academicJournals

Vol. 10(18), pp. 2590-2598, 23 September, 2015
DOI: 10.5897/ERR2015.2356
Article Number: F2B2C5C55426
ISSN 1990-3839

http://www.academicjournals.org/ERR

Educational Research and Reviews

Full Length Research Paper

How six sigma methodology improved doctors' performance

George Zafiropoulos

Orthopaedic Department, Prince Charles Hospital, Merthyr Tydfil, University of South Wales, Wales, United Kingdom.

Received 20 June, 2015; Accepted 13 August, 2015

Six Sigma methodology was used in a District General Hospital to assess the effect of the introduction of an educational programme to limit unnecessary admissions. The performance of the doctors involved in the programme was assessed. Ishikawa Fishbone and 5 S's were initially used and Pareto analysis of their findings was performed. The results were analysed and it was found that it was favouring the use of this technique, as the Six Sigma value increased from 2.6 to 4 producing a 99.4% yield. In conclusion this study stresses that The Six Sigma methodology is an acceptable tool which can be used for improvement of the performance of a Hospital Department and also of individuals; it can easily be used to improve the service safety and the patients' requirements.

Key words: Education, health, quality, six sigma methodology.

INTRODUCTION

Six sigma is a methodology used to improve the quality of any product. It started to be used in the manufacturing industry, as it was created and introduced in 1987 in Motorola. Since then many prominent industries as General Electric, Toyota and many others used it in trying to improve their quality (Basu, 2001; Bhote, 2003; Juran and De Feo, 2010; Pande et al., 2000; Pyzdek, 2003; Tomsett, 2005; Yang and El-Haik, 2003).

The methodology takes serious consideration of the customers' opinion and their requirements and by using these as the base improves the quality of the service.

The name is based on the Greek letter σ (σιγμα = sigma) which is the symbol of Standard Deviation. It is calculated that if the 6σ will be achieved the yield of the improvement is rising to 99.9997% (Bhote, 2003; Pyzdek, 2003; Yang and El-Haik, 2003; Tomsett, 2005; Juran and De Feo, 2010).

The methodology is based on the DMAIC (Define – Measure – Analyse – Improve – Control) concept. For service providing industry the 5 S's (Surrounding – Suppliers – Systems – Skills – Safety) system is used (Tomsett, 2005).

Six Sigma is known to be used in the industry (Bhote, 2003; Yang and El-Haik, 2003; Goffnett, 2004; Tomsett, 2005; Juran and De Feo, 2010; Pande et al., 2000; Reosekar and Pohekar, 2013).Since 2000 it started to be used in private educational institutes to improve educational performance and the outcome (Goffnett, 2004; Bandyopadhyah and Lichman, 2007; Kaushik and Khanduja, 2010; Mehrabi, 2012; Ramasubramanian,

E-mail: georgezafi@aol.com. Tel: 00447968093557.

2012; Prasad et al., 2012; Pryor et al., 2012; Lakshminarayanan and Pamanakumar, 2014), but it is not considered as method to be used openly in the health system, although since the early years of the turn of the millennium there are publications indicating the use of the methodology and mainly the lean six sigma application to different health institutions (Bahensky et al., 2005; Koning et al., 2006; Taner and Sezen, 2007; Schweikhart and Dembe, 2009; Stuenkel and Faulkner, 2009; Sanders, 2015).

The present study will concentrate on the impact the Six Sigma Methodology has in the quality improvement of the Orthopaedic Department in a District General Hospital with an increased in its emergency admissions and thus the quality and effect of individual doctors' performance following the implementation of an educational scheme in their daily curriculum. The aim is to answer if an educational programme would be possible to change doctors' behaviour and reduce the unnecessary admissions in the Orthopaedic Department.

METHODS

The Orthopaedic Department, in a 450 bed District General Hospital, had been the subject of major changes following the retirement of all the previously existing consultants due to age or sickness within the last two years and the replacement of them with newly appointed consultants. The existing middle grades were still employed and they were few years away from their own retirement. The department was manned by four newly appointed consultants, four middle grade and three junior doctors. In every on call duty, the Team consisted by one member of each grade. Decision for the admission of a patient was mainly made by the middle grade doctor, as they were at all times present in the hospital supporting the juniors and only in case of any doubt, they were contacting the Consultant for further advice.

It was observed that the emergency admissions of the Orthopaedic Department were higher than expected and on particular days even more. Patients who may have their assessment and final treatment in their first visit in the Accident and Emergency Department following their referral to Orthopaedics have been admitted for "further" treatment in the Hospital. This practice was leading to the patients being reviewed by the admitting consultant the following morning and after instructions to be discharged. Despite this, due to man-power limitations the majority of the patients' discharges were delayed an extra day thus resulting to an almost daily bed crisis and funding problems. This has a direct impact in patients' satisfaction and of their relatives as they had to spend time within the hospital understanding that it was not necessary for their loved one to be admitted in the first place.

Due to the arising problems it was necessary to find the reasons that led to these unwanted admissions. In the face of this problem which was established as a quality limitation the Six Sigma Methodology was used and the 5 S's and DMAIC were implemented (Tomsett, 2005).

The **5 S's** system reviewed:

Surrounding: The environment and the timing of the potential unnecessary admissions were recorded.

Suppliers: For this category the individual doctors' activities reviewed

Systems: The admission process was recorded

Skills: The doctors' actions observed

Safety: The safety of the doctors as well as that of the patients was reviewed.

DMAIC analysed

Define: Open and constructive discussions with the admitting doctors took place in a departmental meeting. Verbal consent from all was taken as notes were kept in the attempt to understand the potential reasons led to the admissions. The opinion of the four middle grade doctors who were giving the instructions to the juniors for the admission was recorded. Each of these doctors had seven or eight days on call duties per month. Initial data of the post on call emergency admissions of each and every middle grade doctor from every day and the sum of the monthly admissions corresponding to them was collected, as well as the unnecessary admissions were gathered for every day and month corresponding to every one of them.

The patients' pathway for the emergency admissions was examined and the different alternatives for the different way of treatment were reviewed. Patients after they were reviewed following their investigations could be either discharged by the Accident and Emergency doctor or be referred to the Orthopaedic team. These who were referred could be discharged following the junior doctor's opinion or referred further to the middle grade. From the referred patients some were discharged and others were admitted and according to their pathway they were separated in different groups. People who underwent surgery were in group a, those who had another kind of treatment in group b and the patients who were discharged following their review by the consultant and characterized as unnecessary admissions in group c.

The Ishikawa Fishbone diagram was used to find the indicative causes leading to the unnecessary admissions. Initially was indicated that there are reasons influenced by the patients or their environment but there are reasons clearly influenced by the doctors' behaviour and understanding of each of the cases (Figure 1).

From the 5 S's there was some evidence that the time of patient presenting to Accident and Emergency Department or their behaviour may influence their admission but based on the discussion with the doctors it was evident that in the name of safety (patient's and their own) and possibly due to either lack of communication, of skills or inexperience they had developed a very low threshold to patient admissions. This indicated that their decision making and diagnostic skills needed support. From the 5 S's the emphasis fell on the suppliers (doctors) and their skills.

The defects per million opportunities (DPMO) equation was applied

$$DPMO = 1000000 \frac{defects}{number\ of\ opportunities}$$

The doctors' opinions were recorded and quantified according to the frequency they were appearing during the departmental meeting. These were tabulated.

Measure: There were two kinds of data. The data following the discussions of the departmental meetings (initial and following the educational programme), where opinions of doctors were gathered, and the data of the total emergency admissions in the Hospital including the unnecessary emergency admissions which was collected by the admission office. The selected data was initially viewed and Pareto diagrams of the doctors' views and activities

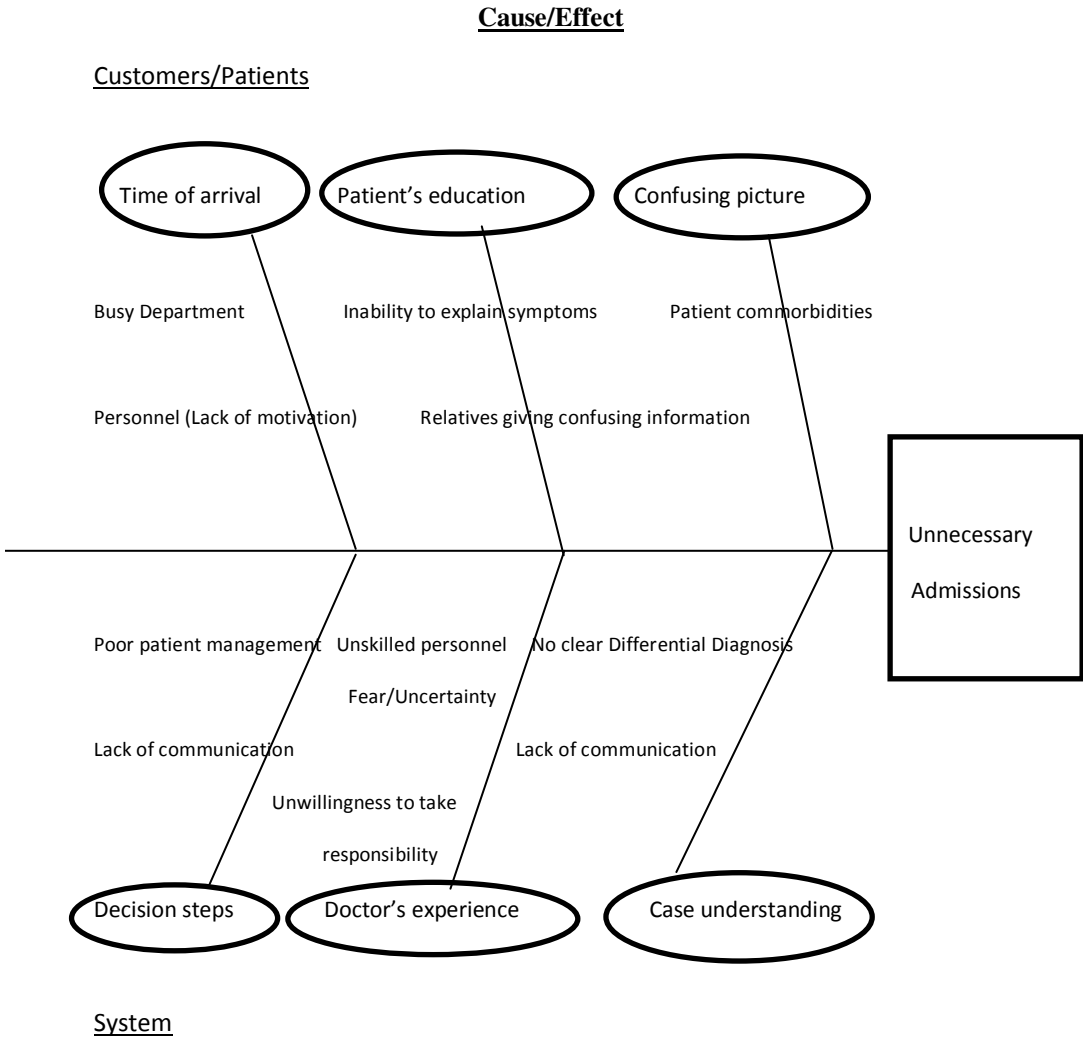

Figure 1. Ishikawa diagram.

were done. In the same time the sigma and the yield was found.

Analysis: An admission pathway was constructed and with Ishikawa diagram and 5 S's list all were reviewed indicating the potential causes influencing the unnecessary admissions. Data collected during the initial departmental meeting was analysed using a qualitative analysis. The data from the admissions (total including the unnecessary and the latter ones in separation) corresponding to each individual doctor was analysed using the Excel analysis and diagrams were made picturing the doctor's performance. The cumulative sigma was calculated using an pre-calibrated computerised six sigma calculator where the data was inserted and automatically it was calculating the sigma and the yield.

Improve: Based on the initial findings and the view that it was possible and more feasible to influence the doctors' behaviour and placing the patient or their relatives at the centre of their treatment, a daily conducted educational meeting was founded. This meeting was unanimously approved by the doctors of the department. In this meeting all emergency admissions were presented by the admitting junior doctor and they were openly discussed and analysed by all members of the department. The potential management was indicated by the juniors and the middle grades leaving the consultants' opinion delivered at the end. The meeting was not confrontational and the discussion was based on evidence based medicine. Prior to their presentations the presenting doctors were preparing themselves in the library if time allowed and in this way it let to other teams to make themselves aware of the cases and prepare for the presentation.

Following this introduction of education, data from the admissions office was gathered for each of the four doctors and the potential changes of their behaviour towards emergency admissions were analysed. The data collected was corresponding to a chosen month, the administrators of the admissions department decided to use in six monthly intervals, on six, twelve and eighteen months, post introduction of the educational programme.

Control: Data of one month's admissions (total and unnecessary corresponding to each individual doctor) was gathered in six monthly intervals, on six, twelve and eighteen month and this was reviewed, analysed and the sigma and the yield of improvement

Table 1. Doctors' opinion in initial departmental meeting

Collective doctors' opinions expressed in departmental meeting			
	Count	**Cumulative count**	**Cumulative %**
Habit	165	165	47.82608696
Skills	100	265	76.8115942
Development/Confidence	80	345	100

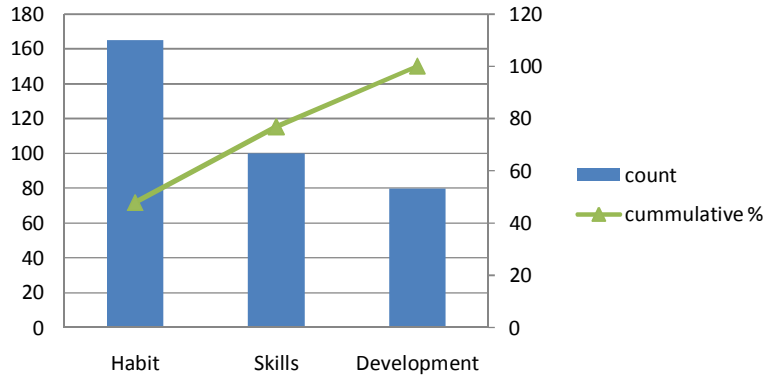

Figure 2. Pareto analysis of doctors' opinions.

was recorded. Further departmental discussions took place and the doctors' opinion was recorded. Further qualitative analysis was performed following their final answers.

The educational programme was evaluated within a Departmental Group Meeting where discussions and assessment of the programme took place. The opinions of each doctor were discussed and recorded by answering how in their opinion the educational programme influenced them and if their practice in their opinion changed and if they were satisfied. In all meetings verbal consent was taken from the participants.

Additional instruments

Departmental group meetings conducted with the doctors: The first was conducted initially to establish the potential reasons of the unnecessary admissions, and reveal the doctors' practices. The answers given were noted and analysed.

The second departmental meeting was conducted, following the educational programme, and verbal consent from all participants obtained. From the data collected after the questions were answered during the meeting for the assessment and evaluation of the programme, the following opinions were tabulated.

The answers of both meetings were analysed using qualitative methods.

RESULTS

Taking into consideration the customers' requirements it was found that this was a twofold condition. The first was based on the doctors' practices considering the safety of the patient within their own skills and understanding and the second is the patients' understanding of quick management and treatment and limited stay in the hospital's premises within a safe environment.

The doctors' expressed opinion during the initial Departmental Meeting were, "*this is how we used to do*" or "*this is how we were told to do by our previous Consultants*" or "*we thought would be safer for the patient as we wanted to ask you*". In these statements it is evident that there are some indications of habitual medicine, old fashion skills and limited professional development and lack of confidence.

The major finding within the Pareto analysis (Pareto principle states that 80% of the observed effects come from the 20% of the causes) is the link of the doctors' practice with that one which was implemented by the retired Consultants in the past years creating some bad habits.

The results are seen in Table 1 and the Pareto analysis in Figure 2.

Figure 3 indicates the different possible ways of the patient's treatment and discharge. All emergency admissions are corresponding to groups a, b, and c. The unnecessary admissions' group is indicated using the letter c.

From the Ishikawa Fishbone diagram, also to be seen were some factors related to the patients but the main factors which could be changed by the internal Departmental processes was the behavioural changes affecting the doctor's experience, their understanding of

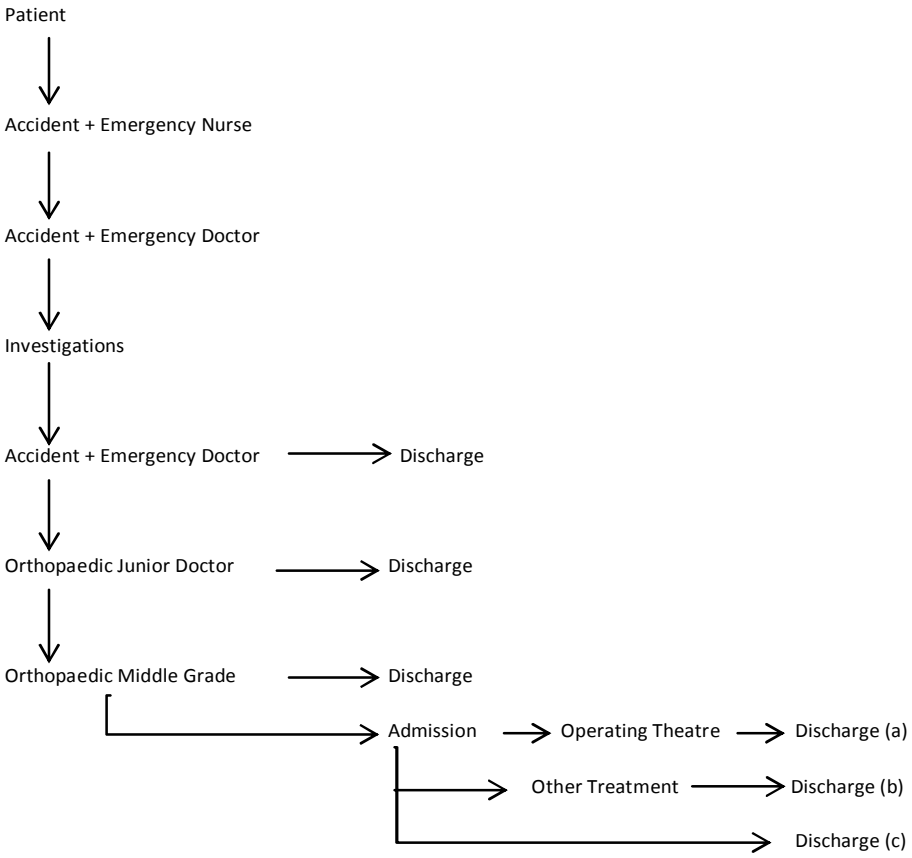

Figure 3. Patients' emergency referral and admission pathway in orthopaedics.

the individual cases and the management by making the correct and safe decisions for the patient.

Figure 4 demonstrates the collected data of the unnecessary admissions corresponding to each individual doctor, per on call day and the sum of all the on calls and the number of all the emergency admissions as collected from the admissions office. It is showing data collected initially before the educational programme was established (initial findings), as well as the data of each one month which the audit office decided to collect, at a six month interval, starting from six months post-educational programme up to the re-view after 18 months following the implementation of it.

From this, can be seen the Six Sigma calculation and the yield corresponding to it on the sum of all admissions of each chronological review. The progressive improvement also can be seen (Table 2).

The data of the total unnecessary admissions throughout the project is seen in Figure 5. This is demonstrating visually for every single doctor that the number of the unnecessary admissions within the studied months showing a progressive improvement of their performance.

From the data demonstrated can be observed that the education with a constructive cognitive way of teaching motivated the doctors of all teams to be prepared for the case presentations. The sigma is improved in all doctors. It is evident that one of them (Doctor C), who was employed at a later date than the other three colleagues, was able to perform better much more quicker as he had no unnecessary admissions since the 12 month review. Cumulatively all started from a Sigma 2.6 indicating 86.40% yield to improve to a Sigma 4 (99.40% yield).

Using the DPMO formula, the Table 6 collected date was analysed and the results found are tabulated in Table 3. It is evident the progress of improvement within the 18 month period since the project commenced.

Both the data collected from Six Sigma methodology and the answers in the questionnaires indicate that the educational programme was successful and achieved the goals of improving the quality of the treatment received by the patients but also improved the confidence of the treating doctors (Table 4).

DISCUSSION

Six Sigma methodology is based on quality improvement and the continuing effort to meet the customers'

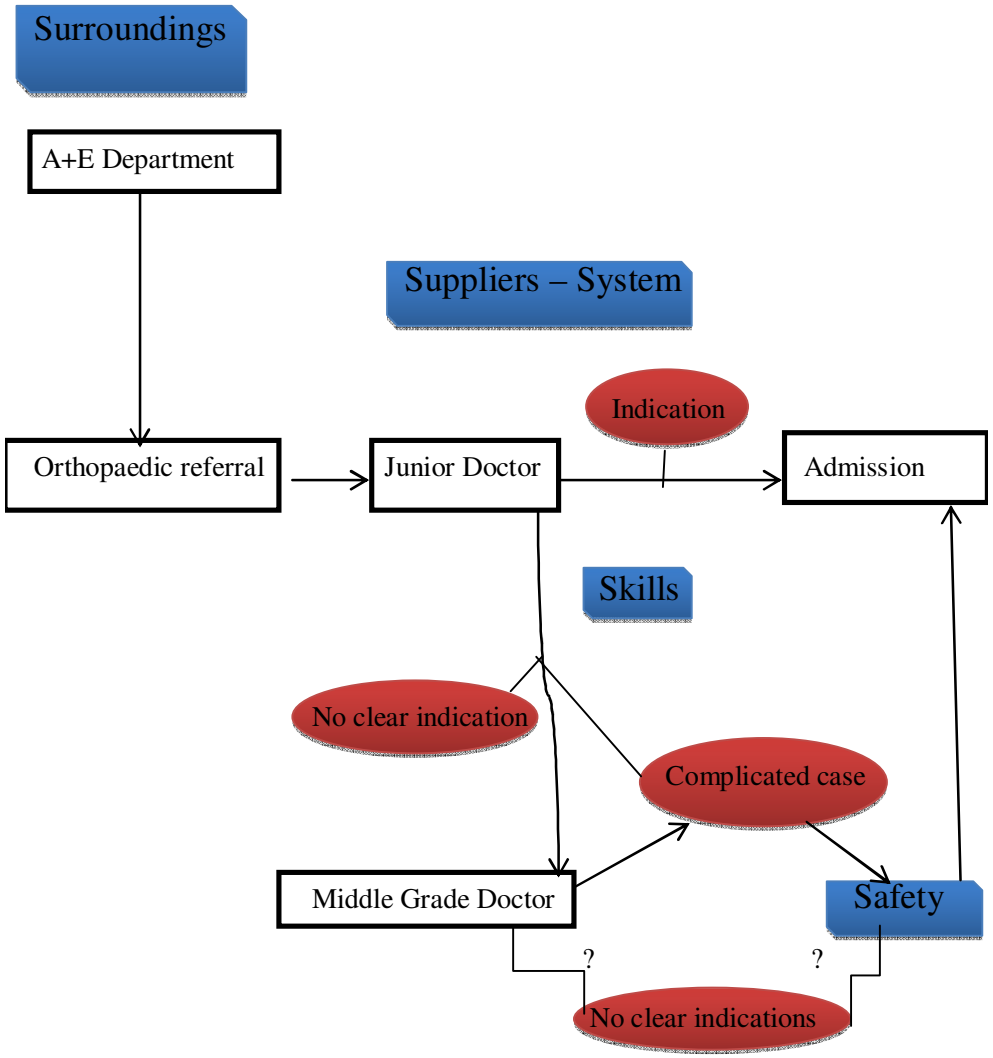

Figure 4. 5 S's analysis showing on the flowchart the pathways for admission.

requirements (Bhote, 2003; Pyzdek, 2003; Yang and El-Haik, 2003; Tomsett, 2005; Juran and De Feo, 2010; Pande et al., 2000). In the health system there are multiple factors which can influence this, but concentrating in a very simplistic way the customers' (patients) requirements have to be defined. Literature indicates that it is necessary to achieve patient satisfaction and this has to be in the centre of healthcare services (Koning et al., 2006; Taner and Sezen, 2007; Stuenkel and Faulkner, 2009). To achieve patient satisfaction is necessary to care about the quality of the provided service, to provide to them what they are asking for, to improve the delivery of services in an effective and timely manner reducing or even eliminating unnecessary activities (Taner and Sezen, 2007; Balensky et al., 2005). Reducing hospital stay is considered as an important factor to achieve patient satisfaction not only by influencing the psychology of the persons involved but also reducing the risk of infection (Taner and Sezen, 2007; Stuenkel and Fulkner, 2009). When patient satisfaction is achieved is observed that health carers' moral is improving. Consequently their performance is improving and they are more willing to participate in professional development activities (Stuenkel and Fulkner, 2009). Improving performance leads to timely predictability of the services and this reflects to the serving community and shows a thriving and successful organisation (Stuenkel and Fulkner, 2009; Taner and Sezen, 2007; Saunders, 2015). The introduction and use of Six Sigma methodology is clearly improving the quality of the provided service (Koning et al., 2006; Schweikhart and Denbe, 2009).

In the present study from the point of view of the patients the most evident is the provision of a quick examination and treatment within a safe environment, as

Table 2. Collected data (initial and of one month in every six month intervals over the period of 18 months)

Doctor	Unnecessary admissions per on call day and doctor (Group c)	Unnecessary admissions per month and doctor (Group c)	Monthly emergency admissions per doctor (Groups a, b and c)	Sigma	Yield
Initial findings					
A (8 on calls)	8	64	125		
B (8 on calls)	9	54	120		
C (7 on calls)	4	28	95		
D (7 on calls)	10	70	90		
Total	31	216	430	sigma 2.6	86.40%
6 months later					
A (8 on calls)	3	24	90		
B (8 on calls)	3	24	115		
C (7 on calls)	2	14	100		
D (7 on calls)	3	21	85		
Total	11	83	390	sigma 3.1	94.50%
12 months later					
A (8 on calls)	1	8	130		
B (8 on calls)	2	16	110		
C (7 on calls)	0	0	106		
D (7 on calls)	2	14	94		
Total	5	38	440	sigma 3.5	97.70%
18 months later					
A (8 on calls)	0	0	167		
B (8 on calls)	1	8	164		
C (7 on calls)	0	0	135		
D (7 on calls)	1	7	124		
Total	2	15	590	sigma 4	99.40%

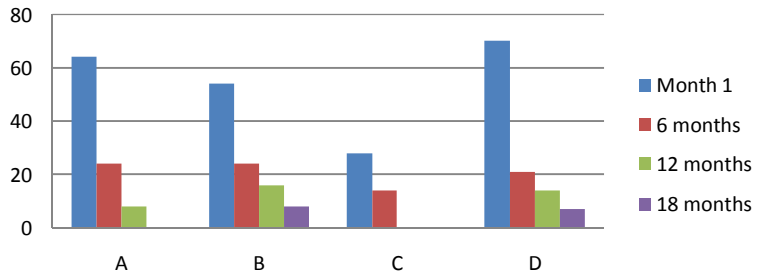

Figure 5. Total average unnecessary admissions per doctor through the project.

Table 3. Defects per million opportunities (DPMO)

DPMO	
Initial	502325
6 months	212820
12 months	86363
18 months	25423

well as limited time spent by them in Hospital. On the other hand, doctors are concentrating to the safe diagnosis and treatment sometimes without considering the time spent.

Although safety is mentioned by both groups (patients and doctors) and it is paramount, it seems that safety maybe the subject that can divide the two groups. The

Table 4. Tabulated answers to the questionnaire given at the second departmental meeting.

Questionnaire of the second departmental meeting	
Questions	**Answers**
In your opinion, how did the educational programme influence you?	1. Increased confidence 2. Made me better to understand the latest developments within our specialty 3. Helped me to create my own opinion based on evidence 4. Improved my self-development
Do you think that the programme should continue?	The answer was positive
Do you think that such programme should be implemented in other departments?	The answer was positive by all
Do you think that the programme achieved the goals?	The answer was positive by all
Do you think that the level of treatment to the patients has been influenced and how?	The confidence and level of knowledge achieved is giving the internal security and self-respect which is reflected to the treatment and the quick and safe management of the patients.

first group wants safe treatment within limited time in the premises of a Hospital and the second wants to keep patients under surveillance just in case that something is missed and makes their treatment unsafe. This can create a gap between the two groups understanding.

Reviewing the 5 S's is evident that the doctors' skills and habits need improvement, if hospital stay and unnecessary admissions need to be decreased.

In the Ishikawa Fishbone Diagram it is evident that it is more than one factor influencing the unnecessary admissions. It was thought whether it was possible to influence mainly changes on the System factors than those of the Customers. Fear, uncertainty, unwillingness to take responsibilities due to habitual outdated practices have been revealed and need change. With this in mind implementation of an educational programme is designed and proved that can bridge this gap.

The programme improved the doctors' confidence and understanding of their art, helping them to meet the patients' requirements.

Six Sigma methodology used for the evaluation the educational programmes helped educational organisations to observe, assess and change their performance (Goffnett, 2004; Ramasubramanian, 2012; Prasad et al., 2012). The methodology was used to change the organisational culture of the institute (Mehrabi, 2012), improve the quality of the leadership in education or improve the quality of the curriculum's assessment (Pryor et al., 2012). The necessity to implement such measures as the Six Sigma methodology in the higher education was the result of the public scrutiny on the subjects mainly to control the check of the higher education funds and stop the unnecessary waste of money. This was shown that it was achieved by using these techniques as the academic programmes had to be redesigned so the quality of them will be optimised and improved (Bandyopadhyah and Lichman, 2007). But the Six Sigma methodology was not only used for the control of the funds but also for the improvement of the students' performance during their studies (Kaushik and Khanduja, 2010), as well as the preparation of them in the open arena of the free market and make them ready for an earlier employment (Lakshminarayanan and Pamanakumar, 2014).

Following the educational programme, doctors in their words achieved "greater internal security and self-respect" which led to treatment quality improvement.

The DPMO was reduced during the 18 month period, by almost 20 times down.

The initial Six Sigma score was 2.6 corresponding to 84.4% yield. After the implementation of the educational programme, the following evaluations showed the gradual improvement of the score leading to 4 giving 99.4% yield.

The goals of the patients' requirements of a safe quick administered treatment in a safe environment without lengthy unnecessary hospital admission and the safe guarded implementation of medicine by the doctors were met and measured successfully by the use of six sigma methodology. In the same time the educational programme was evaluated successfully by the same means. Six Sigma methodology was proven to be very successful in improving the departmental, as well as the individual doctors' performance. The programme continues with the goal to improve to six sigma score of 6, corresponding to 99.9997% yield. This study proves that such methodology can be implemented in the Educational as well as the Health system.

Conclusion

Six sigma methodology is proven to be beneficial for the assessment of individual doctors by evaluating their

performance and also improving the overall performance of the whole department and consequently the performance of the hospital.

Conflict of Interests

The author has not declared any conflicts of interest.

REFERENCES

Bahensky JA, Roe J, Bolton R (2005). Lean six sigma – will it work for healthcare? J. Healthcare Inf. Manag. 19(1): 39-44.

Bandyopadhyah JK, Lichman R (2007). Six Sigma approach to quality and productivity improvement in institution for higher education in United States. Intl. J. Manag. 24(4): 1-5.

Basu R (2001). Six sigma to FIT Sigma – The new wave of operational excellence. Institution. Industrial Eng. Solut. 33(7): 28-33.

Bhote KR (2003). The power of ultimate six sigma. American Management Association (AMACOM), New York, pp. 3-63.

Goffnett SP (2004). Understanding Six Sigma. Implications for Industry and education. J. Industrial Technol. 20(4): 2-9.

Juran J, De Feo J (2010). Juran's Quality Handbook. The complete guide to performance excellence. 6th edition. McGraw-Hill, New York, pp. 355-386, 541-582.

Kaushik P, Khanduja D (2010). Utilising Six Sigma for improving pass percentage of students: A technical institute case study. Edu. Res. Rev 5(9): 471-483.

Koning H, De Velner JPS, Van den Hevvel J, Bisgaard S, Does RJMM (2006). Lean six sigma in healthcare. J. Healthc. Qual. 28(2):4-11.

Lakshminarayanan R, Ramanakumar KM (2014). Six Sigma methodology for Addressing Employability Issue of engineering Graduates. Intl. J. Mod. Educ. Forum 3(2):59-66.

Mehrabi J (2012). Application of Six-Sigma in educational quality management. Procedia Soc. Behav. Sci. 47:1358-1362.

Pande PS, Neuman RP, Cavanach RR (2000). The Six Sigma way. How GE, Motorola and other top companies are honing their performance. McGraw-Hill, New York, pp.4-18.

Prasad KGD, Subbaiah KV, Padamavathi G (2012). Application of Six Sigma methodology in an engineering educational institution. Int. J. Emerg. Sci. 2(2):222-237.

Pryor MG, Alexander C, Taneja S, Tirumalasetty S, Chadalavada D (2012). The application of Six Sigma methodologies to university processes: The use of student teams. J. Case Stud. Accredit. Assess. 2:1-14.

Pyzdek T (2003). The Six Sigma project planner. The step by step guide to leading a Six Sigma project through DMAIC. McGraw-Hill, New York, pp. 95-164.

Ramasubramanian P (2012). Six Sigma in educational institutions. Intl. J. Eng. Pract. Res. 1(1):1-5.

Reosekar RS, Pohekar SD (2013). Design and development of Six Sigma implementation framework for Indian industries. Intl. J. Eng. Bus. Enterp. Appl. 5(2):147-152.

Sanders JH (2015). Improving ED specimen TAT using lean six sigma. Intl. J. Healthc. Qual. Assur. 28(5):428-440.

Schweikhart SA, Dembe AE (2009). The application of lean and six sigma techniques to clinical and translational research. J. Investigating Med. 57(7):748-755.

Stuenkel K, Faulkner T (2009). A community hospital's journey into lean six sigma. Front. Health Serv. Manag. 26(1):5-13.

Taner MT, Sezen B (2007). An overview of six sigma applications in Healthcare industry. Intl. J. Healthc. Qual. Assur. 20(4):329-340.

Tomsett MC (2005). Getting started in Six Sigma. Comprehensive coverage. A practical working guide. Wigley and sons, New Jersey, pp.5-164.

Yang K, El-Haik B (2003). Design for Six Sigma. A roadmap for product development. McGraw-Hill, New York, pp.1-67.