Defensive Medicine in Medical Imaging

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Abstract.
Numerous previous authors have investigated how the fear of medical malpractice liability might affect the decisions for medical imaging orders and this paper adds to the previous literature offering a comparative analysis on the subject, focusing on the National Healthcare System (NHS), enforced in the UK.

Keywords: Medical Liability, Medical Malpractice, Medical Imaging.

1 Introduction

With the term Defensive Medicine are commonly indicated all those practices with which doctors and healthcare providers try to prevent legal liability actions for Medical Malpractice against them. And of course, within Medical Malpractice are included all those cases where physicians deviate from the standards of their profession, causing injuries to a patient. Some defensive medicine practices may include resorting to additional or unnecessary diagnostic and therapeutic services, but also avoiding riskier procedures even though beneficial for the patients. [1]
This practice is seen by the countries as a phenomenon to be curbed in the interest of the patients, of the healthcare providers and of the state itself, given the huge increase in healthcare that it might cause, but also the potential decrease in the quality of the services. [2]
In the USA, the compensations tend to be much higher than those of the other countries. As for the reason for this discrepancy it might be a consequence of the different judicial system and to the fact that a jury typically decides whether or not there has been a case of medical malpractice, while in other states it is typically the judge or a committee of specialists that assess the issue. This said, this paper does not want to be an analysis on what are the possible causes of inter-countries differences and it is therefore advisable to refer to the specific literature.

2 UK Setting

2.1 NHS and Medical Malpractice

The United States are not obviously the only country having to deal with the issue of defensive medicine. In 2008 the NHS paid out £538 million for negligence

compensation claims, although it is comforting to observe that while the amount of compensation has risen over the last decade, the number of cases has increased less dramatically. [3]
Based on a survey of Ortashi et al. conducted on 300 English hospitals, the 78% of the physicians interviewed admitted to practicing defensive medicine ordering for example unnecessary exams but also recommending their patients referral to other specialists. [4]

2.2 National Health Service (NHS)

As we have already anticipated we will focus on the British healthcare system, the NHS (just for the simplicity in finding publicly available data).
The NHS offers mainly free medical assistance to all those residing in England, since 1948, namely since it was enforced, and it is financed through taxes. In parallel medical assistance from private entities is also contemplated. The system contemplates the presence of the so-called NHS Trusts, organization units supervising specific geographical areas and with specific functions. Every trust must have a board and its members must act based on the performance indicators, quality, and safety. [5]

The main NHS trusts are:

- Hospital trusts which can supervise more than one hospital;
- Ambulance services trust;
- Community health trust;
- Mental health trust.

3 Collection of data and methodology

3.1 Reasoning

Over prescription of medical imaging is another form of defensive medicine practice because of concerns of unexpected findings and fear of litigation. Inside his paper Franz Kainberger reports that Lambert L. found a significant increase of emergency cranial CTs in a trauma setting compared to CTs of other body regions, concluding that it cannot be justified solely by clinical need. [6] Other papers on the subject only confirm the existence of a correlation between the two phenomena reinforcing the idea behind this paper, of using the variation in the number of medical imaging orderings as an indicator for the effects that a medical malpractice accusation might have on a hospital.

3.2 First Step: Data Collection and Preprocessing

We recovered from the NHS official website [7] the data relating to the number of monthly medical scans ordered from April 2012 to March 2019 at the trust level (not at a single hospital level) and at a national level, regarding:

- Computerized Axial Tomography (CT scan);
- Diagnostic Ultrasonography;
- Fluoroscopy;
- Magnetic Resonance Imaging (MRI);
- Medical Photography;
- Nuclear Medicine;
- Plain Radiography;
- Positron Emission Tomography;
- Single Photon Emission Computerized Tomography.

Due to the high presence of missing data for these modalities we decided to exclude from our analysis Medical Photography, Nuclear Medicine, Positron Emission Tomography and Single Photon Emission Computerized Tomography.
Moreover we decided to keep the providers that had at least 84 observations (namely one monthly observation from April 2012 to March 2019), for every modality/medical imaging considered, discarding those that were dismissed during the various years of operativity.

Focusing on the time series for the CT scan, MRIs, and Radiographies at a national level (for which we have the data for all the modalities) we observe the following:

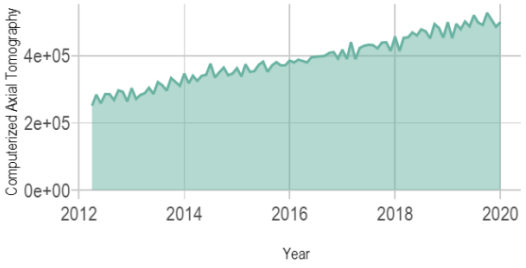

Fig. 1. Time series for Computerized Axial Tomography, national level

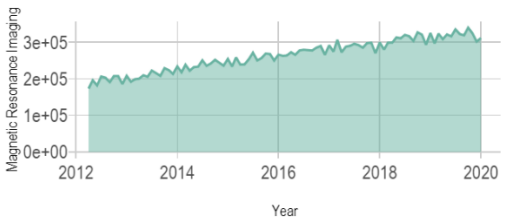

Fig. 2. Time series for Medical Resonance Imaging, national level

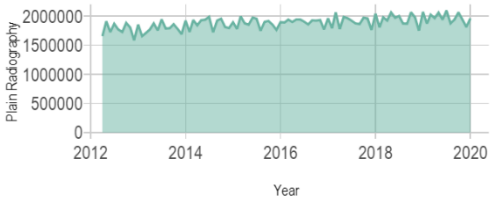

Fig. 3. Time series for Plain Radiography, national level.

It is possible to observe that orders for what is defined Plain Radiography has remained quite constant throughout time (from 2012 to 2020), while a positive trend is evident from the time series of both the MRIs and the CT scans requests.

3.3 Second step: Clustering

The second step consisted in finding data on the characteristics of these trusts representing their organizational and performance. We collected therefore data on:

- Critical care bed capacity. [8]
- Delayed transfers. [9]
- Attendances and emergency admission. [10]
- Summary Hospital-level Mortality Indicator (SHMI). [11]

All relative to the period 2018-2019, although we used only three variables of the dataset we originally built (the choice of the variables was a choice of the author, as to the ones perceived as the most meaningful) for performing a clustering to obtain groups of similar trusts.

Specifically, the three variables considered are:

- Number of patients who have waited 4 to 12 hours before admission.
- SHMI indicator.
- Number of adult critical care beds occupied.

Clustering

Clustering is an unsupervised machine learning technique that given a set of data points performs a grouping on them.
There are various clustering algorithm, the most well-known and the one we used in this paper is the *K-means* clustering which iteratively determines the best k center points (namely the centroid) and assigns each example to the closest centroid. The k-means algorithm picks centroid locations to minimize the cumulative square of the distances from each example to its closest centroid.
Although we run the k-means algorithm with 2 clusters, we used and considered the results of the hierarchical clustering.

Hierarchical clustering needs a distance matrix to be performed and it starts by treating each observation in a separate cluster. Then it identifies the two clusters that are closest to each other and merges the two most similar clusters together; the distance between two clusters is computed. Through this technique we obtained 5 visible clusters of trusts. [12] [Fig 1]

3.4 Last step

The final step consisted in considering three trusts, belonging to a different cluster. Each one of these trusts has been accused of medical malpractice by the Medical Negligence Team, a British legal consultancy, and claims management company whose primary focus are clinical negligence litigations. [13]
It is necessary to specify that the choice of this company and method is because the company shares the litigations pursued with a brief introduction to the case, and in particular the official files of the judgment reporting the data on the plaintiffs, the defendant, the specific accusation and most importantly, the hearing dates.
The next step was that of selecting a “comparison trust or group”, namely a trust belonging to the same cluster but that has not any accusation of medical malpractice accordingly to the database of the Medical Negligence Team.

The three cases selected for our investigations are [Table 1]:

Plain-tiff	Defendant	month-year	Clus-ter	Comparison Trust
Har-ding	Buckinghamshire Healthcare NHS Trust	May 2017	N° 2	Northumbria Healthcare NHS Foun-dation Trust
AB	Royal Devon & Exeter NHS Foundation Trust	Febru-ary 2016	N°4	Airedale NHS Foun-dation Trust
Barnett	Medway NHS Founda-tion Trust	March 2017	N° 5	Mid Yorkshire Hospi-tals NHS Trust

Table 1. Medical Malpractice cases considered and Comparison Trusts

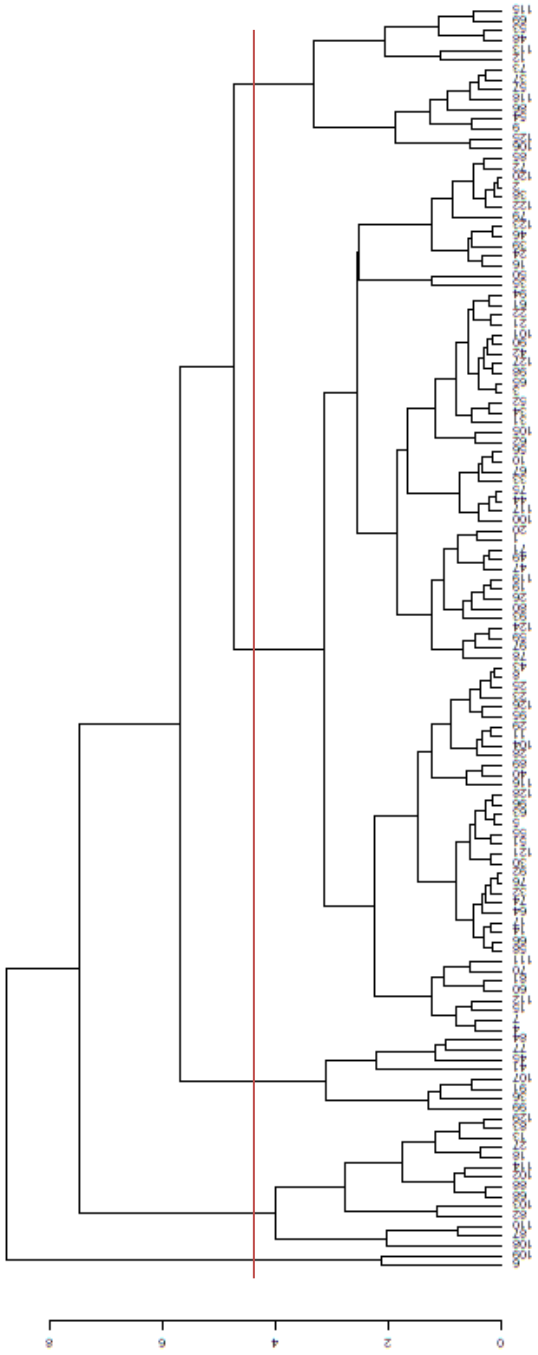

Fig. 2. Dendrogram of the clusters, the numbers represent the identificatory of the trusts.

4 Results

We considered the value for each modality during the month of the lawsuit, the previous and the following ones and we computed the relative variation with respect to the previous, for example:

$$(CAT_{05\text{-}17} - \mathrm{CAT}_{04\text{-}17})\frac{100}{\mathrm{CAT04-17}} = \Delta_{04\text{-}17/05\text{-}17}$$

We compute this for both the trust with the litigation and its control and then compare these variations trying to understand whether or not they are significant compared also with those of the previous years, during the same time-frame.

Royal Devon and Exeter NHS Foundation Trust vs Airedale NHS Foundation Trust [Table 2 & Table 3]

The accusation brought by the representatives of the plaintiff in this case was that should an MRI scan been performed, then it could have allowed a successful surgery.
Comparing therefore the orders for MRI scans during the month on the accusation we can see that the relative difference is smaller for the Royal Devon with respect to the Airedale Foundation.
In the following month, the orders decreased even more for the former while for the latter there is a positive difference signaling an increase in requests.
Two things must be noted though:

- The Royal Devon orders for every modality studied has been always greater that the numbers of the Airedale Foundation.
- The only positive variation in MRI request for the month of February is that of 2013; the variation during the year of the litigation, although negative, is still the smallest one with respect to the others.

Provider Name	CAT	ΔCAT%	MRI	ΔMRI%	PR	ΔPR%	mm-yy
Royal Devon and Exeter NHS Foundation Trust	2850	16,56441718	1790	35,09433962	10870	15,69984034	01-17
Royal Devon and Exeter NHS Foundation Trust	2695	-5,438596491	1765	-1,396648045	9895	-8,969641214	02-17
Royal Devon and Exeter NHS Foundation Trust	2830	5,009276438	1530	-13,31444759	10845	9,600808489	03-17

Table 2. Absolute values and relative values for Royal Devon and Exeter NHS Foundation Trust of CT, MRI, and PR.

Provider Name	CAT	ΔCAT%	MRI	ΔMRI%	PR	ΔPR%	mm-yy
Airedale NHS Foundation Trust	1235	6,008583691	645	19,44444444	6835	7,807570978	01-17
Airedale NHS Foundation Trust	1200	-2,834008097	590	-8,527131783	6100	-10,75347476	02-17
Airedale NHS Foundation Trust	1335	11,25	680	15,25423729	6985	14,50819672	03-17

Table 3. Absolute values and relative values for Airedale NHS Foundation Trust of CT, MRI, and PR.

Medway NHS Foundation Trust vs Mid Yorkshire Hospitals NHS Trust [Table 4 & Table 5]

As for what concerns the Medway and the Mid Yorkshire Trusts we can notice that contrary to the previous case, the latter has always requested a greater number of scans for all the categories.
Focusing on the period of the litigation and again, being the lack of an in-time MRI scan the basis of the case, we can notice an increase of 10.34% ca of the orderings for MRI scans from the Medway Foundation during the period of the hearings of the litigation, almost twice the value for the Mid Yorkshire Trust. However, we cannot consider this variation significant since it can be observed that apart from two years, 2013 and 2016, the month of March is typically characterized by variation with respect to the previous month and the time interval considered is too short to make further assumptions.

Provider Name	CAT	ΔCAT%	MRI	ΔMRI%	PR	ΔPR%	mm-yy
Medway NHS Foundation Trust	2315	-8,678500986	1885	-4,071246819	12205	-3,821907013	02-17
Medway NHS Foundation Trust	2720	17,49460043	2080	10,34482759	13870	13,64195002	03-17
Medway NHS Foundation Trust	2430	-10,66176471	1965	-5,528846154	11715	-15,5371305	04-17

Table 4. Absolute values and relative values for Medway NHS Foundation Trust of CT, MRI, and PR.

Provider Name	CAT	ΔCAT%	MRI	ΔMRI%	PR	ΔPR%	mm-yy
Mid Yorkshire Hospitals NHS Trust	4400	-7,27081138	2315	-0,215517241	20315	-9,971194327	02-17
Mid Yorkshire Hospitals NHS Trust	4985	13,29545455	2420	4,535637149	23055	13,48757076	03-17
Mid Yorkshire Hospitals NHS Trust	4560	-8,52557673	2310	-4,545454545	20255	-12,14487096	04-17

Table 5. Absolute values and relative values for Mid Yorkshire Hospitals NHS Trust of CT, MRI, and PR.

Buckinghamshire Healthcare NHS Trust vs Northumbria Healthcare NHS Foundation Trust [Table 6 & Table 7]

In the case of Harding v Buckinghamshire Healthcare NHS Trust the representatives of the plaintiff identify in the absence on an immediate CT scan, among the others, the cause of the lack of a rapid diagnosis and consequently the lack of a much fuller recovery.
In this case we observe for the CT scans ordered by Buckinghamshire Trust a significant increase during May, that of the litigation's hearings, a value that is also the highest increase observed in the previous and the following years during the same month and this could be compatible with the phenomenon of defensive medicine that we are investigating on.
And this result could be also confirmed by the fact that for the Northumbria Foundation instead we observe a negative variation, and both the trusts experimented a negative variation the previous year.

Again, we should note that the Northumbria Foundation has always performed a higher number of medical imaging for all the modalities and that we are considering a short time interval considered (from 2012 to early 2019).

Provider Name	CAT	ΔCAT%	MRI	ΔMRI%	PR	ΔPR%	mm-yy
Buckinghamshire Healthcare NHS Trust	2650	-14,92776886	1595	-9,116809117	12520	-13,53833866	04-17
Buckinghamshire Healthcare NHS Trust	3040	14,71698113	1695	6,269592476	14355	12,78300244	05-17
Buckinghamshire Healthcare NHS Trust	2860	-5,921052632	1625	-4,12979351	13810	-3,946415641	06-17

Table 6. Absolute values and relative values for Buckinghamshire Healthcare NHS Trust of CT, MRI, and PR.

Provider Name	CAT	ΔCAT%	MRI	ΔMRI%	PR	ΔPR%	mm-yy
Northumbria Healthcare NHS Foundation Trust	3455	-7,743658211	1840	-5,641025641	17215	-7,916555229	04-17
Northumbria Healthcare NHS Foundation Trust	3400	-1,591895803	1660	-9,782608696	17255	0,232355504	05-17
Northumbria Healthcare NHS Foundation Trust	3540	4,117647059	1790	7,831325301	18035	4,520428861	06-17

Table 7. Absolute values and relative values for Northumbria Healthcare NHS Foundation Trust of CT, MRI, and PR.

5 Conclusion

We can conclude by stating that the lack of a longer time frame is probably the main issue of this type of analysis since we can only be certain about the monthly seasonality while cycles are not easily identifiable with such a short interval of time (approximately 8 years).
We could say that the variations in medical imaging orders for the case of Buckinghamshire Healthcare NHS Trust vs Northumbria Healthcare NHS Foundation Trust might be a consequence of the litigation against the trust, but the contradictory results for the other two cases decrease the significance of such a result.

What we cannot deny is a visible increase in time in the number of scans requested by hospitals that cannot be simply justified by a decrease in the healthcare costs, a greater coverage by the National Healthcare Service or affordability of the machineries.

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