TITLE

Primary care referral for knee MRI in the United Kingdom: Association with patient demographics and subsequent surgical intervention.

ABSTRACT

BACKGROUND

Since 2008 primary care physicians (GPs) in our region have been allowed open access to knee MRI scans. There are questions about whether this changes referral practice and if it is an effective use of resources.

PURPOSE

To describe the change in demographics of patients referred for knee MRI following implementation of a new referral pathway.

STUDY TYPE

Retrospective observational study.

POPULATION

All primary care referrals between 2008 and 2015 for knee MRI from a population of 900,000.

FIELD STRENGTH/SEQUENCE

Not applicable.

ASSESSMENT

Demographic profile and number of knee MRI referrals and subsequent arthroscopies.

STATISTICAL TESTS

Comparisons between urban and rural populations used T-test. Test for normality used Shapiro-Wilk. Comparison between abnormal MRI proportions used Chi-squared test.

RESULTS

There were 23928 knee MRI referrals (10695 from GPs) between 2000 and 2015.

MRI knee referrals rose from 210 in 2008 to 2379 in 2015. The average age of the patient decreased from 46.8 (SD=14.9) in 2008 to 41.3 (SD=14.7) in 2015. Conversion to arthroscopy declined from 15.4% to 10.2% but there was no significant change in abnormal scan proportion.

Conversion rates showed no significant difference between rural (9.6%) and urban populations (10.5%). Referral rates were significantly higher in low socioeconomic status areas (47.3% vs 34.6%). The median referral rate per 1,000 patients was 13.8 (IQR=8.4). Referral rates varied widely between practices.

DATA CONCLUSION

Despite a large rise in knee MRI referrals from primary care there has been no substantial change in the age profile, suggesting that there has been no increase in inappropriate referral of elderly patients in whom MRI is unlikely to influence management. A modest decrease in conversion rate to arthroscopy may be reasonably offset against a decrease in secondary care referrals. Socioeconomic status of the target population must be considered when planning primary care knee MRI services.

KEYWORDS:

Knee MRI, primary care referral, open access, MRI value

INTRODUCTION

MR imaging can be an accurate and non-invasive method of diagnosing internal derangements of the knee (1). Most patients with knee problems present first to their primary care physician, known as general practitioners (GPs) in the UK (2). A proportion of these patients cannot be managed with conservative methods. In the National Health Service (NHS) in the UK the traditional patient pathway has been to refer to a consultant orthopaedic surgeon to see if they are suitable for surgical intervention. For some of these patients an orthopaedic surgeon might request an MRI scan to confirm a diagnosis or plan surgery.

In the last ten years it has become increasingly common for GPs in the NHS to refer patients directly to radiology departments for MRI of the knee, instead of or prior to requesting an orthopaedic opinion (3). This has been seen as an alternative pathway for patients where capacity in orthopaedic clinics is limited (4, 5). Prior to 2008, our institution only accepted MRI knee requests from hospital specialists, predominantly orthopaedic surgeons and rheumatologists. Our institution began to provide open access to knee MRI to GPs in 2008. All MRI requests, regardless of referrer, must have been vetted by a radiologist prior to the scan. The number of knee MRI examinations performed for primary care has increased at our institution from 227 in 2008 to 2174 in 2015.

However, it has been suggested that open primary care access to knee MRI may not be an effective use of resources, leading to increased costs without improved outcomes (6, 7). Moreover, the role of imaging in several musculoskeletal pathways has recently been challenged. For example, current National Institute of Health and Care Excellence (NICE) guidelines state that there is no role for imaging in the

routine diagnosis of osteoarthritis (OA) (8). There is also doubt that arthroscopic interventions such as partial meniscectomies or washouts are effective, especially in older (>35 years old) patients (9, 10). As the reason for performing MRI examination in a substantial number of patients in this age group would traditionally have been to determine suitability for such interventions, the relevance of MRI for this indication ("?meniscal tear") is increasingly being called into question.

On this background there is concern that providing open access to knee MRI for GPs may lead to rapid rises in the number of MRI examinations without any useful changes in clinical management and in particular decreasing proportions of patients progressing from MRI to surgical intervention. To date there are no published data that describe the relationship between primary care referral for knee MRI as an intervention and surgery as an outcome.

Therefore, the primary aim of this study was to measure the proportion of patients being referred for knee MRI from primary care who subsequently go onto arthroscopy, and how this proportion varies with age and how it has changed following implementation of GP open access. The secondary aims were to measure the degree of variability in referral practices between GP practices, rural and urban environments, and socioeconomic status of patients. This is important as wide variability in referral practices may be an indicator of poor quality care (11).

MATERIALS AND METHODS

This retrospective observational study was part of a registered service evaluation of the primary care referrals to the Department of Radiology at a large teaching hospital. As this was a service evaluation, the requirement for research ethics approval and informed consent was waived.

Patient selection & number of MRI referrals

A database search was carried out within the radiology information system (RIS) for all MRI knee referrals from 2000 to 2015.This database was filtered to obtain MRI knee referrals from GPs only between 2008 and 2015, which is from when direct primary care referral became available. The age, sex, GP code, GP practice code, and postcode for each patient were recorded.

Proportion of abnormal knee MRI examinations

The reports of knee MRI scans from 2008 were evaluated to determine the number of abnormal versus normal/near-normal examinations. A normal or near-normal scan was defined as demonstrating no significant intra-articular pathology (e.g. no meniscal/ligamentous tear, no osteochondral pathology and no significant extensor mechanism disruption). Scan reports from 2015 were randomly sorted in Excel, and a consecutive number (equal to that of 2008), were evaluated to determine the change in rate of abnormal reports.

Arthroscopy

A parallel search was performed on the orthopaedic database for interventions from 2008 to June 2018. Only arthroscopic interventions were included. Joint replacements were excluded as the decision to operate would have been based on plain radiograph and clinical examination rather than MRI findings.

A script was written in Microsoft Excel to combine the two datasets using the patients' hospital numbers in order to identify the number of patients who underwent a surgical intervention after an MRI examination of the same knee. If a patient had multiple MRI scans prior to arthroscopy, only the latest scan preceding the arthroscopy was counted as relevant.

A 2.5 years follow-up interval between MRI and arthroscopy was set based on the end of MRI data capture in 2015 and the end of surgical data capture in June 2018. This is to allow for the inclusion of patients who choose to delay their intervention as the orthopaedic clinic allows patients to return at a later date at the discretion of the surgeon. The operation notes for patients whose arthroscopy occurred beyond 2.5 years following the scan were reviewed to check whether the indication was related to the MRI findings.

Patient socioeconomic characteristics

Our institution's catchment includes a mix of urban and rural populations. The variability in referral patterns by locality was performed by categorising each patient as living in either an urban or rural location based on the Rural-Urban Classification

(12) for the Census Lower Super Output Area zone that their home postcode was assigned to.

As a measure of neighbourhood socioeconomic status, the Index of Multiple Deprivation (IMD) score (13) was obtained for each patient based on the Census Lower Super Output Area zone that their home postcode was allocated to. The IMD is an England-wide score calculated by the British Department for Communities and Local Government, assigning a score to each postcode based on seven distinct domains of income, employment, health and disability, barriers to housing and services, living environment, crime, and education, skills and training. It is a measure of relative deprivation comparing one postcode to another, and is not a measure of affluence.

Statistical analysis

Participant characteristics, raw number of knee MRI examinations from primary care referrals performed per year and the percentage of knee MRI referrals originating from primary care per year were analysed using descriptive statistics. Differences in referral rates, and mean age at referral between rural and urban populations were analysed using Student's *t* tests.

We compared the proportion of abnormal knee MRI scans in 2008 and 2015 using a chi-squared test.

Knee MRI examination to arthroscopic surgery conversion rate was analysed for each year using simple percentages. This analysis was also performed stratified by

patient age, rural vs urban location and IMD score. Differences in conversion rate between rural and urban location were analysed using Student's *t* tests.

The frequency of knee MRI referral per 1,000 practice population was calculated for each included GP practice. The normality of the distribution of these frequencies was analysed using visual inspection of the frequency histogram and the Shapiro-Wilk test.

All statistical analyses were performed in Microsoft Excel. We considered $p < 0.05$ to be statistically significant, without multiple comparison correction.

RESULTS

Patient characteristics & number of MRI referrals

A total of 23928 MRI knee referrals were made between 2000 and 2015 from 93 GP practices. GP requests for MRI knees rose from 210 (16.7% of all knee MRI requests) in 2008, the year when the direct referral pathway was opened, to 2379 in 2015 (70.5% of all knee MRI requests) (Figure 1).

There were a total of 10695 GP referral knee MRIs performed between 2008 and 2015, with 1047 subsequent interventions. 275 scans were excluded due to the patient's GP practice code being incorrectly recorded, leaving 10420 cases. There was a steady increase in MRI numbers from 2008 to 2015 with a peak of 2646 in 2014 (Table 1). The mean age of patient at MRI demonstrated a decrease from 46.8 years (SD=14.7) in 2008 to 41.3 years (SD=14.9) in 2015. The mean age for the 8-year period was 44.5 years (SD=15.6) (Figure 2).

Rate of abnormal MRI scans

There were 178 abnormal (78.4%) out of a total of 227 scans in 2008. A random sample of an equal number of scans showed 171 abnormal scans (75.3%) in 2015. There was no significant difference between the two years (p=0.46). The sample size was adequately powered (beta = 0.8) to detect a change in abnormal proportion of greater than 10% which we considered the threshold for a meaningful change in practice.

Arthroscopy

37 out of 1047 (3.5%) surgical interventions occurred after 2.5 years. The indications for all these arthroscopies were obtained from the operation notes and were found to be directly related to the MRI scan.

The number of operations demonstrated a much more limited increase (Figure 1). The conversion rate to arthroscopy as a percentage of number of MRIs performed showed a steady decline during this time from 15.4% to 10.2% (Table 1, Figure 1). The age at operation shows a bimodal distribution with peaks in the second and fourth decades (Figure 3). The conversion rate to arthroscopy showed a steady decline with increasing age from a peak in the second decade of 14.7% down to 3.3% in the 9th decade (Figure 4).

Patient socioeconomic characteristics

Rural versus Urban

The number of MRI referrals for rural (n=4930) and urban (n=5425) populations showed a similar increasing trend between 2008 and 2015 (Table 1). The number of subsequent interventions over this time period was 478 rural and 569 urban, giving conversion rates of 9.6% rural and 10.5% urban, which were not statistically significantly different (p=0.62). The conversion rates showed decreases from 2008 to 2015 from 14.7% to 10.1% for rural and from 16.2% to 10.3% for urban (Table 1).

The mean age at MRI was 46.0 for rural and 43.2 for urban. Both showed a decline between 2008 and 2015; 49.2 (SD=14.8) to 43.2 (SD=15.4) for rural and 46.8 (SD=14.6) to 41.3 (SD=14.5) for urban (p=0.03, t-test) (Figure 5).

Deprivation Index

The median deprivation index for all MRI referrals was 13.9 (IQR 9.4–20.9). This was significantly lower than the median deprivation index for the primary care referral population (median 18.1, IQR 7.7-28.1) (p<0.001, t-test) (Figure 6). Fewer than 34.56% (n= 3601) of the patients referred for knee MRI were in the Deprivation Deciles of more than 5 compared to 47.25% of the general population in this category (14).

Variation between General Practices

The frequency distribution of referrals per practice per 1,000 patient population demonstrated a non-parametric distribution (Shapiro-Wilk p = 0.002). The median referral rate was 13.8 per 1,000 with an interquartile range of 8.4 to 21.6 (Figure 7).

The median number of patients going onto arthroscopy was 1.47 per 1,000 with an interquartile range of 0.95 to 2.28.

DISCUSSION

There has been a steady increase in the number of referrals for knee MRI from primary care, starting in 2008 and peaking in 2014 in our institution. These now make up the majority of requests and have substantially overtaken requests from hospital consultants, who have consistently referred about 1000 patients per year for the last 10 years. This rapid rise in referral for knee MRI has been mirrored in other countries with different healthcare systems. In Australia the national insurance based health-care system has been overwhelmed by a rise in knee MRI costs from $16 million to $38 million in a single year. Attempts at limiting this demand have been controversial (15).

There was no meaningful difference in the proportion of abnormal MRI scans between 2008 and 2015. The fact that a large increase in the number of scans performed has not led to a large increase in the proportion of normal or near-normal studies suggests that MRI referral is being used appropriately by our primary care referrers.

As the number of MRIs performed has increased, the rate of conversion to surgical interventions has decreased from 15.4% to 10.2%. There are two possible explanations for this. The first is that surgical capacity may not have kept up with increasing demand. This is probably not the case because our institution has been meeting its time-to-treat targets for orthopaedic surgical interventions. This would

suggest that those patients who are deemed suitable for arthroscopy are being treated. The second explanation is that increasing numbers of knee MRIs were performed that do not change surgical management, which seems the more likely scenario.

However, the conversion rate has decreased more slowly than the increase in the number of MRI knees and the 10.2% conversion rate to arthroscopy may be considered acceptable by commissioners when they consider that many of those patients who did not progress to arthroscopy will also not have needed the cost of a hospital consultation.

The overall age of MRI referrals has steadily decreased for both rural and urban populations. This suggests some improvement in patient selection for MRI over the years. This may be the result of a local policy of mandatory plain radiographs for patients over the age of 50, selecting out those patients with severe OA that are clearly not suitable for arthroscopic intervention. It may also reflect accumulated experience of the referrers in using MRI to manage their patients.

The number of MRI examinations and surgical interventions are highest between the ages of 40–49 suggesting that this is the peak of surgically remediable disease. The likelihood of conversion from MRI to surgical intervention then declines with age, which mirrors the body of opinion that arthroscopic intervention in the knee is less effective in patients over the age of 50 (9, 10).

A small statistically significant mean difference of about 3 years is seen in the age at MRI referral for urban and rural populations; the rural population is slightly older at the time of referral than the urban population. The conversion rate to arthroscopy is

slightly lower for rural compared to urban patients but this does not reach statistical significance.

A comparison between the deprivation scores for patients referred for knee MRI and the overall deprivation scores for the local county demonstrates a significant difference with patients of lower socioeconomic status more likely to be referred for an MRI scan than patients with higher socioeconomic status. These latter patients are more likely have private health care cover and this may account for some of these findings. These differences are similar to findings from studies into differences in mortality that suggest that socio-economic status is a more important measure of healthcare outcomes than rural or urban locations (16).

There was considerable variability between numbers of referrals per 1000 population between the 93 General Practices. Almost as many practices referred 20-25 patients per 1000 as those that referred 5 or less per 1000. The location in urban or rural settings did not appear to influence this referral rate. Such variability may reflect differences in demographics or in individual GP referral preferences and knowledge between practices. As variability is often linked with lower quality of care, the numbers presented here are of concern.

The authors acknowledge several limitations to this study. Not all confounding factors can be accounted for due to the retrospective nature of this study. Factors other than a change in referral guidance could have influenced treatment, for example a change in orthopaedic staff. This study has also been conducted in a single centre, and the results may not be applicable to other cities or countries.

A detailed examination of the contents of the MRI reports was not undertaken as the conversion rate to arthroscopy was used as a single, limited measure for impact on

patient management. Patients may choose not to undergo arthroscopy as a result of an abnormal scan, and equally a normal scan may provide diagnostic benefit by excluding suspected pathologies. Further study is required for a more comprehensive analysis of how the outcome of a knee MRI scan influences subsequent management.

A further limitation of this study that it does not account for a small cohort of patients who have their MRI towards the end of our data capture period (2015), who may yet choose to have arthroscopy beyond the 2.5 year period. This would cause the conversion rate to arthroscopy for more recent year-groups to be underestimated, as they were followed up for a shorter period overall. Second, it is assumed that the MRI scan within this follow-up period prompted the arthroscopy. This raises the possibility of including patients who have arthroscopy subsequent to an interval MRI performed through orthopaedic referral within this follow-up period.

Finally, we were unable to capture data on patients who have arthroscopy elsewhere. However, this usually as a result of patient relocation within the follow-up period. However, our institution is the main referral centre for both knee MRI and orthopaedic surgery for the region, meaning that nearly all the patients imaged in our institution would also have their arthroscopy with the in-house orthopaedic team, hence facilitating comprehensive data collection.

All of these limitations are predicted to individually and collectively affect only a tiny proportion of the cohort, and should not materially change the conclusion.

This large-scale population study has demonstrated a rapid rise in the number of referrals for knee MRI from primary care at a large UK teaching hospital following the introduction of open access, with a more gradual decrease in the number of patients

progressing to arthroscopy. Although this suggests that in this setting knee MRI is less likely to influence surgical management, this should be balanced against the cost saving of reducing secondary care consultation and improving diagnostic confidence of GPs when planning future care pathways.

REFERENCES

1. Smith C, McGarvey C, Harb Z, et al.: Diagnostic Efficacy of 3-T MRI for Knee Injuries Using Arthroscopy as a Reference Standard: A Meta-Analysis. AJR Am J Roentgenol 2016; 207:369–377.

2. Royal College of General Practitioners, McCormick A, Fleming D, et al.: Morbidity Statistics from General Practice: Fourth National Study 1991-1992. London: H.M.S.O.; 1995.

3. Watura R, Lloyd DC, Chawda S: Magnetic resonance imaging of the knee: direct access for general practitioners. BMJ 1995; 311:1614.

4. DAMASK (Direct Access to Magnetic Resonance Imaging: Assessment for Suspect Knees) Trial Team: Effectiveness of GP access to magnetic resonance imaging of the knee: a randomised trial. Br J Gen Pract 2008; 58:e1-8; discussion 774.

5. Berg HF, Vermeulen M, Algra PR, Boonman-de Winter LJM: Direct access to magnetic resonance imaging improved orthopaedic knee referrals in the Netherlands. Fam Pract 2016; 33:482–487.

6. Karel YHJM, Verkerk K, Endenburg S, Metselaar S, Verhagen AP: Effect of routine diagnostic imaging for patients with musculoskeletal disorders: A meta-analysis. Eur J Intern Med 2015; 26:585–595.

7. van Oudenaarde K, Swart NM, Bloem JL, et al.: General Practitioners Referring Adults to MR Imaging for Knee Pain: A Randomized Controlled Trial to Assess Cost-effectiveness. Radiology 2018; 288:170–176.

8. Osteoarthritis: care and management | Guidance and guidelines | NICE [https://www.nice.org.uk/guidance/CG177]

9. Sihvonen R, Paavola M, Malmivaara A, et al.: Arthroscopic partial meniscectomy versus sham surgery for a degenerative meniscal tear. N Engl J Med 2013; 369:2515–2524.

10. Thorlund JB, Juhl CB, Roos EM, Lohmander LS: Arthroscopic surgery for degenerative knee: systematic review and meta-analysis of benefits and harms. BMJ 2015; 350:h2747.

11. Lee VS, Kawamoto K, Hess R, et al.: Implementation of a Value-Driven Outcomes Program to Identify High Variability in Clinical Costs and Outcomes and Association With Reduced Cost and Improved Quality. JAMA 2016; 316:1061–1072.

12. 2011 Rural-Urban Classification of Local Authorities and other geographies. [https://www.gov.uk/government/statistics/2011-rural-urban-classification-of-local-authority-and-other-higher-level-geographies-for-statistical-purposes]. Accessed 30-06-18.

13. Department for Communities and Local Government, English Indices of Deprivation 2010 data. About the product: www.gov.uk/government/statistics/english-indices-of-deprivation-2010. Accessed 28-04-2017.

14. Norfolk Insight. Indices of deprivation 2015 - population by deciles. [http://www.norfolkinsight.org.uk/dataviews/tabular?viewId=291&geoId=54&subsetid=12]. Accessed 30-06-18.

15. Bagshaw E: Medical revolt over MRI restrictions for over-50s. The Sydney Morning Herald 2018.

16. Gartner A, Farewell D, Dunstan F, Gordon E: Differences in mortality between rural and urban areas in England and Wales, 2002-04. Health Stat Q 2008:6–13.

TABLES

Table 1

		Year of MRI							
		2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Number of MRIs	Urban	111	228	346	441	632	1075	1383	1209
	Rural	116	267	396	454	559	975	1263	965
	Total	**227**	**495**	**742**	**895**	**1191**	**2050**	**2646**	**2174**
Average age at MRI	Urban	46.8	47.4	45.9	42.6	43.4	42.8	43.5	41.3
	Rural	49.2	49.0	49.3	45.3	45.8	47.1	45.7	43.2
	Total	**48.0**	**48.3**	**47.8**	**44.0**	**44.5**	**44.9**	**44.6**	**42.1**
Number of Operations	Urban	18	36	46	54	86	111	132	124
	Rural	17	37	58	52	50	100	118	97
	Total	**35**	**73**	**104**	**106**	**136**	**211**	**250**	**221**
Conversion rate (%)	Urban	16.2	15.8	13.3	12.2	13.6	10.3	9.5	10.3
	Rural	14.7	13.9	14.6	11.5	8.9	10.3	9.3	10.1
	Total	**15.4**	**14.7**	**14.0**	**11.8**	**11.4**	**10.3**	**9.4**	**10.2**

Table summarising the number of MRI examinations of the knee performed with the number of subsequent operations performed.

LEGENDS

Figure 1

Histogram demonstrating the increase in the number of MRI knee examinations between 2008 and 2015, with a relatively small increase in the number of subsequent arthroscopies.

Figure 2

Line chart demonstrating the frequency of patients undergoing knee MRI by age between 2008 and 2015 (light grey lines) with the mean plotted as a black line. The mean age for the 8-year period was 44.5 years (SD=15.6 years) and mode was 48 years.

Figure 3

Line chart demonstrating the frequency of patients undergoing arthroscopy after knee MRI, by age, between 2008 and 2015 (grey lines) with the mean represented by a black line. The graph demonstrates a bimodal distribution with peaks in the second and third decades.

Figure 4

Histogram demonstrating the mean percentage conversion rate by decade for 2008 to 2015. This demonstrates a steady decline with increasing age. The error bars represent one standard deviation for the data for each decade. The wide standard deviations in the 8^{th} and 9^{th} decades reflect the small number of patients.

Figure 5

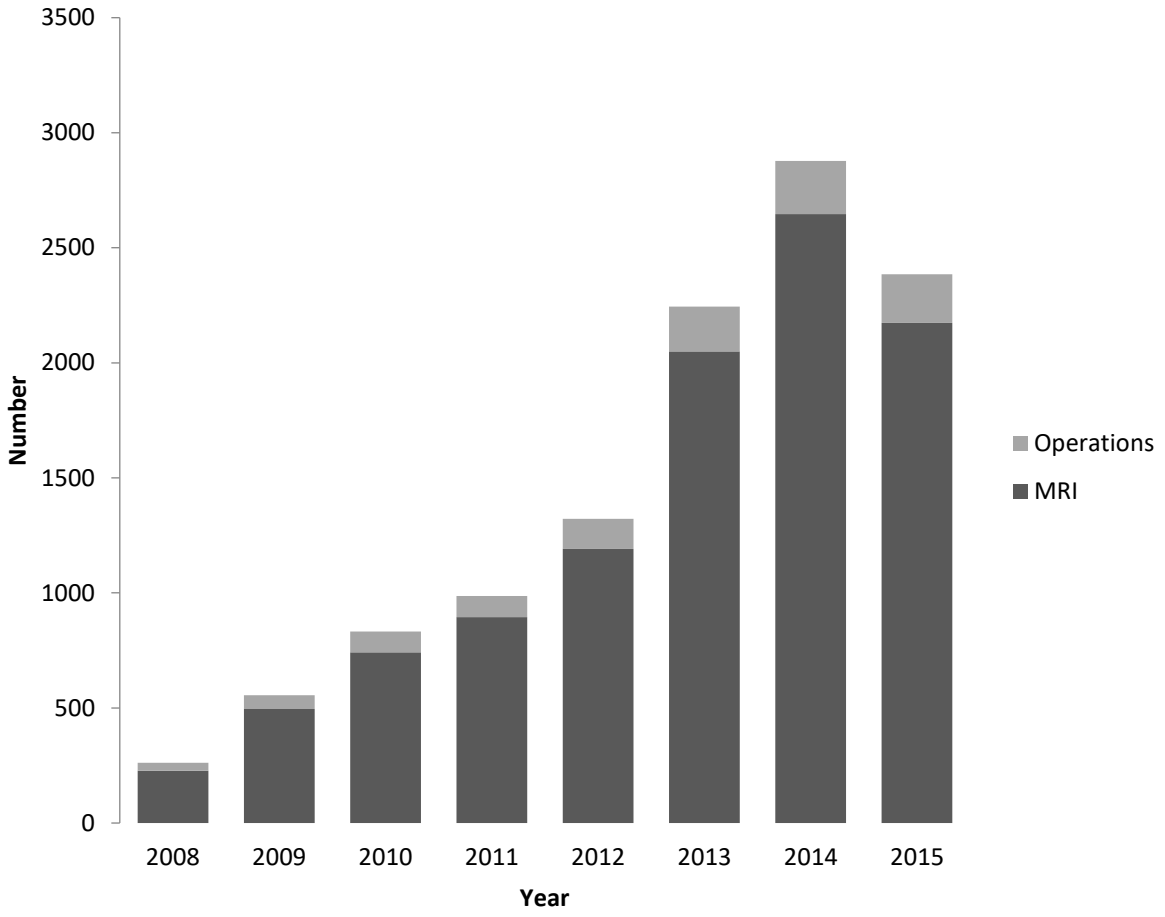
Line chart demonstrating the average age at MRI in urban and rural populations between 2008 and 2015. The rural population is significantly older than the urban population for all years and both show a decrease in the average age with time.

Figure 6

Frequency histograms demonstrating the deprivation index of patients being referred from primary care for knee MRI compared to the deprivation index of the general population of Norfolk. The patients who have the lowest socioeconomic status, with the lowest deprivation scores, have higher rates of referral for knee MRI.

Figure 7

Frequency histogram demonstrating the number of referrals per GP practice per 1000 patients.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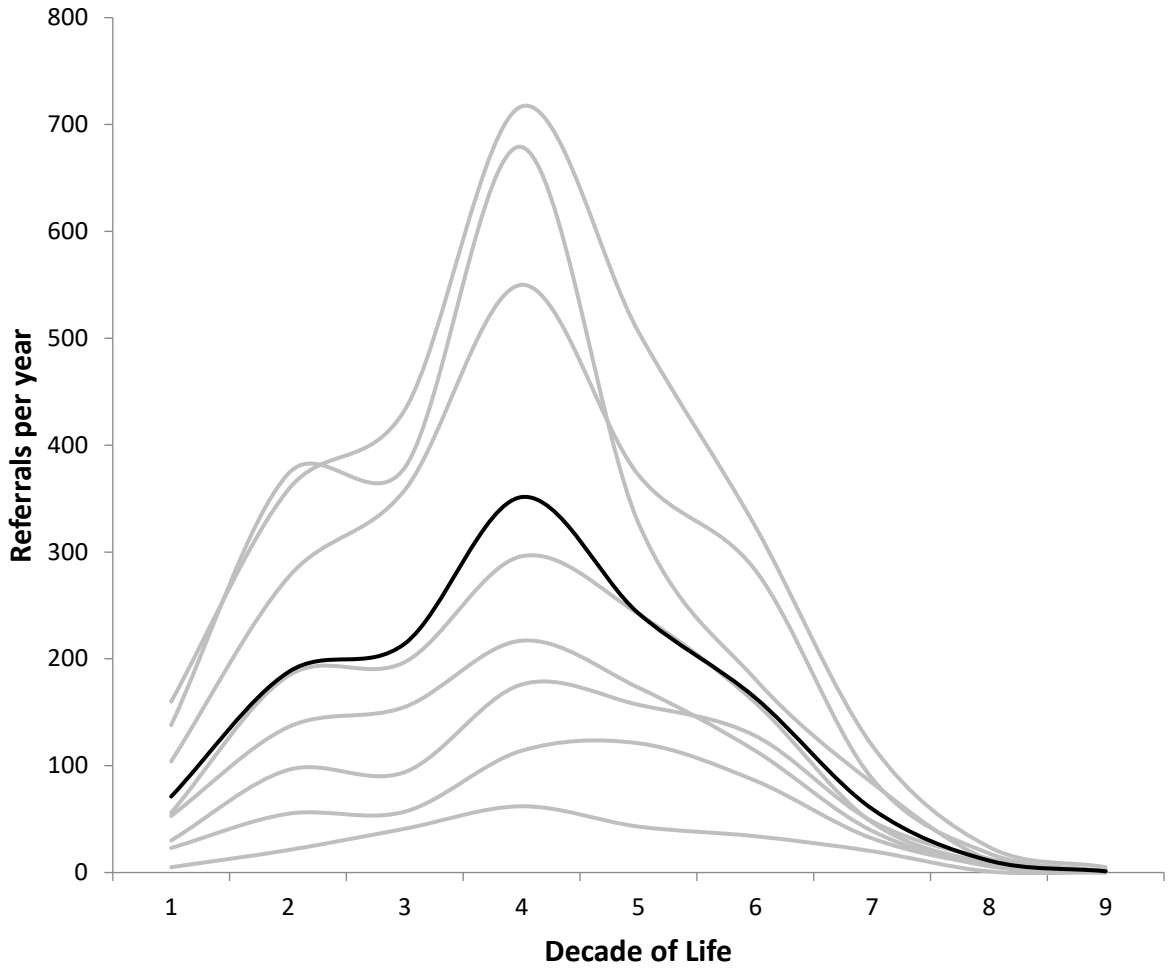
Operations
MRI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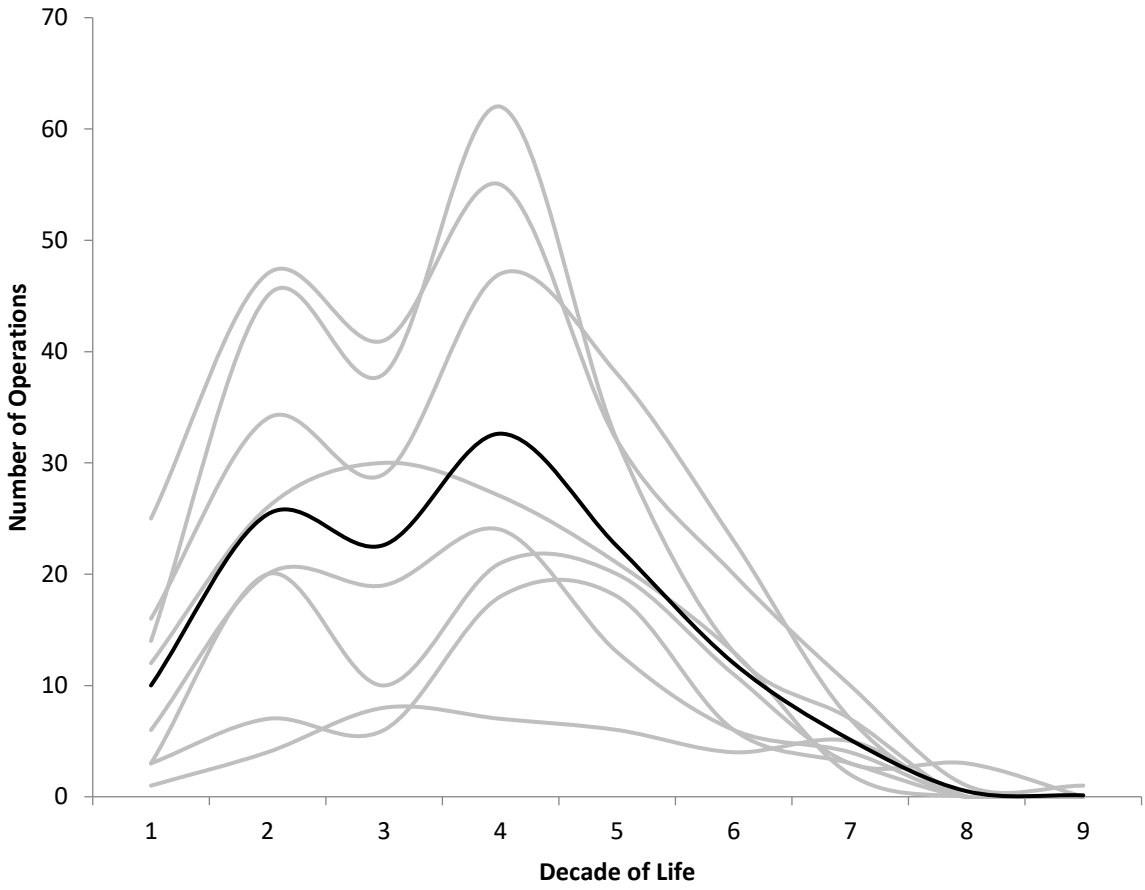
Decade of Life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Number of Operations
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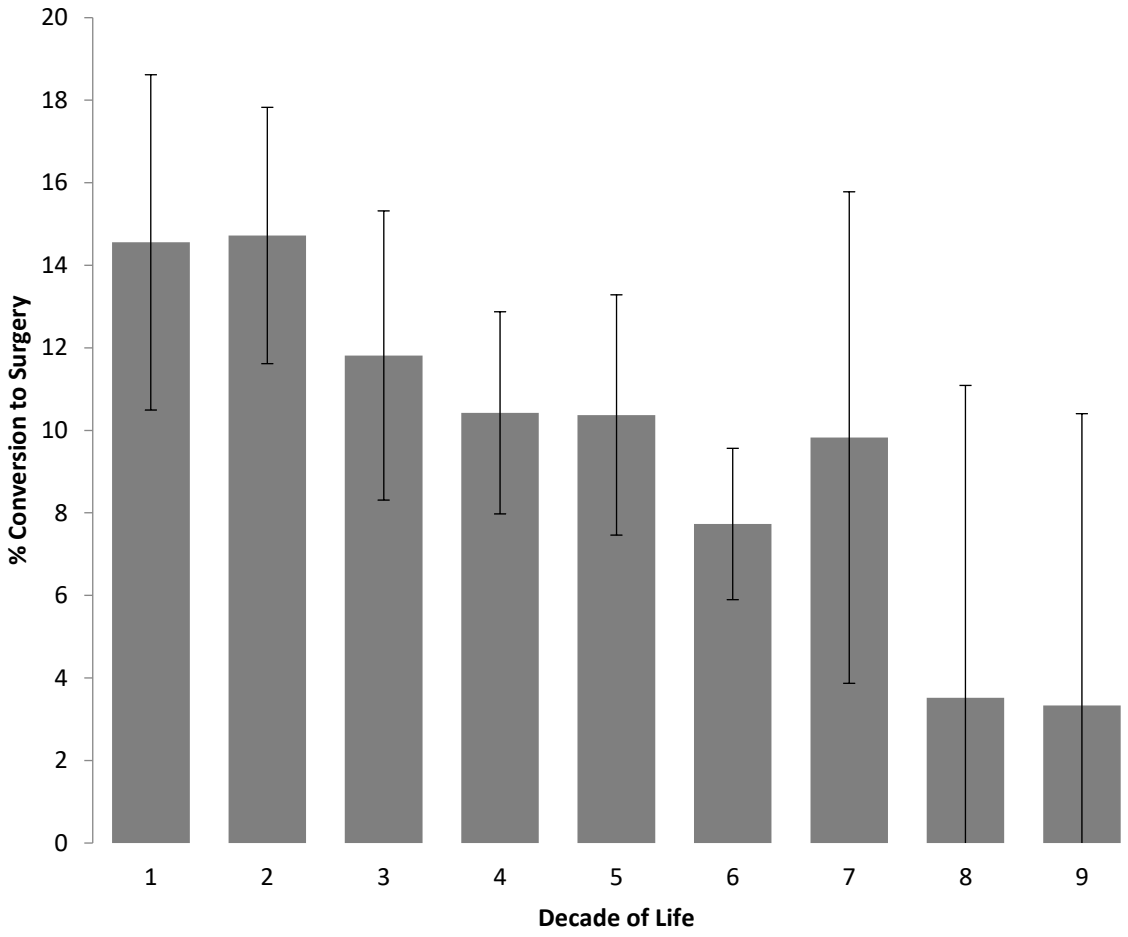
Decade of Life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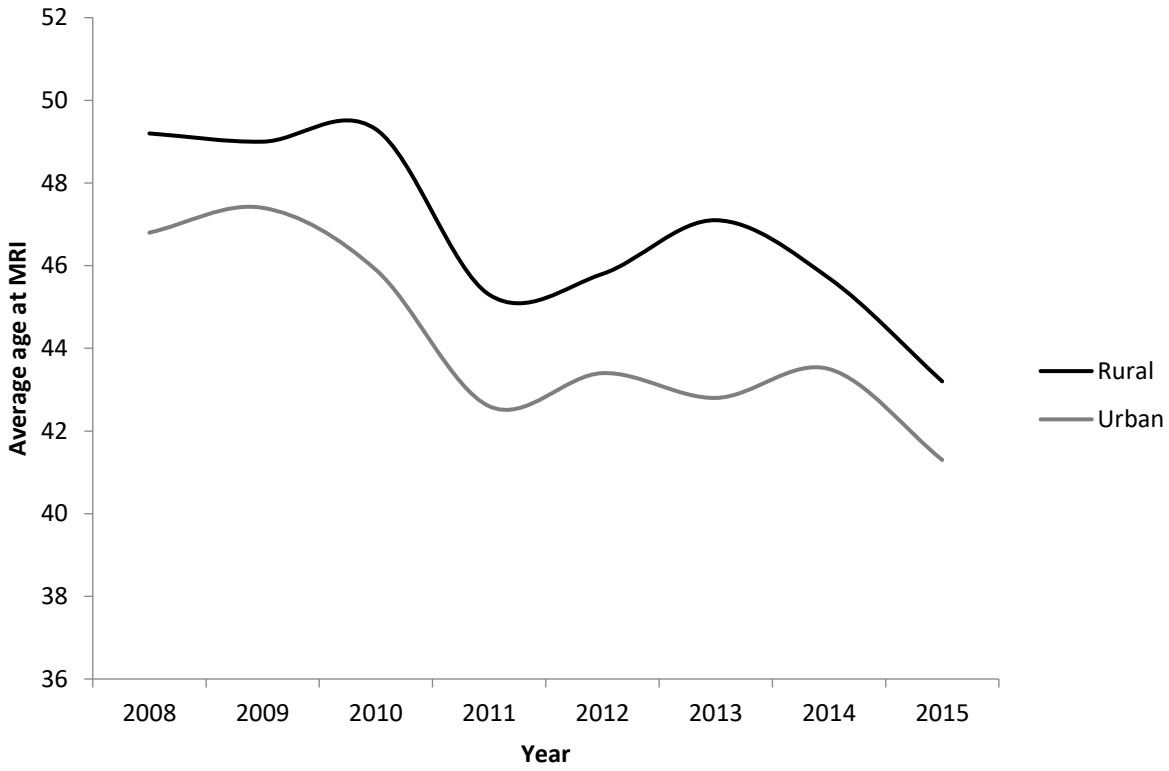
Decade of Life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Average age at MRI
2008
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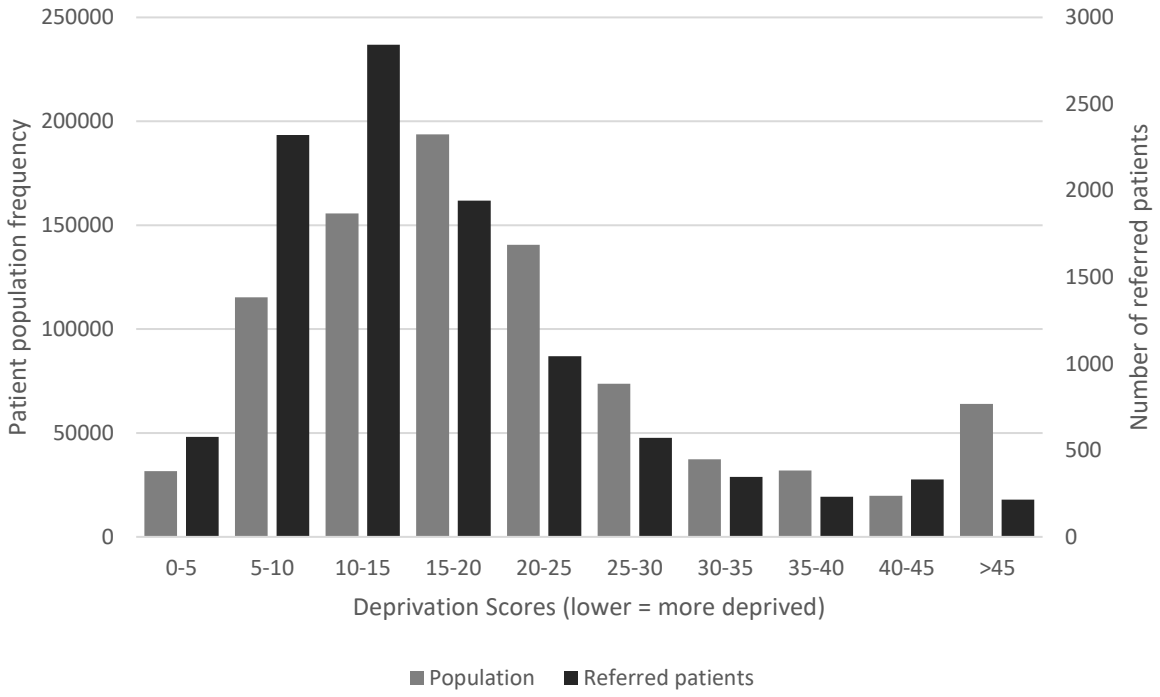
2010
2011
2012
2013
2014
2015
Year
Rural
Urban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200000
150000
100000
50000
0
3000
2500
2000
1500
1000
500
0
Patient population frequency
Number of referred patients
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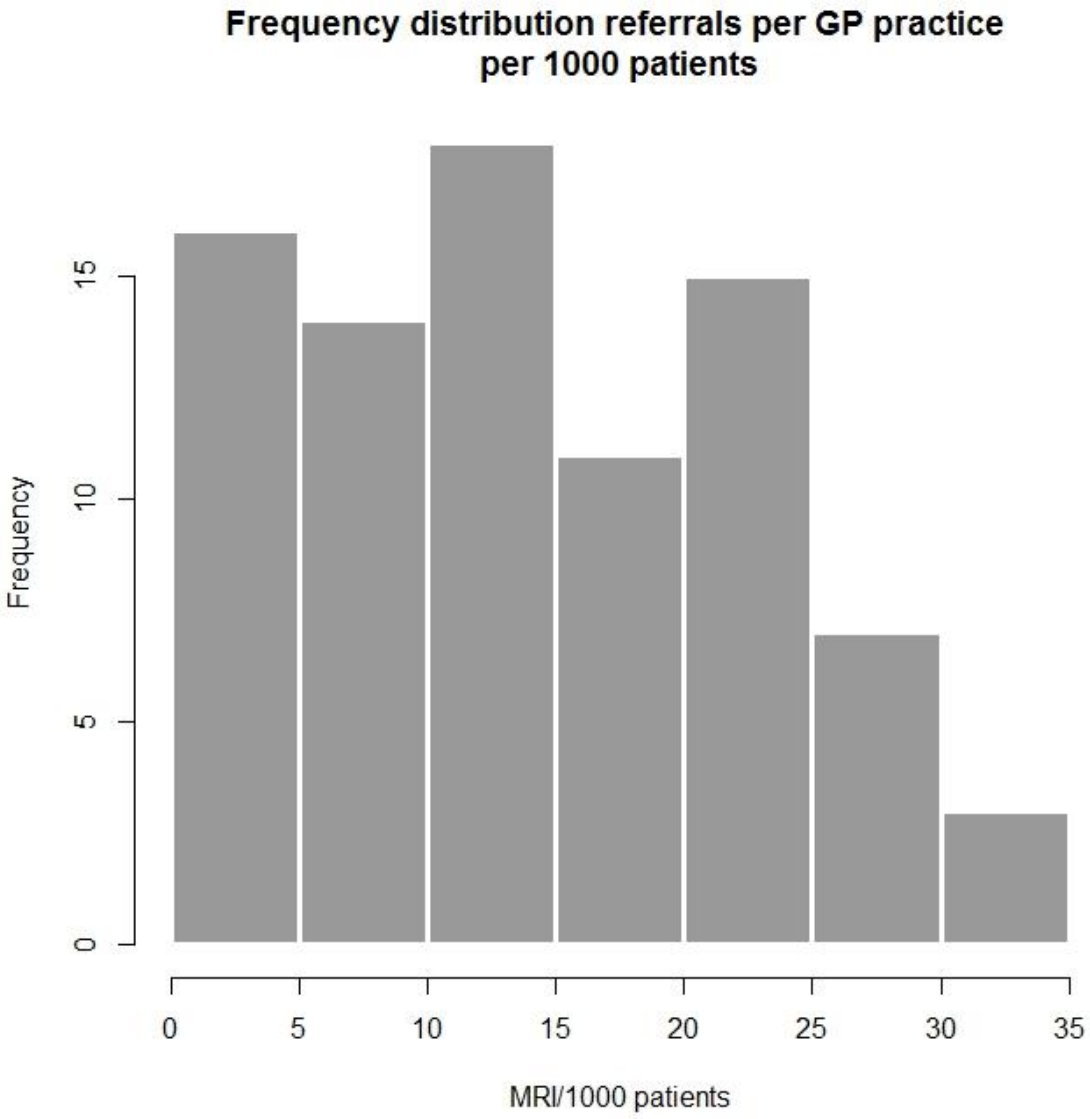
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
>45
Deprivation Scores (lower = more deprived)
Population
Referred patients


Frequency distribution referrals per GP practice
per 1000 patients
Frequency
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5
10
15
0
5
10
15
20
25
30
35
MRI/1000 patients