using standard survival methods, that is, Kaplan-Meier survival curves and the Cox proportional hazards model. The outcome of interest is usually the time from the primary procedure until occurrence of a single event – revision of the prosthesis. Other outcomes may also be of interest, for example, time to death, time to receiving another arthroplasty and the association between covariates and these events. The rise in life expectancy of the population combined with an increasing number of joint replacements being performed has resulted in many patients experiencing several joint replacement procedures during their lifetime. The analyses of registry data such as these require the use of more sophisticated statistical methods. Application and evaluation of statistical methods to analyse registry data containing complex arthroplasty histories are lacking.

Aim: The aim of this thesis was to investigate the use of statistical methods in the analysis of multiple event data contained in arthroplasty registries. Within this broad aim the objectives were to investigate the use of competing risks methods in estimating the risk and rate of revision, investigate methods for handling covariates with time-varying effect, investigate the use of multi-state modelling techniques in providing a more comprehensive analysis and description of complex arthroplasty histories than traditional survival methods and to develop a notation system to facilitate the description and analysis of arthroplasty event history data.

Methods: Data were obtained from the Australian Orthopaedic Association National Joint Replacement Registry and the Norwegian Arthroplasty Register. Estimates of revision from the Kaplan-Meier method were compared to estimates from the cumulative incidence function which accounts for the competing risk of death. Effects of covariates on the rate and risk of revision were estimated with competing risk regression and compared to estimates from the Cox proportional hazards model.
Multi-state models were set up and applied to the data. The Summary Notation for Arthroplasty Histories (SNAH) was developed in order to help manage and analyse this type of data.

Results: The Kaplan-Meier method substantially overestimated the risk of revision compared to estimates using competing risks methods when the incidence of the competing risk of death was high. The influence of some covariates on the hazard rate was different to the influence on the actual probability of occurrence of the event as this was modulated by their relationship with the competing event. Multi-state models, in combination with SNAH codes, were well suited to the management and analysis of arthroplasty registry data on patients who had multiple joint procedures over time. Multi-state modelling techniques proved useful in the investigation of the progression of end-stage osteoarthritis in data from two national arthroplasty registries.

Conclusion: In the presence of competing risks, the Kaplan-Meier method may lead to biased estimates of the risk of revision, and hazard ratios obtained from the Cox proportional hazards model and competing risks regression models need to be interpreted with care. Multi-state models provide a useful tool to analyse data containing complex arthroplasty histories.


_**Declaration**_

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Manuscripts Contributing to this Thesis


Supplementary article data: [http://www.actaorthop.org/sup_files/5260_SAD.pdf](http://www.actaorthop.org/sup_files/5260_SAD.pdf)

Presentations Arising from this Thesis

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Gillam MH. Investigation of the progression of end stage osteoarthritis using data from the Australian and Norwegian joint replacement registries. School of Population Health Seminar Series. Adelaide, August 2012.

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Abbreviations

AOANJRR: Australian Orthopaedic Association National Joint Replacement Registry

CIF: Cumulative Incidence Function

Cox PH: Cox Proportional Hazards

CPR: Cumulative Percent Revision

FNOF: Fractured Neck of Femur

HR: Hazard Ratio

KM: Kaplan-Meier

NAR: Norwegian Arthroplasty Register

OA: Osteoarthritis

RD: Relative Differences

SNAH: Summary Notation for Arthroplasty Histories

SubHR: Subdistribution Hazard

THA: Total Hip Arthroplasty

TKA: Total Knee Arthroplasty