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# Long and Short Term Risk of Death for Total Hip Replacement Cases in United Kingdom - A Matched Retrospective Cohort Study of 10,155 THR Cases.

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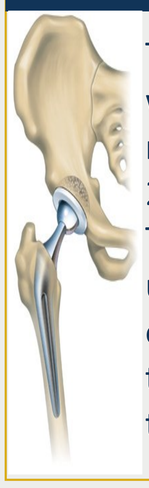
## Abstract

Number of total hip replacement (THR) procedures is increasing worldwide. We analysed the short and long term post-operative hazard of death for 10,155 THR patients' data from THIN database. Post-THR hazard ratio of death relative to matched controls is 1.49 and 1.08 in the short and long term respectively.

## Background Information



The number of THR procedures have increased worldwide [1,2] as well as in the United Kingdom where the average yearly increase in number of THR procedures have consistently been 8% [3] since 2008. This trend has significant impacts for the actuarial industry. The number of life assurance, pension and annuity customers undergoing THR procedures is expected to grow. The management of mortality and longevity risk associated with THR procedures in the short and long term for actuarial purposes is an area that needs to be addressed.

## Objective

In this project, the primary objective is to identify variations in mortality and longevity risk in the short and long term after THR procedures.

## Methods

The study design is a retrospective matched cohort study. Patients who underwent primary THR procedure (cases) were selected from The Health Improvement Network (THIN) database. For each case, 3, 4 or 5 controls matched on gender, year of birth and general practitioners (GP practice) were randomly selected from the same population and clustered by GP practice. A Gamma shared frailty Cox regression model [4] of the form shown below, are used to estimate the short and long term effect of THR procedure on the hazard of death, $\lambda_{ki}$, for the $i^{th}$ individual with a set of $Z$ covariates, described in Table 1, from the $K^{th}$ GP practice. A cluster effect, $\varepsilon_k$, is added to estimate the frailty associated with each GP practice.

$$\lambda_{ki} = \varepsilon_k \lambda_0(t) exp(\beta^T Z_{ki})$$

## Results

A total of 10,155 primary THR cases and 49,559 controls were investigated. It is observed THR procedure increase the hazard of death in the short ($HR_{short}$) and long ($HR_{long}$) term. 968 THR cases died within a 2 year period after their THR surgery with estimated $HR_{short}$=1.49 while those surviving more than 2 years after THR procedure had an estimated $HR_{long}$=1.08.

Male cases have higher risk of death than female cases ($HR_{short}$=1.31, $HR_{long}$=1.18). $HR_{short}$ and $HR_{long}$ increase by 0.31 and 0.18 respectively for every unit increase in age of patients at time of THR. Being a smoker raises $HR_{short}$ and $HR_{long}$ by 0.37 and 0.17.

Living in an area where proportion of white individuals exceed more than 20% increases $HR_{short}$ only. The more deprived the residential ward of THR cases, the higher is their $HR_{short}$ and $HR_{long}$ after surgery as displayed in Table 2.

Blood pressure (BP), body mass index (BMI), cholesterol level (Choles), osteoporosis (OS), osteopenia (OP), myocardial infarction (MI), angina, osteoarthritis (OA) and rheumatoid arthritis (RA) before THR procedure, increase $HR_{short}$ and $HR_{long}$ for THR cases as described in Table 2.

Only having Type II diabetes ($HR_{short}$=0.99, $HR_{long}$=0.97) and being obese ($HR_{long}$=0.92 only), both prior to surgery, improve the risk of death after THR procedure.

## Data Description and Analysis Results

| Description of Patients' Characteristics | | Cases | Controls |
|---|---|---|---|
| Total number of patients | | 10155 | 49559 |
| Gender | Male | 38% | 37% |
| | Female | 62% | 63% |
| Category of Year of birth | Cat A (1920-24) | 32% | 32% |
| | Cat B (1925-29) | 26% | 26% |
| | Cat C (1930-34) | 22% | 22% |
| | Cat D (1935-40) | 20% | 20% |
| Smoking Status | Current smoker | 9% | 9% |
| | Non-smoker | 54% | 47% |
| | Ex-smoker | 37% | 44% |
| Body Mass Index (BMI) Category | Normal | 61% | 64% |
| | Obese | 12% | 11% |
| | Pre-Obese | 28% | 15% |
| | Underweight | 0% | 10% |
| Townsend Score | Quintile 1 | 30% | 37% |
| | Quintile 2 | 24% | 21% |
| | Quintile 3 | 20% | 18% |
| | Quintile 4 | 16% | 15% |
| | Quintile 5 | 9% | 8% |
| | Unknown | 11% | 11% |
| Urban-Rural Classification | Rural | 88% | 88% |
| | Urban | 1% | 2% |
| Proportion of white individuals living in same residential area as patients | Quintile 1 | 11% | 11% |
| | Quintile 2 | 19% | 20% |
| | Quintile 3 | 21% | 21% |
| | Quintile 4 | 19% | 19% |
| | Quintile 5 | 16% | 16% |
| | Quintile 6 | 14% | 14% |
| Type of THR procedures | Unilateral | 82% | Not Applicable |
| | Bilateral | 18% | |
| Type of THR procedures fixation | Cemented | 36% | Not Applicable |
| | Uncemented | 54% | |
| | Hybrid | 9% | |
| Osteoarthritis (OA) | Yes | 43% | 33% |
| | No | 57% | 67% |
| Rheumatoid Arthritis (RA) | Yes | 7% | 4% |
| | No | 93% | 96% |
| Hip Fracture (HF) | Yes | 2% | Not Applicable |
| | No | 98% | |

Table 1

| Estimated Hazard Rates | | | |
|---|---|---|---|
| Variables | Levels | Short Term | Long Term |
| Cases versus Controls (CC) | Case | 1.49 | 1.08 |
| Year of birth category (YOB) | Cat B | 1.57 | 1.09 |
| | Cat C | 1.55 | 1.06 |
| | Cat D | 1.37 | 1.02 |
| Gender | Male | 1.31 | 1.18 |
| Smoking status pre-surgery time (SMOKE) | Current | 1.37 | 1.17 |
| | Ex-smoker | 1.20 | 1.01 |
| Age at time of THR surgery | N/A | 1.18 | 1.01 |
| Urban/rural classification of patients residential | Rural | 1.08 | 1.01 |
| Proportion of white individuals in patients residential ward (WHITE) | Quintile = 2 | 1.20 | |
| | Quintile = 3 | 1.08 | Not |
| | Quintile = 4 | 1.15 | Applicable |
| | Quintile = 5 | 1.10 | |
| Townsend score of patients residential ward (TOWNSEND) | Score = 2 | 1.09 | 1.02 |
| | Score = 3 | 1.17 | 1.10 |
| | Score = 4 | 1.19 | 1.16 |
| | Score = 5 | 1.20 | 1.21 |
| BP category pre-surgery time (BP) | Pre-hypertension | 1.20 | 1.02 |
| | High | 1.39 | 1.10 |
| BMI category pre-surgery time (BMI) | Obese | 1.09 | 0.92 |
| | Pre-obese | 1.08 | 1.09 |
| | Underweight | 1.07 | 1.04 |
| Cholesterol category pre-surgery time (CHOLES) | High | 1.08 | 1.06 |
| | On Medication | 1.09 | 1.03 |
| BMD category pre-surgery time | Osteoporosis | 1.07 | 1.04 |
| | Osteopenia | 1.09 | 1.03 |
| Type II Diabetes status pre-surgery time | Yes | 0.99 | 0.97 |
| Myocardial Infarction | Yes | 1.43 | 1.33 |
| Angina | Yes | 1.33 | 1.14 |
| Ostearthitis diagnosis | Yes | 1.10 | 1.04 |
| Rheumatoid arthritis diagnosis | Yes | 1.22 | 1.14 |
| CC:YOB | Case:Cat B | 1.42 | 1.03 |
| | Case:Cat C | 1.38 | 1.07 |
| | Case:Cat D | 1.31 | 1.11 |
| CC:Gender | Case:Male | 1.25 | 1.03 |
| CC:Age at time of surgery | Case:Age | 1.06 | 1.01 |
| CC:WHITE | Case:Quintile = 2 | 1.12 | |
| | Case:Quintile = 3 | 1.09 | Not |
| | Case:Quintile = 4 | 1.04 | Applicable |
| | Case:Quintile = 5 | 1.11 | |
| CC:TOWNSEND | Case:Score = 2 | 1.12 | 1.01 |
| | Case:Score = 3 | 1.15 | 1.03 |
| | Case:Score = 4 | 1.18 | 1.04 |
| | Case:Score = 5 | 1.16 | 1.05 |
| CC:BP | Case:Prehypertension | 1.17 | 1.09 |
| | Case:High | 1.11 | 1.01 |
| CC:BMI | Case:Pre-obese | Not | 1.10 |
| | Case:Obese | Applicable | 1.12 |
| CC:CHOLES | Case:High | 1.12 | 1.06 |
| | Case:On Medication | 1.06 | 1.03 |
| CC:DIABETES | Case:Type II diabetes | 1.05 | 1.12 |
| YOB:Gender | Cat B:Male | 1.19 | Not |
| | Cat C:Male | 1.16 | Applicable |
| | Cat D:Male | 1.11 | |
| Gender:SMOKE | Male:Current | 1.16 | 1.09 |
| | Male:Ex-smoker | 1.10 | 1.06 |
| SMOKE:DIABETES | Current:Type 2 diabetes | 1.19 | 1.09 |
| | Ex-smoker:Type 2 diabetes | 1.09 | 1.03 |
| BP:BMI | Pre-hypertension:Obese | 1.10 | |
| | Pre-hypertension:Pre-obese | 1.03 | |
| | Pre-hypertension:Underwei | 1.12 | Not |
| | High BP:Obese | 1.20 | Applicable |
| | High BP:Pre-obese | 1.10 | |
| | High BP:Underweight | 1.19 | |
| BP:CHOLES | Pre-hypertension:High Chol | 1.19 | |
| | Pre-hypertension:On Medic | 1.13 | Not |
| | High BP:High Choles | 1.23 | Applicable |
| | High BP:On Medication | 1.15 | |

Table 2

DATA ANALYSIS DATA ANALYSIS DATA ANALYSIS

## Novelty of Research

This current research provides a direct comparison of the effects of THR procedures on the risk of death by taking into account the cluster effects into the analysis. No such studies have accounted for the differences between each GP practice or centre of surgery in literature by the use of frailties.

## Conclusion

THR procedures cause an increase in risk of death in the short and long term creating a source of basis risk for actuaries.

Life assurance, pension and annuity customers undergoing THR will have a higher mortality risk within 2 years post-THR surgery and that risk will fall if the customers survive more than 2 years.

Premium of life assurance customers undergoing THR surgery should be adjusted to accommodate for the increase in mortality risk after THR procedures.

Benefits allocated to pension and annuity customers undergoing THR procedure should be adjusted to reflect the higher hazard of death after THR procedures. This gives rise to the need to develop more pension and enhanced annuity products.

## Limitation

The results of the analysis showed significant variations (P<0.001) in the frailty associated with each GP practice. However no spatial description of the GP practice is available in the THIN database. Therefore a spatial analysis of the frailty associated with each GP practice after THR procedures cannot be carried out.

## Future Research

The THIN data analysis depicted significant variations in mortality across each GP practice. The existence of a spatial distribution of the risk of death after THR procedures can be hypothesised. Future works in this project involves the use of the National Joint Registry (NJR) data to carry out a spatial analysis of the risk of death after THR procedures.

## Acknowledgement

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## References

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