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# Observing the NHS's A&E performance objectives: is lean the cure?



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# Observing the NHS's A&E Performance Objectives: Is Lean the Cure?

## 1. Introduction

The NHS has for a long time now been regarded as one of the chief sources of waste within the public sector; known for its long patient waiting times and miss and under-utilisation of resources. When this is coupled with mounting budgetary concerns, an increase in demand; placing stress on the NHS's already fragile operations, it is clear that changes are necessary.

Pym (2014) and Triggle (2014) have reported that the NHS will face a funding gap of approximately £2 billion over the next financial year. The medical director of NHS England, Keogh (2014), suggests that the current winter season is adding further pressures to the NHS, particularly within A&E.

Foundation trust hospitals treated 2.7 million patients in A&E during April – June 2014, an increase of 100,000, when compared to the same period last year (Campbell, 2014). Campbell (2014) suggests that patient numbers are at record highs due to; GPs referring many patients to A&E and more frail and elderly people; a result of an ageing population.

The NHS have internally set a performance target in the A&E department; 95% of patients should be seen within four hours of arriving at A&E (Triggle, 2014). This paper will critically analyse the NHS, with a particular focus on the A&E aspect of the organisation; and predominantly emphasising the issues associated with the increase in demand (which is assumed to increase patient waiting times) and general waste. As the NHS has attempted to implement a Lean philosophy into the parts of the organisation; this paper will continue in this vein. Antony (2011) defined lean as "...determining the value of any process by distinguishing value-added activities or steps from non-value added activities or steps and eliminating waste so that every step adds value to the process." Therefore based on the objectives of Lean (to remove NVA and waste) the author believes that such an approach is able to tackle the 'core' issues; patient waiting times and waste.

## 2. Literature

Authors appear to be at a consensus that lean aims to remove NVA (waste) and that value should be specified from the customer's perspective (Antony, 2011; Jones et al, 1996; Dahlgaard & Dahlgaard-Park, 2006; Slack et al 2013; Waters, 2009; Hines & Taylor, 2000). However, when we drill down further disagreements appear.

Bicheno (2004) argues that lean is more than just a set of tools and that for an organisation to be truly be lean, there must be a philosophical change within the organisation and its culture. Petterson (2009) contradicts this viewpoint and argues that the practitioner view of lean is a set of tools which when utilised effectively can reduce waste. In reality neither is incorrect; lean can in fact be both a philosophy which is deeply embedded into the organisa-

tional culture and it can be used in isolation to target particular processes and resources which there is a desire to improve. It is important to realise that lean therefore has a strategic and operational place within organisations (Hines et al, 2004; Shah & Ward, 2007).

## 2.1 Alternatives

There are alternatives to Lean, which are considered to be efficiency improvement methodologies, such as six sigma, business process reengineering (BPR) and agile.

Six sigma is defined by Chakravorty (2009) as "…programs that improve operational performance in order to enhance customer satisfaction with a company's products and services". Although six sigma and lean may hold some resemblances including quality improvements, productivity drives and customer satisfaction. Six sigma's main focus is to measure quality/performance and reduce defects (Slack et al, 2009). Agile one the other hand, focuses on both speed and flexibility, however no consideration is given to cost (Inman et al. 2011). While the speed and flexibility is a characteristic the NHS could certainly benefit from, the fact that there is no cost consideration is a major block for an organisation which is publicly funded and is already facing a funding gap of approximately £2 billion. BPR seeks to gain dramatic results in a short period of time and is therefore aggressive in nature; its purpose is to innovate processes or systems (Chan & Choi, 1997).

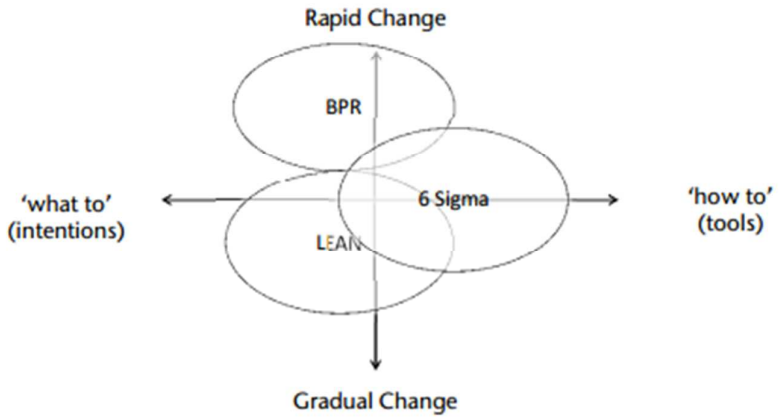



**Figure 1:** Lean, Six Sigma & BPR. (Ritchie, 2014) adapted from (Slack et al, 2013)

Alexander (2012) reports that the NHS is the world's fifth largest employer, employing 1.7 million workers, therefore issues such as resistance to change and the time which change takes to filtrate through the organisation are exacerbated. Lean appears to be the logical

choice for the NHS to improve its operations; it doesn't aim for rapid change as BPR does, this would not be practical in an organisation as large as the NHS with such widespread problems. While it will take a considerable amount of time for Lean to effectively penetrate throughout the NHS's organisational culture; it is the change that the organisation needs. Gradual and widespread, allowing time for people to adapt and change their mind-sets and processes in a manner that places emphasis on value from the customer perspective and stripping away waste or 'muda' throughout.

## 2.2 Lean in Healthcare

Waring & Bishop (2010) suggests that because of the emphasis that Lean places on creating value streams and reducing waste, it has the ability to transfer healthcare work. After a review of public sector publications concerned with efficiency methodologies, Radnor (2010) found that 51% were concerned with Lean, 13% on Business Process Reengineering (BPR) and of these 35% were in the health sector. Radnor & Boaden (2008) have observed that successful implementations of Lean in healthcare offers a number of measurable benefits, including; cost reductions, quality (fewer errors), satisfaction of customers and staff and arguably most appropriate for the NHS; waiting time reduction.

An important part of Lean is to first identify the value stream and highlight any non-value adding (NVA) activities from the customers' perspective (Hines and Taylor, 2000). Table one identifies waste in the NHS.

**Table 1:** Seven wastes in the NHS

| **Seven Wastes** (Jacob & Chase, 2008) | **Examples of Waste in the NHS** (NHS, 2007) |
|---|---|
| Correction (Defects) | • Readmission (incorrect treatment/diagnosis)<br>• Repeated tests due to incorrect information |
| Inventory | • Excess stock – in part to stock proliferation<br>• Patients waiting to be discharged |
| Motion | • Unnecessary staff movement - looking for paperwork and not having basic equipment in each room |

| | |
|---|---|
| Waiting | • Patients<br>• Theatre staff<br>• Results, prescriptions and medicines<br>• Doctors to discharge patients |
| Overproduction | • Requesting unnecessary tests from pathology<br>• Keeping investigation slots 'just in case' |
| Over-Processing | • Duplication of information<br>• Repeatedly asking for patients' details<br>• Repeated clerking of patient |
| Transportation | • Staff walking to the other end of a ward to pick up notes<br>• Central equipment stores for commonly used items in-stead of items being located where required |

## 2.3 Lean Principles and Tools

There are a number of lean tools and frameworks to be considered when considering the implementation and intricacies of Lean. During this subsection the five Lean Principles (Womack & Jones, 1996) and the 5S framework (Gapp et al, 2008).

Melton (2005) describes the 5S Framework as "a visual housekeeping technique which de-volved control to the shop floor", Abdulmalek & Rajgopal (2007) similar explain the model as "focuses on effective work place organization and standardized work procedures." The aim is for organisation of the workplace environment and to change attitudes towards this environment.

**Table 2:** The 5S Framework

| **Japanese** (Gapp et al, 2008) | **Bicheno translation** (Bicheno & Holweg, 2009) | **Definition** |
|---|---|---|
| Seiri | Sort | Organising the workplace environment, through the disposal of items/equipment which is unused and therefore irrelevant and waste (Arnold et al, |

| | | |
|---|---|---|
| | | 2011). |
| Seiton | Simplify | Neatness, everything must have an allocated rational space (Gapp et al, 2008). |
| Seiso | Scan | This involves cleaning/tidying on a regular basis, items which means identifying items which do not belong. |
| Seiketsu | Standardise | All employees should be aware of and following a set of standard operating prodecures. |
| Shitsuke | Sustain | Everybody should be participating and striving for improvements. Success stories are often published on notice boards/intranets to encourage employees. |

Some authors also include a sixth S 'Safety', JISHA (1999) suggests that the 5S approach goes beyond the singular goal of productivity as it is aligned with decreasing industrial accidents. While the 5S framework is a useful tool for organising the workplace environment and can lead to more efficient operations and less waste, there are a number of drawbacks that can be associated with this framework. There is a danger that the 5S becomes an end goal and will cause the organisation and employees to deviate from the goal of continuous improvement (Kyle, 2013). Additionally, creativity can be stifled for one of two reasons, first of all that organisations simply try to emulate what others have done. Secondly, when considering 'Seiketsu' (standardise), employees are encouraged operate in a uniformed way, it is still important to encourage creativity and value employee ideas and opinions.

Underpinning Lean are the Lean Principles. Womack & Jones (1996) identify five lean principles:

**Table 3:** Lean Principles

| **Lean Principle** | **Explanation** |
|---|---|
| Specifiy | Value should be specified by the customer and not by the organisation |
| Identify | The value stream, this allows NVA activities to be identified and removed |
| Flow | VA activities should flow without interruption |

| | |
|---|---|
| Pull | Lean operates with a pull approach, therefore demand should be driven by the customer |
| Perfection | It is essential to view the removal of waste as ongoing, a mind-set is required that strives to continuously improve operations and processes |

## 2. Hypotheses

H1a: There is a relationship of statistical evidence between patient volume and the performance (percentage of patients seen in less than four hours). H1a will be examined through the use of a bivariate correlation test using the performance and volume variables. This hypothesis was found to be unsupported as after running a bivariate correlation (Pearson's). This produced a value of -0.13 (pre log-transformation) and 0.142 (post log-transformation), showing only a weak relationship (see appendix two).

H1b: Month number plays significant role in influencing patient volume. H1b has been examined by subjecting the volume and month number variables to regression analysis. This produced an r-squared value of 0.461, meaning 46.1% of the time month number impacts patient volume.

The tests employed to investigate the hypotheses are discussed further in the following chapter.

## 3. Methods, Analysis and Findings

A deductive research approach has been deemed most appropriate for this type of research. A deductive approach is when a theoretical proposition is tested through a research strategy specifically designed for it's testing. From a philosophical perspective, a positivist stance has been selected. This is because the data and concepts being examined can be observed in the 'real world', the end product can be "law-like generalisations" (Saunders et al, 2012).

As previously mentioned the NHS has set a 95% performance objective within A&E to see patients within a four hour period, previously at 98%, the performance objective was relaxed to 95% in 2010 (Triggle, 2013).

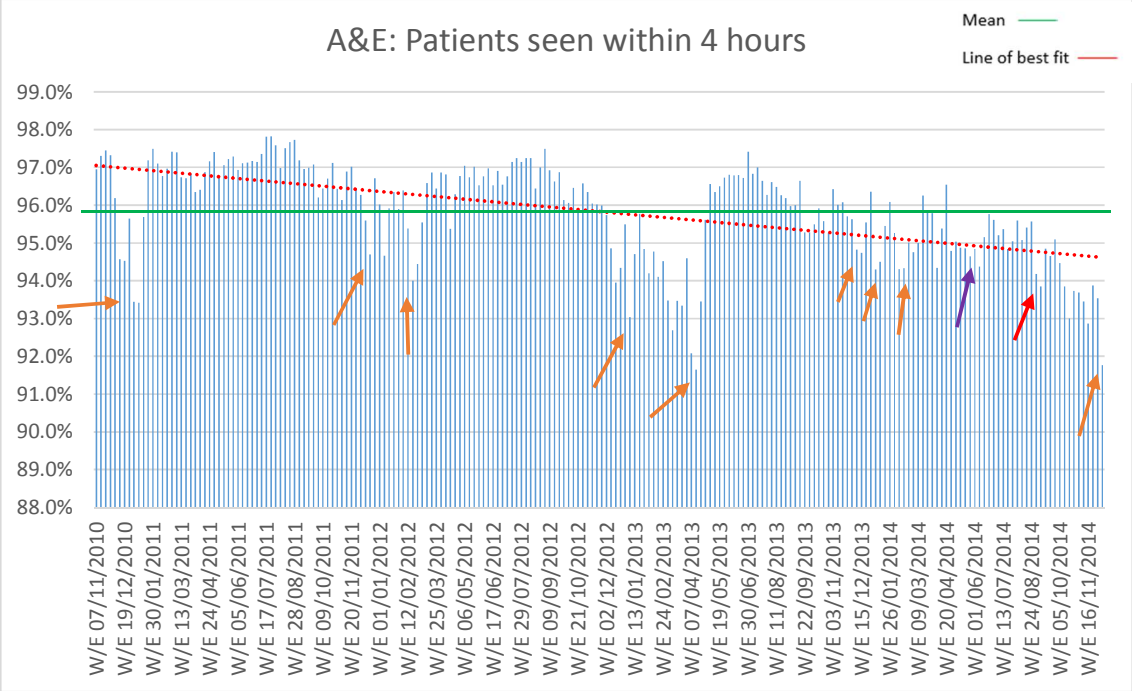



**Figure 2:** Percent of A&E patients seen within 4 hours

*Based on data from NHS England (2014) – Weekly date from November 2010 – December 2014 – Dataset can be found in Appendix one.*

From the data displayed in figure two above, there are a number of interpretations and observations that can be made. The first observation that can be made is that there is a decrease in performance (percentage of patients seen in 4 hours), as shown by the line of best fit, from approximately 97% (2010) to 94.7% (2014). This coincides with the NHS's performance objective being reduced in 2010 from 98% to 95% (Triggle, 2013). In addition to this, figure six (below) shows volume or demand, we can see from the line of best fit (yellow/orange) that is there is a clear upward trend, in other words, the trend shows demand on A&E services is increasing.

We can see in figure three that there are nine downward trends in performance (noted by orange arrows), when the performance drops below the line of best fit and mean for at least two consecutive weeks; eight of these nine trends coincide with the winter months (November – February). However; there is one point outside of this range, around March/April 2013. "From around 10 March to 10 April the UK experienced a prolonged spell of below average temperatures" (Met Office, 2013). The purple arrow coincides with the World Cup 2014; a time when alcohol consumption and as a result accidents tend to increase. As for the red arrow; there is no *known* explanation for this decrease in performance.

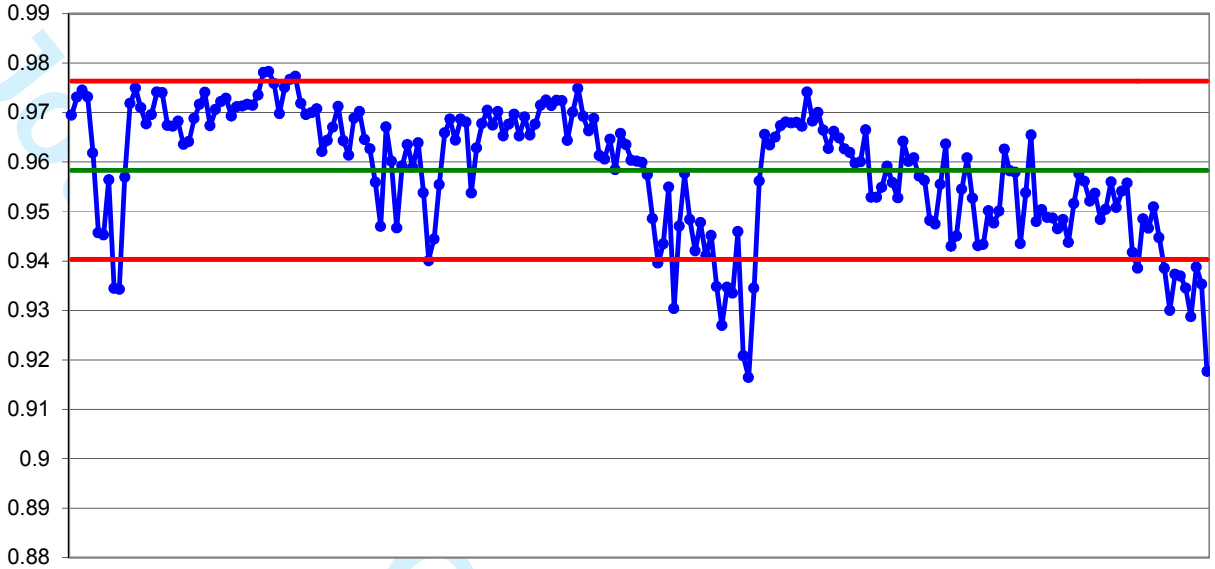



**Figure 3:** Statistical Process Control (SPC) chart

The data can also be analysed from a more technical standpoint, by using a Statistical Process Control (SPC) chart. It allows processes to be monitored and for responses to be taken when deviations from the acceptable performance level or quality are detected (Slack et al, 2013). There are four rules when interpreting the output data. *Rule one*; any points which are outside the upper control limit (UCL) and the lower control limit (LCL) denoted by the horizontal red lines. *Rule two;* a run of seven points or more in one direction, or if there are seven or more points below or above the mean. *Rule three;* an usual trend, such as a cyclical patter and *rule four;* an unusual distribution (Ritchie, 2014).

For the purpose of the analysis and interpretation of this data, not all of the rules will be enforced and some will only be only partially enforced. *Rule one* will be partially enforced; points which only breach the LCL will be discussed, this is because the NHS performance objective of 95% is considered to be a minimum requirement, therefore the problematic data points are those which fall 'significantly' below the mean and therefore outside the LCL. *Rule two* will also be partially enforced; the instances where points run below the mean will only be discussed, *rule three* will be enforced fully, as will rule four.

**Table 4:** SPC rules applied to NHS A&E data

| Rule Number | Data points / timeframe | Possible explanation/correlation |
|---|---|---|
| 1 | 9, 10: January 2011 | Winter causing extra strain on the system |
| 1 | 114: January 2013 | Winter causing extra strain on the system |
| 1 | 122, 123, 124, 125: March 2013 | Unseasonal cold weather/snow fall |
| 1 | 127, 128, 129: April 2013 | Unseasonal cold weather |
| 2 | 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130: January to April 2013 | Winter causing extra strain on the system + unseasonal cold weather/snow fall (Met Office, 2013) |
| 2 | 182, 183, 184, 185, 186, 187, 188, 189: April to June 2014 | April/May 2014: Unknown<br>June 2014: Coincides with the World Cup |
| 2 | 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214: July to December 2014 | July to October 2014: Unknown<br>November to December 2014: Winter causing extra strain on the system (Keogh, 2014) |

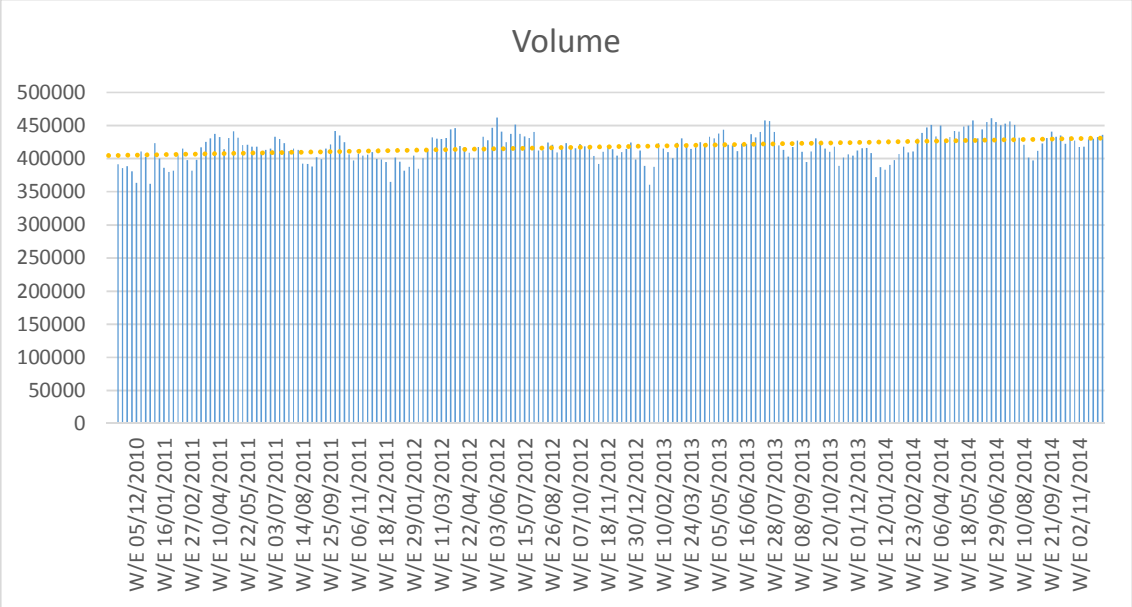



**Figure 4:** Volume of A&E patients

The gradual increase in demand of A&E services between 2010 and 2014 (figure four) can be attributed to a number of factors. The Office for National Statistics or ONS (2014) has suggested that the projected total population annual growth rate between 2012 and 2037 will be +0.6% for England, of course the larger the population, the more demand on medical services such as A&E. In addition to this factor, the population of the state pension age is projected to grow annually by +1.1% between 2012 and 2037; as there is an ageing population, we can also attribute this factor to placing additional strain on public services such as A&E.

**Table 5:** Statistical measures of percentage of A&E patients seen within 4 hours

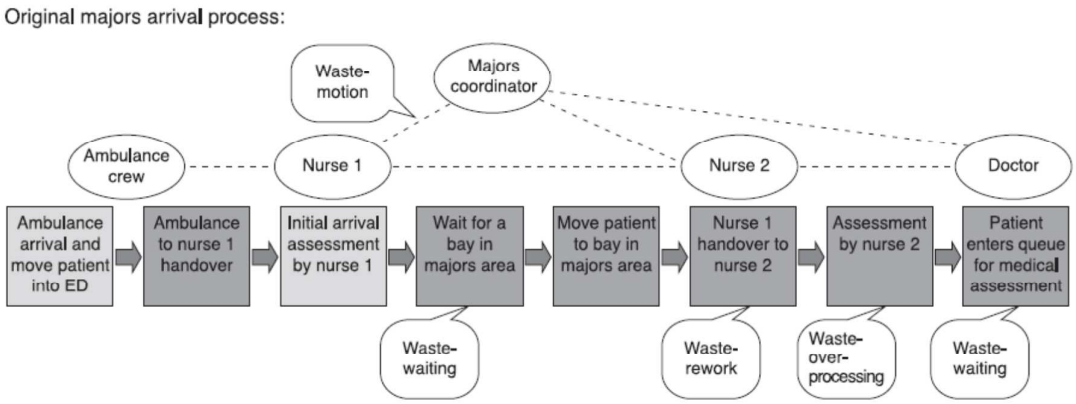
**Table 5:** Statistic measures of percentage of A&E patients seen within 4 hours

| | | | |
|---|---|---|---|
| N | 215 | Sum Weights | 215 |
| Mean | 0.958 | Sum Observations | 205.975 |
| Std Deviation | 0.013 | Variance | 0.00017901 |
| Skewness | -1.086 | Kurtosis | 1.528 |
| Uncorrected SS | 197.367 | Uncorrected SS | 0.038 |
| Coeff Variation | 1.396 | Std Error Mean | 0.00091248 |

As skewness and kurtosis are not a value of zero, we know that the data is not normally distributed. This restricts the models that can be used for analytical purposes, it is possible to normalise the distribution of the data through a log or square root transformation, as it is a negative skew, it is important that the scores are first reflected (Field & Miles, 2010).

The hypothesis h1a; there is a relationship of statistical evidence between patient volume and the performance (percentage of patients seen in less than four hours) is not supported as demonstrated after running a bivariate correlation (Pearson's). This produced a value of -0.13 (pre log-transformation) and 0.142 (post log-transformation), showing only a weak relationship (see appendix two).

After running a General Linear Model in SPSS, a regression-coefficient (r-squared value) for the independent variable (month number) and its effect/relationship with the dependent variable (total attendances) was derived. Producing a value of 0.461, 46.1% of the variances associated with attendance/volume in A&E can be explained by the month number (time of year). As there is an element of psychology involved, we are examining people and in many cases there is choice whether to visit A&E or not. Frost (2014) suggests that when psychology is involved it is rare for an r-squared value to be above 50%, this value is acceptable. Therefore hypothesis h1b; month number plays significant role in influencing patient volume is supported. Additionally, it is assumed that it is only the winter/cold months that have a strong relationship/impact on A&E attendances.

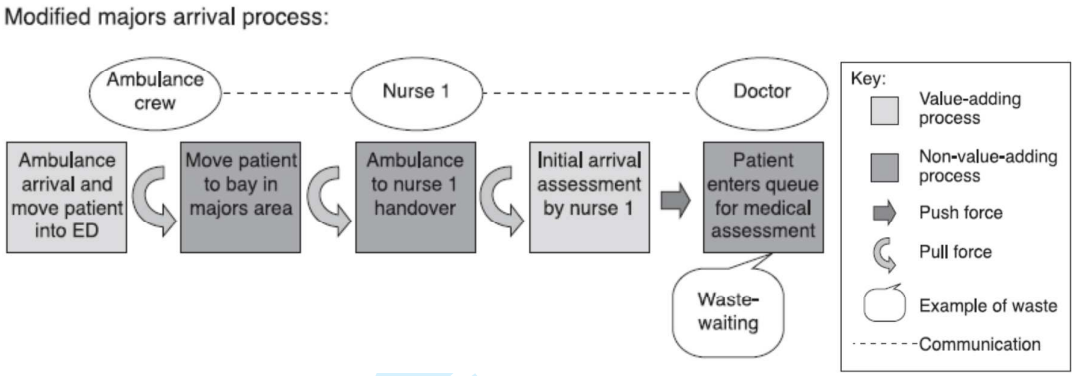



(Cookson, 2011)

**Figure 5:** Original A&E Arrival Process

Figure 5 (above) there are a number of wastes (NVAs) that can be identified. Over-processing; such as patients that are seen by and assessed by two separate nurses. There are multiple occasions where there is unnecessary waiting time, waste through motion and rework. Throughout the entire arrivals process there are only two value-adding activities (light grey); the ambulance arrival and patient movement and the initial assessment by

nurse one. Not only are there only two VA activities compared to four NVA activities, but also the VA activities have interruptions, so there is not the concept of flow.




(Cookson, 2011)
**Figure 6:** Modified Arrival Process & Key

After the Lean Principles have been applied to the arrival process we can see that this is comparably streamlined. The process is now mostly 'pull' focused as opposed to 'push', the elements of duplication have been removed; such as being assessed by two nurses. There are still some elements of waste/NVA activities, however, these can be considered as essential-non-value adding waste.

Through the application of the Lean Principles and consequently the streamlined effect that can be seen in the flow chart; not only are fewer resources required but the process is also quicker. In theory allowing the reallocation of resources to bottlenecks further down in A&E, the combination of this and the new efficient arrivals process will allow the 95% performance objective to be achieved more consistently. This would also allow the system to cope better under pressure at times of high capacity/demand such as winter.

**Table 6:** The 5S Framework with Healthcare applications

| **Japanese** (Gapp et al, 2008) | **English translation** (Bicheno & Holweg, 2009) | **Applications** | **Applications** |
|---|---|---|---|
| Seiri | Sort | "A National Audit Office sample of 61 trusts found they bought 21 different types of A4 paper, 652 different types of surgical and examination glove and 1,751 different cannulas." (Hitchcock. 2011) – | Removal of old and broken equipment<br>Out-of-date stock in store rooms/medicine cupboards |

| | | | |
|---|---|---|---|
| | | Workplace should be organised and items should be removed. | |
| Seiton | Simplify | See seven and eight (below) for visual management examples within healthcare. | Labels/descriptions in stores and medicine cupboards<br>Patient files to be in a logical order in appropriate filing storage<br>Pharmacy items sorted in order of most frequently required<br>Colour-coded specimens for pathology |
| Seiso | Scan | | Ward offices and nursing stations should be uncluttered<br>Infection control/hand control |
| Seiketsu | Standardise | Linking with the quote from Hitchcock (above); procurement should be standardised. It is also worth noting that this is only a snapshot (surgical gloves and cannulas) and there are likely to be other examples in a similar vein such as syringes etc. A lack of standarised procurement is likely to not only lead to increase procurement costs, but also less efficient operations. | Discharge and admission procedures should be standardised so that only the required information is collected<br>Standardised rules/procedures should be accessible/visible where appropriate (figure nine, below). This example states the items and quantities which should be in the storage cupboard, this prevents overstocking but also ensures there is no stock-out. |
| Shitsuke | Sustain | Success stories are displayed on notice boards for all employees to see. The idea is that success should encourage other and that everyone should be involved, see figure ten (below). | Regular measurements to ensure results are maintained: SPC charts/NHS weekly measurements of patients admitted within 4 hours<br>Sharing success stories on notice boards |

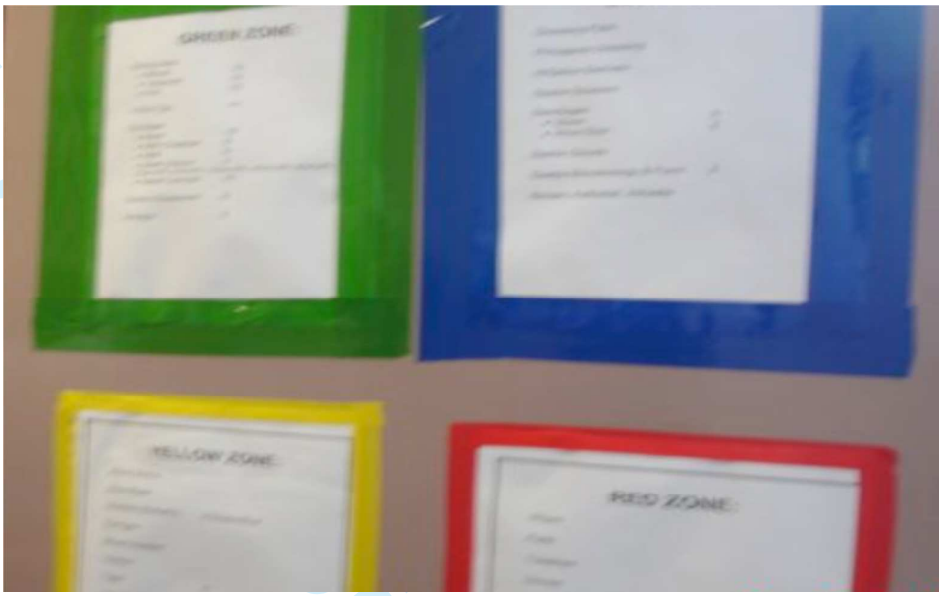
(NHS, 2010)

**Figure 7:** Visual management in NHS


(NHS, 2010)

**Figure 8:** Shadow boards in NHS

The above examples show where equipment can be found and where it should be returned to when the operator has finished using it. This means employees don't produce waste in trying to find an item, it also keeps the area tidy; ultimately making the process more efficient.




(NHS, 2010)

**Figure 9:** Standardisation in the NHS


(NHS, 2010)

**Figure 10:** Successes in the NHS

# 4. Conclusions

The data analysed depicts a story about the NHS and its ongoing challenges within A&E, in this case, these issues are primarily three-fold. First of all it can be seen that the NHS is falling ever shorter of its 95% performance objective to see patients in A&E within a four hour period. Secondly, a gradual increase in patients/demand on A&E services; fuelled by an ageing and growing population and a finally a further constraint exists in the shape of a funding gap, believed to be approximately £2 billion. From the statistical analyses, it is suggested that the month number (seasonality) has an impact on volume, with an r-squared value of 0.461, however there is only a weak correlation between volume of patients and the NHS's ability to meet its 95% target. This can perhaps be attributed to the NHS effectively foreseeing peaks in demand due to seasonality and then deploying additional resources to cope with these peaks.

Mazzocato et al (2010) systemically reviewed the outcomes of Lean application in healthcare and found a number of benefits:

- Time-savings
- Timeliness of service
- Cost reductions/productivity improvements
- Quality improvements – fewer errors/mistakes
- Improved staff and patient satisfaction
- Reduced mortality

The above suggest that Lean in the NHS will in some part, at least, work towards solving the three issues identified. However it is important to note that it has been suggested by Bhasin and Burcher (2006) that only 10 percent of business who attempt to implement lean are successful, although this figure is taken from a manufacturing context and therefore is not entirely reliable when considering services.

It is also important to note that with Lean, typically less inventory is carried and this can have serious impacts within a healthcare environment. "…most hospitals only carry two to three days' supplies... Because of deliveries in the NHS being organised on a just-in-time basis, the action could have a huge and immediate impact." (Choonara. 2006). This could lead to ineffective treatment and even fatalities should an unexpected spike in patients/demand for medical services arise.

The proposed solution for the NHS to accelerate and fully embrace the Lean Philosophy and ways into its organisational culture does not guarantee a dramatic turnaround in the NHS, it will take considerable time and success is not ensured. Mullins (2010) suggests that "despite the potential positive outcomes, change is often resisted at both the individual and the organizational level." So while the decision to go Lean must be communicated from the top-down, it can be argued that it is equally important to ensure employees are fully aware of the reasoning for Lean, the benefits it offer to the NHS and themselves and that they're fully involved and empowered throughout this transformational process. A desire for change must be created to give Lean a fighting chance of succeeding within the NHS.

# 7. Appendix

*Appendix One*

| Month Number | Period | Total at-tendances | Percentage in 4 hours or less (all) |
|---|---|---|---|
| 11 | W/E 07/11/2010 | 391,495 | 96.9% |
| 11 | W/E 14/11/2010 | 385,685 | 97.3% |
| 11 | W/E 21/11/2010 | 388,743 | 97.4% |
| 11 | W/E 28/11/2010 | 381,273 | 97.3% |
| 12 | W/E 05/12/2010 | 363,410 | 96.2% |
| 12 | W/E 12/12/2010 | 411,130 | 94.6% |
| 12 | W/E 19/12/2010 | 402,809 | 94.5% |
| 12 | W/E 26/12/2010 | 361,870 | 95.6% |
| 1 | W/E 02/01/2011 | 423,295 | 93.4% |
| 1 | W/E 09/01/2011 | 400,282 | 93.4% |
| 1 | W/E 16/01/2011 | 386,293 | 95.7% |
| 1 | W/E 23/01/2011 | 380,241 | 97.2% |
| 1 | W/E 30/01/2011 | 382,155 | 97.5% |
| 2 | W/E 06/02/2011 | 405,190 | 97.1% |
| 2 | W/E 13/02/2011 | 414,931 | 96.8% |
| 2 | W/E 20/02/2011 | 398,042 | 97.0% |
| 2 | W/E 27/02/2011 | 382,208 | 97.4% |
| 3 | W/E 06/03/2011 | 398,141 | 97.4% |
| 3 | W/E 13/03/2011 | 416,788 | 96.7% |
| 3 | W/E 20/03/2011 | 425,003 | 96.7% |
| 3 | W/E 27/03/2011 | 430,512 | 96.8% |
| 4 | W/E | 437,280 | 96.4% |

| | | | |
|---|---|---|---|
| | 03/04/2011 | | |
| 4 | W/E 10/04/2011 | 433,066 | 96.4% |
| 4 | W/E 17/04/2011 | 414,417 | 96.9% |
| 4 | W/E 24/04/2011 | 430,923 | 97.2% |
| 5 | W/E 01/05/2011 | 441,657 | 97.4% |
| 5 | W/E 08/05/2011 | 431,361 | 96.7% |
| 5 | W/E 15/05/2011 | 420,448 | 97.1% |
| 5 | W/E 22/05/2011 | 420,850 | 97.2% |
| 5 | W/E 29/05/2011 | 418,370 | 97.3% |
| 6 | W/E 05/06/2011 | 418,503 | 96.9% |
| 6 | W/E 12/06/2011 | 410,394 | 97.1% |
| 6 | W/E 19/06/2011 | 413,409 | 97.1% |
| 6 | W/E 26/06/2011 | 415,143 | 97.2% |
| 7 | W/E 03/07/2011 | 433,196 | 97.1% |
| 7 | W/E 10/07/2011 | 429,461 | 97.4% |
| 7 | W/E 17/07/2011 | 423,223 | 97.8% |
| 7 | W/E 24/07/2011 | 411,310 | 97.8% |
| 7 | W/E 31/07/2011 | 415,310 | 97.6% |
| 8 | W/E 07/08/2011 | 413,321 | 97.0% |
| 8 | W/E 14/08/2011 | 392,425 | 97.5% |
| 8 | W/E 21/08/2011 | 391,908 | 97.7% |
| 8 | W/E 28/08/2011 | 388,154 | 97.7% |
| 9 | W/E 04/09/2011 | 402,034 | 97.2% |
| 9 | W/E 11/09/2011 | 399,391 | 97.0% |
| 9 | W/E 18/09/2011 | 415,195 | 97.0% |
| 9 | W/E 25/09/2011 | 421,368 | 97.1% |

| | | | |
|---|---|---|---|
| 10 | W/E 02/10/2011 | 441,732 | 96.2% |
| 10 | W/E 09/10/2011 | 435,304 | 96.4% |
| 10 | W/E 16/10/2011 | 424,876 | 96.7% |
| 10 | W/E 23/10/2011 | 406,739 | 97.1% |
| 10 | W/E 30/10/2011 | 397,553 | 96.4% |
| 11 | W/E 06/11/2011 | 407,619 | 96.1% |
| 11 | W/E 13/11/2011 | 404,644 | 96.9% |
| 11 | W/E 20/11/2011 | 406,047 | 97.0% |
| 11 | W/E 27/11/2011 | 410,069 | 96.5% |
| 12 | W/E 04/12/2011 | 399,684 | 96.3% |
| 12 | W/E 11/12/2011 | 398,930 | 95.6% |
| 12 | W/E 18/12/2011 | 395,212 | 94.7% |
| 12 | W/E 25/12/2011 | 365,203 | 96.7% |
| 1 | W/E 01/01/2012 | 401,695 | 96.0% |
| 1 | W/E 08/01/2012 | 395,703 | 94.7% |
| 1 | W/E 15/01/2012 | 382,031 | 95.9% |
| 1 | W/E 22/01/2012 | 388,000 | 96.4% |
| 1 | W/E 29/01/2012 | 404,509 | 95.9% |
| 2 | W/E 05/02/2012 | 384,615 | 96.4% |
| 2 | W/E 12/02/2012 | 400,664 | 95.4% |
| 2 | W/E 19/02/2012 | 412,534 | 94.0% |
| 2 | W/E 26/02/2012 | 431,996 | 94.4% |
| 3 | W/E 04/03/2012 | 430,063 | 95.5% |
| 3 | W/E 11/03/2012 | 429,589 | 96.6% |
| 3 | W/E 18/03/2012 | 431,047 | 96.9% |
| 3 | W/E 25/03/2012 | 444,324 | 96.4% |

| | | | |
|---|---|---|---|
| 4 | W/E 01/04/2012 | 446,183 | 96.9% |
| 4 | W/E 08/04/2012 | 419,246 | 96.8% |
| 4 | W/E 15/04/2012 | 417,098 | 95.4% |
| 4 | W/E 22/04/2012 | 408,582 | 96.3% |
| 4 | W/E 29/04/2012 | 401,215 | 96.8% |
| 5 | W/E 06/05/2012 | 417,493 | 97.0% |
| 5 | W/E 13/05/2012 | 433,468 | 96.7% |
| 5 | W/E 20/05/2012 | 427,886 | 97.0% |
| 5 | W/E 27/05/2012 | 446,483 | 96.5% |
| 6 | W/E 03/06/2012 | 461,794 | 96.8% |
| 6 | W/E 10/06/2012 | 440,940 | 97.0% |
| 6 | W/E 17/06/2012 | 424,523 | 96.5% |
| 6 | W/E 24/06/2012 | 437,392 | 96.9% |
| 7 | W/E 01/07/2012 | 451,587 | 96.5% |
| 7 | W/E 08/07/2012 | 437,175 | 96.8% |
| 7 | W/E 15/07/2012 | 433,563 | 97.1% |
| 7 | W/E 22/07/2012 | 431,075 | 97.3% |
| 7 | W/E 29/07/2012 | 440,375 | 97.1% |
| 8 | W/E 05/08/2012 | 412,380 | 97.2% |
| 8 | W/E 12/08/2012 | 412,776 | 97.2% |
| 8 | W/E 19/08/2012 | 424,420 | 96.4% |
| 8 | W/E 26/08/2012 | 421,012 | 97.0% |
| 9 | W/E 02/09/2012 | 409,328 | 97.5% |
| 9 | W/E 09/09/2012 | 416,144 | 96.9% |
| 9 | W/E 16/09/2012 | 423,360 | 96.6% |
| 9 | W/E 23/09/2012 | 416,603 | 96.9% |

| | | | |
|---|---|---|---|
| 9 | W/E 30/09/2012 | 415,433 | 96.1% |
| 10 | W/E 07/10/2012 | 421,737 | 96.1% |
| 10 | W/E 14/10/2012 | 418,557 | 96.5% |
| 10 | W/E 21/10/2012 | 420,037 | 95.8% |
| 10 | W/E 28/10/2012 | 404,020 | 96.6% |
| 11 | W/E 04/11/2012 | 391,891 | 96.3% |
| 11 | W/E 11/11/2012 | 410,820 | 96.0% |
| 11 | W/E 18/11/2012 | 417,281 | 96.0% |
| 11 | W/E 25/11/2012 | 414,435 | 96.0% |
| 12 | W/E 02/12/2012 | 404,784 | 95.7% |
| 12 | W/E 09/12/2012 | 409,890 | 94.9% |
| 12 | W/E 16/12/2012 | 414,700 | 94.0% |
| 12 | W/E 23/12/2012 | 424,281 | 94.3% |
| 12 | W/E 30/12/2012 | 399,014 | 95.5% |
| 1 | W/E 06/01/2013 | 412,216 | 93.0% |
| 1 | W/E 13/01/2013 | 389,236 | 94.7% |
| 1 | W/E 20/01/2013 | 360,739 | 95.8% |
| 1 | W/E 27/01/2013 | 388,036 | 94.8% |
| 2 | W/E 03/02/2013 | 423,114 | 94.2% |
| 2 | W/E 10/02/2013 | 415,039 | 94.8% |
| 2 | W/E 17/02/2013 | 409,586 | 94.1% |
| 2 | W/E 24/02/2013 | 400,726 | 94.5% |
| 3 | W/E 03/03/2013 | 423,610 | 93.5% |
| 3 | W/E 10/03/2013 | 430,769 | 92.7% |
| 3 | W/E 17/03/2013 | 420,997 | 93.5% |
| 3 | W/E 24/03/2013 | 414,799 | 93.3% |

| | | | |
|---|---|---|---|
| 3 | W/E 31/03/2013 | 416,972 | 94.6% |
| 4 | W/E 07/04/2013 | 424,499 | 92.1% |
| 4 | W/E 14/04/2013 | 417,763 | 91.6% |
| 4 | W/E 21/04/2013 | 433,446 | 93.4% |
| 4 | W/E 28/04/2013 | 430,561 | 95.6% |
| 5 | W/E 05/05/2013 | 438,030 | 96.6% |
| 5 | W/E 12/05/2013 | 443,718 | 96.3% |
| 5 | W/E 19/05/2013 | 420,859 | 96.5% |
| 5 | W/E 26/05/2013 | 420,304 | 96.7% |
| 6 | W/E 02/06/2013 | 411,475 | 96.8% |
| 6 | W/E 09/06/2013 | 422,308 | 96.8% |
| 6 | W/E 16/06/2013 | 422,005 | 96.8% |
| 6 | W/E 23/06/2013 | 437,033 | 96.7% |
| 6 | W/E 30/06/2013 | 432,126 | 97.4% |
| 7 | W/E 07/07/2013 | 440,751 | 96.8% |
| 7 | W/E 14/07/2013 | 457,675 | 97.0% |
| 7 | W/E 21/07/2013 | 457,046 | 96.6% |
| 7 | W/E 28/07/2013 | 440,753 | 96.3% |
| 8 | W/E 04/08/2013 | 420,149 | 96.6% |
| 8 | W/E 11/08/2013 | 413,461 | 96.5% |
| 8 | W/E 18/08/2013 | 403,535 | 96.3% |
| 8 | W/E 25/08/2013 | 417,216 | 96.2% |
| 9 | W/E 01/09/2013 | 427,343 | 96.0% |
| 9 | W/E 08/09/2013 | 410,663 | 96.0% |
| 9 | W/E 15/09/2013 | 395,337 | 96.6% |
| 9 | W/E 22/09/2013 | 410,869 | 95.3% |

| | | | |
|---|---|---|---|
| 9 | W/E 29/09/2013 | 430,353 | 95.3% |
| 10 | W/E 06/10/2013 | 423,344 | 95.5% |
| 10 | W/E 13/10/2013 | 415,362 | 95.9% |
| 10 | W/E 20/10/2013 | 410,503 | 95.6% |
| 10 | W/E 27/10/2013 | 418,366 | 95.3% |
| 11 | W/E 03/11/2013 | 389,081 | 96.4% |
| 11 | W/E 10/11/2013 | 401,448 | 96.0% |
| 11 | W/E 17/11/2013 | 406,615 | 96.1% |
| 11 | W/E 24/11/2013 | 404,822 | 95.7% |
| 12 | W/E 01/12/2013 | 412,303 | 95.6% |
| 12 | W/E 08/12/2013 | 415,790 | 94.8% |
| 12 | W/E 15/12/2013 | 415,972 | 94.7% |
| 12 | W/E 22/12/2013 | 408,501 | 95.5% |
| 12 | W/E 29/12/2013 | 372,162 | 96.4% |
| 1 | W/E 05/01/2014 | 387,463 | 94.3% |
| 1 | W/E 12/01/2014 | 383,566 | 94.5% |
| 1 | W/E 19/01/2014 | 390,532 | 95.4% |
| 1 | W/E 26/01/2014 | 398,018 | 96.1% |
| 2 | W/E 02/02/2014 | 406,929 | 95.3% |
| 2 | W/E 09/02/2014 | 418,413 | 94.3% |
| 2 | W/E 16/02/2014 | 409,118 | 94.3% |
| 2 | W/E 23/02/2014 | 410,878 | 95.0% |
| 3 | W/E 02/03/2014 | 429,996 | 94.8% |
| 3 | W/E 09/03/2014 | 438,615 | 95.0% |
| 3 | W/E 16/03/2014 | 446,850 | 96.3% |
| 3 | W/E 23/03/2014 | 450,955 | 95.8% |

| | | | |
|---|---|---|---|
| 3 | W/E 30/03/2014 | 433,777 | 95.8% |
| 4 | W/E 06/04/2014 | 449,931 | 94.3% |
| 4 | W/E 13/04/2014 | 427,975 | 95.4% |
| 4 | W/E 20/04/2014 | 432,610 | 96.5% |
| 4 | W/E 27/04/2014 | 442,081 | 94.8% |
| 5 | W/E 04/05/2014 | 440,942 | 95.0% |
| 5 | W/E 11/05/2014 | 448,841 | 94.9% |
| 5 | W/E 18/05/2014 | 450,096 | 94.9% |
| 5 | W/E 25/05/2014 | 457,670 | 94.6% |
| 6 | W/E 01/06/2014 | 430,472 | 94.8% |
| 6 | W/E 08/06/2014 | 444,073 | 94.4% |
| 6 | W/E 15/06/2014 | 455,739 | 95.2% |
| 6 | W/E 22/06/2014 | 460,803 | 95.8% |
| 6 | W/E 29/06/2014 | 455,264 | 95.6% |
| 7 | W/E 06/07/2014 | 450,424 | 95.2% |
| 7 | W/E 13/07/2014 | 452,998 | 95.4% |
| 7 | W/E 20/07/2014 | 456,493 | 94.8% |
| 7 | W/E 27/07/2014 | 450,999 | 95.0% |
| 8 | W/E 03/08/2014 | 431,492 | 95.6% |
| 8 | W/E 10/08/2014 | 421,257 | 95.1% |
| 8 | W/E 17/08/2014 | 401,499 | 95.4% |
| 8 | W/E 24/08/2014 | 397,239 | 95.6% |
| 8 | W/E 31/08/2014 | 411,938 | 94.2% |
| 9 | W/E 07/09/2014 | 422,711 | 93.9% |
| 9 | W/E 14/09/2014 | 430,940 | 94.8% |
| 9 | W/E 21/09/2014 | 441,071 | 94.7% |

| | | | |
|---|---|---|---|
| 9 | W/E 28/09/2014 | 433,490 | 95.1% |
| 10 | W/E 05/10/2014 | 435,105 | 94.5% |
| 10 | W/E 12/10/2014 | 422,514 | 93.8% |
| 10 | W/E 19/10/2014 | 433,282 | 93.0% |
| 10 | W/E 26/10/2014 | 427,194 | 93.7% |
| 11 | W/E 02/11/2014 | 417,360 | 93.7% |
| 11 | W/E 09/11/2014 | 418,269 | 93.5% |
| 11 | W/E 16/11/2014 | 429,166 | 92.9% |
| 11 | W/E 23/11/2014 | 430,273 | 93.9% |
| 11 | W/E 30/11/2014 | 432,415 | 93.5% |
| 12 | W/E 07/12/2014 | 436,229 | 91.8% |

*Appendix two – SPSS Outputs: General Linear Model & Bivariate Correlation*

**Between-Subjects Factors**

| | | N |
|---|---|---|
| Month Number | 1 | 18 |
| | 2 | 16 |
| | 3 | 18 |
| | 4 | 17 |
| | 5 | 17 |
| | 6 | 18 |
| | 7 | 18 |
| | 8 | 17 |
| | 9 | 18 |
| | 10 | 17 |
| | 11 | 21 |
| | 12 | 19 |

**Multivariate Tests[a]**

| Effect | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Intercept | Pillai's Trace | 1.000 | 168114689.156[b] | 5.000 | 198.000 | .000 |
| | Wilks' Lambda | .000 | 168114689.138[b] | 5.000 | 198.000 | .000 |
| | Hotelling's Trace | 4245320.433 | 168114689.138[b] | 5.000 | 198.000 | .000 |
| | Roy's Largest Root | 4245320.433 | 168114689.138[b] | 5.000 | 198.000 | .000 |
| MonthNumber | Pillai's Trace | 1.257 | 6.165 | 55.000 | 1010.000 | .000 |
| | Wilks' Lambda | .164 | 8.002 | 55.000 | 920.084 | .000 |
| | Hotelling's Trace | 2.958 | 10.562 | 55.000 | 982.000 | .000 |
| | Roy's Largest Root | 2.246 | 41.243[c] | 11.000 | 202.000 | .000 |

a. Design: Intercept + MonthNumber

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

**Tests of Between-Subjects Effects**

| Source | Dependent Variable | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Corrected Model | Type 1 Departments - Major A&E | 14412932799.298[a] | 11 | 1310266618.118 | 15.709 | .000 |
| | Type 2 Departments - Single Specialty | 61789496.868[b] | 11 | 5617226.988 | 13.567 | .000 |
| | Type 3 Departments - Other A&E/Minor Injury Unit | 7384530987.565[c] | 11 | 671320998.870 | 19.510 | .000 |
| | Total attendances | 43896097123.934[d] | 11 | 3990554283.994 | 19.237 | .000 |
| | Percentage in 4 hours or less (type 1) | 123.985[e] | 11 | 11.271 | 3.486 | .000 |
| | Percentage in 4 hours or less (all) | 56.627[f] | 11 | 5.148 | 3.579 | .000 |
| Intercept | Type 1 Departments - Major A&E | 15959427270651.908 | 1 | 15959427270651.908 | 191336.621 | .000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Type 2 Departments - Single Specialty | 31418472695.613 | 1 | 31418472695.613 | 75883.007 | .000 |
| | Type 3 Departments - Other A&E/Minor Injury Unit | 3734530051391.360 | 1 | 3734530051391.360 | 108532.194 | .000 |
| | Total attendances | 3726700775832 9.140 | 1 | 3726700775832 9.140 | 179654.040 | .000 |
| | Percentage in 4 hours or less (type 1) | 1872221.200 | 1 | 1872221.200 | 579093.698 | .000 |
| | Percentage in 4 hours or less (all) | 1956880.700 | 1 | 1956880.700 | 1360567.799 | .000 |
| MonthNumber | Type 1 Departments - Major A&E | 14412932799.299 | 11 | 1310266618.118 | 15.709 | .000 |
| | Type 2 Departments - Single Specialty | 61789496.868 | 11 | 5617226.988 | 13.567 | .000 |
| | Type 3 Departments - Other A&E/Minor Injury Unit | 7384530987.565 | 11 | 671320998.870 | 19.510 | .000 |
| | Total attendances | 43896097123.934 | 11 | 3990554283.994 | 19.237 | .000 |
| | Percentage in 4 hours or less (type 1) | 123.985 | 11 | 11.271 | 3.486 | .000 |
| | Percentage in 4 hours or less (all) | 56.627 | 11 | 5.148 | 3.579 | .000 |
| Error | Type 1 Departments - Major A&E | 16848861955.505 | 202 | 83410207.701 | | |
| | Type 2 Departments - Single Specialty | 83635740.127 | 202 | 414038.317 | | |
| | Type 3 Departments - Other A&E/Minor Injury Unit | 6950703213.145 | 202 | 34409421.847 | | |
| | Total attendances | 41902400703.548 | 202 | 207437627.245 | | |
| | Percentage in 4 hours or less (type 1) | 653.070 | 202 | 3.233 | | |
| | Percentage in 4 hours or less (all) | 290.533 | 202 | 1.438 | | |
| Total | Type 1 Departments - Major A&E | 16048768922052.000 | 214 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Type 2 Departments - Single Specialty | 31653516089.000 | 214 | | | |
| | Type 3 Departments - Other A&E/Minor Injury Unit | 3757523370818.000 | 214 | | | |
| | Total attendances | 37471992020215.000 | 214 | | | |
| | Percentage in 4 hours or less (type 1) | 1881096.930 | 214 | | | |
| | Percentage in 4 hours or less (all) | 1965672.606 | 214 | | | |
| Corrected Total | Type 1 Departments - Major A&E | 31261794754.803 | 213 | | | |
| | Type 2 Departments - Single Specialty | 145425236.995 | 213 | | | |
| | Type 3 Departments - Other A&E/Minor Injury Unit | 14335234200.710 | 213 | | | |
| | Total attendances | 85798497827.482 | 213 | | | |
| | Percentage in 4 hours or less (type 1) | 777.055 | 213 | | | |
| | Percentage in 4 hours or less (all) | 347.160 | 213 | | | |

a. R Squared = .461 (Adjusted R Squared = .432)

b. R Squared = .425 (Adjusted R Squared = .394)

c. R Squared = .515 (Adjusted R Squared = .489)

d. R Squared = .512 (Adjusted R Squared = .485)

e. R Squared = .160 (Adjusted R Squared = .114)

f. R Squared = .163 (Adjusted R Squared = .118)

**Correlations (pre-transformation)**

| | | Total attend-ances | Percentage in 4 hours or less (all) |
|---|---|---|---|
| Total attendances | Pearson Correlation | 1 | -.132 |
| | Sig. (2-tailed) | | .053 |

| | | | | | |
|---|---|---|---|---|---|
| | N | | | 214 | 214 |
| | Bootstrap[c] | Bias | | 0 | -.001 |
| | | Std. Error | | 0 | .054 |
| | | 95% Confidence Interval | Lower | 1 | -.235 |
| | | | Upper | 1 | -.022 |
| Percentage in 4 hours or less (all) | Pearson Correlation | | | -.132 | 1 |
| | Sig. (2-tailed) | | | .053 | |
| | N | | | 214 | 214 |
| | Bootstrap[c] | Bias | | -.001 | 0 |
| | | Std. Error | | .054 | 0 |
| | | 95% Confidence Interval | Lower | -.235 | 1 |
| | | | Upper | -.022 | 1 |

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

**Correlations (post-transformation)**

| | | | | Total attend-ances | Rlog10 |
|---|---|---|---|---|---|
| Total attendances | Pearson Correlation | | | 1 | .142* |
| | Sig. (2-tailed) | | | | .038 |
| | N | | | 214 | 214 |
| | Bootstrap[c] | Bias | | 0 | .001 |
| | | Std. Error | | 0 | .058 |
| | | 95% Confidence Interval | Lower | 1 | .032 |
| | | | Upper | 1 | .263 |
| Rlog10 | Pearson Correlation | | | .142* | 1 |
| | Sig. (2-tailed) | | | .038 | |
| | N | | | 214 | 214 |
| | Bootstrap[c] | Bias | | .001 | 0 |
| | | Std. Error | | .058 | 0 |
| | | 95% Confidence Interval | Lower | .032 | 1 |
| | | | Upper | .263 | 1 |

*. Correlation is significant at the 0.05 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

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