A study on Ishikawa's original basic tools of quality control in healthcare

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Abstract

Purpose – The main objective of this study is to investigate Ishikawa's statement that "*95% of problems in processes can be accomplished using the 7 Quality Control (QC) tools"* and explore its validity within the healthcare sector. The study will analyse the usage of the 7 QC tools in the healthcare service sector and the benefits, challenges, and critical success factors for the application of the 7 QC tools in this sector.

Design/methodology/approach – In order to evaluate Ishikawa's statement and how valid his statement is for the healthcare sector, an online survey instrument was developed, and data collection was performed utilizing a stratified random sampling strategy. The main strata/clusters were formed by healthcare professionals working in all aspects of healthcare organisations and functions. A total of 168 participants from European healthcare facilities responded to the survey.

Findings – The main finding of this study is that 62% of respondents were trained in the 7 QC tools. Only 3% of participants in the healthcare sector perceived that the seven tools of QC can solve above 90% of quality problems as originally claimed by Dr Ishikawa. Another relevant finding presented in this paper is that Histograms, Cause & Effect diagrams and check sheets are the most used tools in the healthcare sector. The least used tools are Stratification and Scatter diagrams. This paper also revealed that the 7 QC tools proposed by Dr. Ishikawa were most used in hospital wards and in administration functions. This work also presents a list of Critical Success Factors required for the proper application of the 7 QC tools in Healthcare.

Research limitations/implications
This research was carried out in European healthcare facilities – and there is an opportunity to expand the study across the global healthcare facilities. There is also an opportunity to study the use of the tools and their impact on hospital performance using Action Research methodology in a healthcare organisation.

Originality/value – Authors understand that this is the very first research within the healthcare sector focused on investigating all of the 7 Basic tools usage and challenging Dr. Ishikawa's statement: "*95% of problems in processes can be accomplished using the 7 Quality Control (QC) tools"* from his book "What is Quality Control?". The results of this study represent an important first step towards a full understanding of the applicability of these tools in the healthcare sector.

Keywords – Ishikawa, 7 Quality Control Tools, Survey, Healthcare

Paper type – Research paper

1. Introduction

With current cost pressures, healthcare organizations are seeking various opportunities to

manage their expenses. During the last two decades, there has been a strong focus on quality improvements in healthcare. Quality improvement has been one such effort to achieve better patient outcomes, better system performance and better professional development (Batalden & Davidoff, 2007). Healthcare organizations with a culture of quality and safety can have a greater impact on improving the patient experience, and thus the quality of care (Feldman et al., 2019). Healthcare professionals do not only require professional knowledge, but also knowledge of how to improve the healthcare processes that they work in (Robinson et al., 2020).

Quality tools are essential ingredients of an improvement process and basic instruments for the success of a quality program (Soković et al., 2009). Dale and McQuater (1998) suggest these tools and techniques provide a means and a starting point for analysing problems, identifying and diagnosing gaps in performance and measuring whether implemented change is producing desired improvements. Quality professionals have many tools and techniques which they use as part of a problem solving process and for continuous quality improvement (McQuater *et al.*, 1995; Bunney and Dale, 1997; Antony *et al.*, 2021a). Typically, the origin of the use of these tools and where they were mostly deployed is within the manufacturing sector.

Quality management has been influenced by several quality "gurus," one of whom was Dr Kaoru Ishikawa who is known for his work on training in the use of quality improvement methods. Ishikawa put forward seven tools, which he called "basic" and asserted that these tools were vital for problem-solving (Ishikawa, 1976). These tools have become known as Ishikawa's tools, the 7 Basic QC tools or the 7 QC tools of Quality and have been widely utilised in quality management programs. The 7 tools include *check sheets, histograms, pareto analysis, cause and effect diagrams, control charts, scatter diagrams and stratification analysis* (Tague, 2005).

In his book "Introduction to Quality Control" Ishikawa (1976, 1990) stated that "the quality control tools, if used skilfully, will enable 95% of workplace problems to be solved and intermediate and advanced statistics are needed in about 5% of cases". Studies have been carried out by Antony et. al (2021a, 2021b) to ascertain the level of use and the integration of the tools into manufacturing and service sectors. However, the use of the 7 QC tools within the Healthcare sector is a research gap and it has not been explored nor has the validity of Ishikawa's statement that the tools can solve 95% of workplace problems being studied within the healthcare sector.

This research will explore the extent of the use of the 7 QC tools in the healthcare sector and across private and public healthcare facilities and within their CI programs therein. The research also analyses the level of training in the tools, frequency of application of the 7 QC tools as well as investigating in what areas of healthcare facilities these tools are most applied. The application of the tools and their use can have challenges, depending on the level of training, and understanding of the tools within an organization as well as the level of organisational commitment, culture and management support to such initiatives.

The following research questions were set by the authors for this research.

1. *What is the level of training, and frequency of usage of the 7 QC tools within healthcare facilities?*

2. *What percentage of healthcare quality problems can be solved utilising the 7 QC tools?*

3. *What are the benefits, challenges, and critical Success factors for the application of the seven QC tools?*

The remainder of the paper is as follows, section 2 describes the literature, followed by research methodology in section 3. The results are explicated in section 4, followed by discussion and implications in section 5. The conclusion, limitations, and scope for future research are elucidated in section 6.

2.0 Literature Review

Ishikawa is considered as the 'father of quality circles' in Japan and put forward the 7 Basic QC tools for solving quality-related problems in organisations. The success of quality circles could be attributed in part to the use of innovative tools by all workers to analyse and solve problems (Maguad, 2006). Ishikawa (1976, 1995) put forward that the seven tools, enabled 95% of workplace problems to be solved but that intermediate and advanced statistical tools are needed for about 5% of cases. He also stated that for most problems when utilising the Pareto principle that there were 2 or 3 assignable causes, so eliminating these will halve the number of defectives, e.g., raise the yield from 60% to 80% or 90 to 95% so thus 95% of problem can be solved utilizing the 7 QC tools (Ishikawa, 1995).

Bunney and Dale (1997), Bamford and Greatbanks (2005) amongst others have discussed the importance of quality tools in quality improvement. The 7 tools can be deemed "basic" because individuals with little or no training in statistics can use them to solve most quality problems (Kiran, 2017).

Mizuno (1979) and the Japanese Union of Science and Engineering (JUSE) have criticised the 7 basic QC tools as while useful for analysing numerical data, are not seen as very useful for dealing with qualitative information and data. JUSE put forward the 7 New QC or Management tools which are more qualitative and can analyse verbal as well as technical information and develop it into specific plans (Mizuno, 1979). However further criticism of Ishikawa's 7 Basic tools is that they are seen as too simplistic (Lamb and Dale, 1994; Spring *et al.*, 1998). The use of the tools outside of manufacturing and in more complex processes such as design and development have been perceived as not useful in contributing to those processes (Spring et al., 1998). However, Lamb and Dale, (1994) found that some of the seven basic quality tools have a place in and are applicable to Research and Development (R&D) projects and not too difficult to introduce.

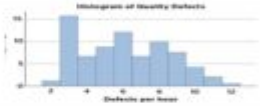
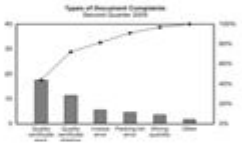
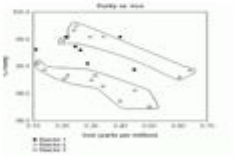
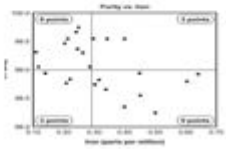
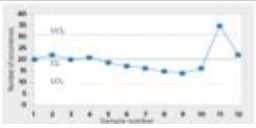
There are critical success factors (CSF's) required to use the quality tools efficiently and effectively (McQuater et al., 1995a); (Hellsten & Klefsjö, 2000). The main CSF's for the proper use of quality tools have been identified by Bunney and Dale (1997) and McQuater *et al.* (1995b). These CSF's included *full management support and commitment; effective, timely and planned training; a genuine need to use the tool or technique; defined aims and objective for use; a co-operative environment; and backup and support from improvement facilitators* were put forwards as CSF's.

In order for quality tools to be used correctly and efficiently, organisations need to ensure managerial understanding of and commitment to these techniques and tools as well as facilitating training (Tarí and Sabater (2004). Dale and McQuater (1998) and Bamford and Greatbanks (2005) reported that the use of the 7 QC tools and techniques is not as widespread and effective as might be expected, and suggest that part of the problem is due to insufficient

training in the use and application of these approaches. There are costs to using a tool incorrectly or for the wrong reason (Spring *et al.* 1998). Utilising the wrong tool can slow down the problem-solving process, lead to flawed conclusions, or even make the problem worse. McQuater et al. (1995b) identified inappropriate use of tools and techniques as an issue in tool utilisation and application.

In order to aid the user to identify and utilise the correct tool at the right time in the problem-solving process, classification schemes for problem-solving tools have been put forward as important to aid correct application (Hagemeyer, Gershenson, and Johnson, 2006; Shahin, Arabzad and Ghorbani, 2010; Alsultan, 2014).

Table 1: The Seven Basic QC Tools (adapted from ASQ (2021)

The Seven Basic QC tools		
Check Sheet	A check sheet is a structured, prepared form for collecting and analyzing data.	
Cause & Effect Diagram	The fishbone diagram identifies many possible causes for an effect or problem. It can be used to structure a brainstorming session.	
Histogram	A histogram is the most commonly used graph to show frequency distributions	
Pareto	A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost and are arranged with longest bars on the left and the shortest to the right.	
Stratification	Stratification is defined as the act of sorting data, people, and objects into distinct groups or layers.	
Scatter Diagram	The scatter diagram graphs pairs of numerical data, with one variable on each axis, to look for a relationship between them.	
Control Chart	The control chart is a graph used to study how a process changes over time. Data are plotted in time order.	

A thorough review of literature indicated that there are no empirical studies on the use of the 7 basic tools of QC applied to a healthcare setting. However, there are many case studies published related to healthcare which utilises a suite of tools for tackling either quality or process related problems in a hospital environment. For example, there have been several

studies on the use of control charts in healthcare quality improvement (Suman and Prajapati, 2018; (Tsironis et al., 2020)(Seoh, Wong and Sirdari, 2021). Picarillo (2018) discussed the use and importance of pareto analysis and cause and effect diagrams as quality tools for clinicians. Examples of cause and effect usage has been to brainstorm reasons for long laboratory testing times (Picarillo, 2018); root causing drivers for rising healthcare system costs (Kumar et al., 2011) and root causing reasons for medication errors (Trakulsunti et al., 2020) . Stratification analysis use and examples have been cited by Kawachi et al. (2002) and Fonarow et. al (2005) but more for long term statistical studies and establishing patterns. This study will ascertain how prevalent the use of the 7 tools is in combination or in isolation in healthcare organisations through an empirical study.

3.0 Methodology

The authors utilised an online survey which was distributed for data collection targeted at professionals working in healthcare facilities across Europe. Online surveys offer the advantages of ease of use, flexibility and expediting dissemination and responses (Schaefer & Dillman, 1998; Levfever, 2006). The nature of an online survey enables expediting collecting of responses within a relatively short time frame (Evans & Mathur, 2005).

The survey consisted of two parts, the first section collected demographic information about the participants and their organisations. The second section of the survey was designed to study the level of training levels and usage of the seven basic QC tools, the benefits, the CSF's and challenges to the use of the tools.

In designing the survey, any question asked about using the 7 QC tools was accompanied by a visual picture of the tools or of the relevant individual tool as applicable as highlighted in table 1. Some tools such as the Cause & Effect diagram can be known by different names (e.g.: fishbone diagram) in different organisations and textbooks. The authors hope that visual representation will aid respondents an expedient answering and recognition of the 7 old QC tools as well as ensuring rapid and accurate identification (Bahn, 2014).

There has been an increasing usage of social networking sites to collect data for research (Antony et al, 2021a; Tambe, 2014). It is found in some studies that current employment, career profiles, and past employment etc are more accurate on LinkedIn database than in other databases (Ge et al., 2016). Besides, the LinkedIn is the world's largest professional networking site, with the large number of users. Therefore, in this study we used Linkedin professionals in this research. Potential participants were contacted prior to the survey to request for their participation. A pilot study was carried out with ten people who worked in healthcare and have a decent understanding on the use of 7 QC tools in a healthcare sector. Piloting is recommended as a good practice before distribution to the wider group of participants (Boynton and Greenhalgh, 2004). The piloting exercise was carried to ascertain if any questions needed modification or improvement from a practical standpoint and that no omission has been made (Forza, 2002). The majority of the respondents from the pilot study were of the view that the survey was well written and hence the survey was ready to send out to respondents.

The criteria for selecting the respondents were that all participants should be working in a healthcare facility and have some understanding on the 7 tools of QC from the current or previous experiences. The survey was sent to 220 healthcare professionals. The total responses received was 168 which was collected over a time frame of 18 weeks. This gave a 76% response rate which is sufficient for data analysis (Easterby-Smith et al., 2012). The Figure 1 depicts the research methodology.

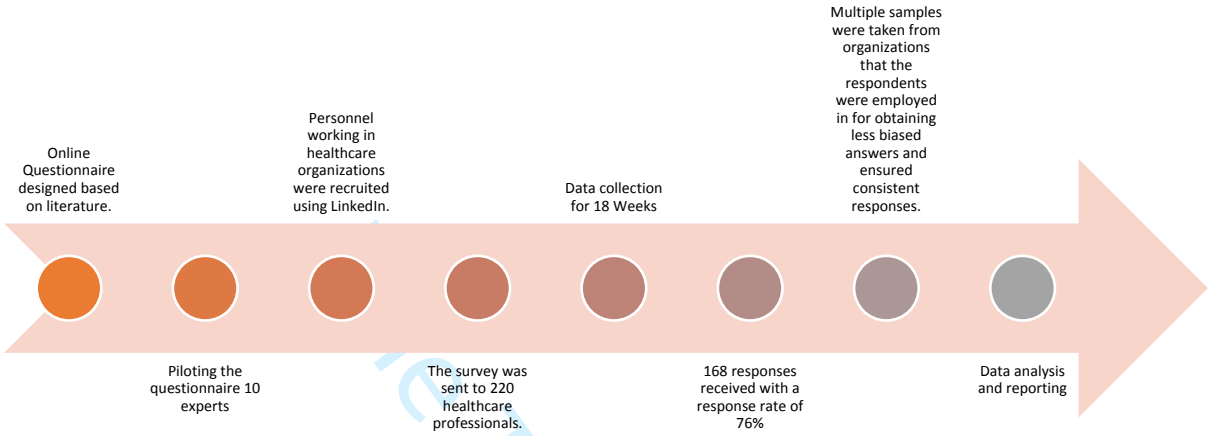


Figure 1: Research Methodology

4.0 Results

There were 168 respondents to the survey. The analysis plan is depicted in Figure 2.

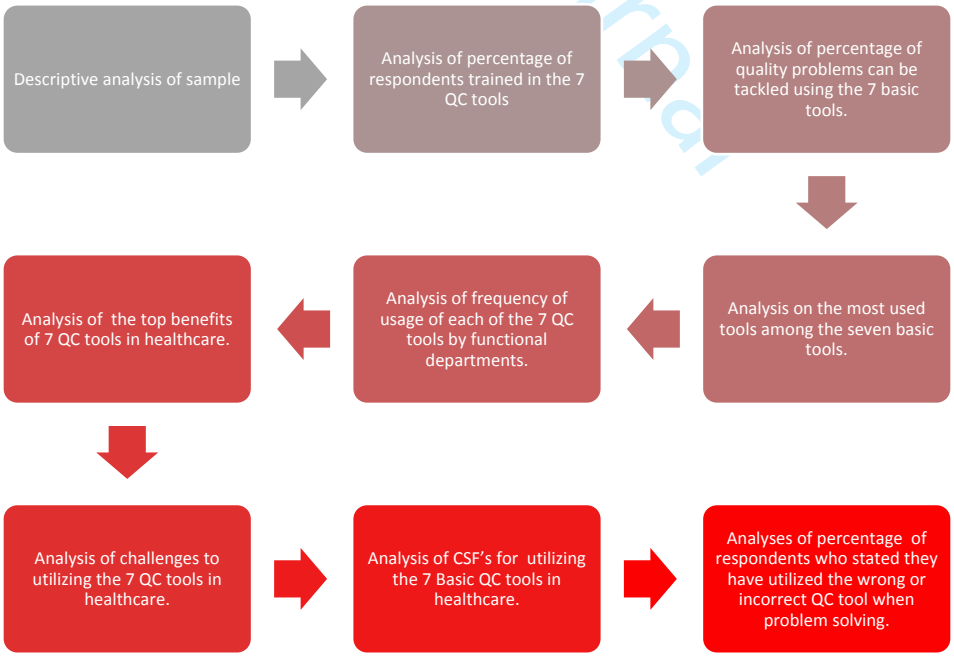


Figure 2: Analysis Plan

The survey was distributed to healthcare professionals working in a variety of functions in both private and public hospitals. 73% of respondents were from public hospitals and 27% came from private hospitals (Figure 3). Public healthcare is usually provided by the government through national healthcare systems. Private health care can be provided through "for profit" hospitals and self-employed practitioners, and "not for profit" non-government providers, including faith-based organizations (Basu et al., 2012). In many countries, private providers play a major role in the delivery system mainly because the public sector is not always sufficiently well-equipped and financed to provide high quality health services that are accessible to all citizens (Herrera et al., 2014).

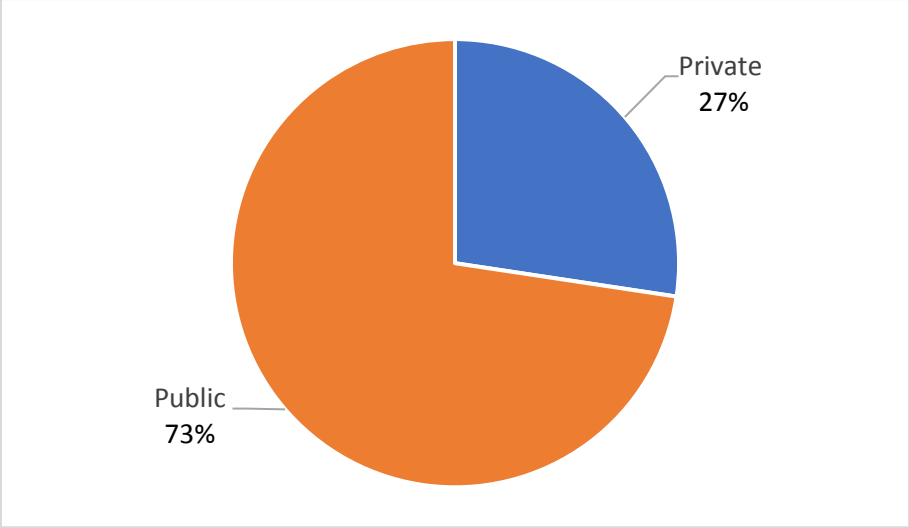


Figure 3: % of respondents in Public versus private healthcare facilities

Information was gathered on the size of each healthcare facility that participated (table 2). More than half of the respondents (55%) were from healthcare facilities with over 500 employees. The majority of the participants were from facilities with over 500 employees were from public healthcare facilities (31% of overall participants).

Table 2: Size of Healthcare organisations participating in the survey

Years of Experience	%
<1 year	4%
Between 1 and 5 yrs.	24%
Between 6 and 10 years	20%
Between 11 and 15 years	30%
Between 16 and 20 years	13%
>20 years	8%

The years of experience of each respondent was also collected and 30% of respondents had between 11 and 15 years' experience in their current organisations with 20% having between 6 and 10 years' experience and 24% having between 1 and 5 years' experience. The current positions, titles and roles of each respondent was collected. The highest % representation was from non-managerial level employees (29%) and doctors (28%), followed by associate or middle manager (16%). The remainder were from a combination of researchers (9%), senior (5%) and executive (3%), consultants (4%), and administrators (6%). (Figure 4).

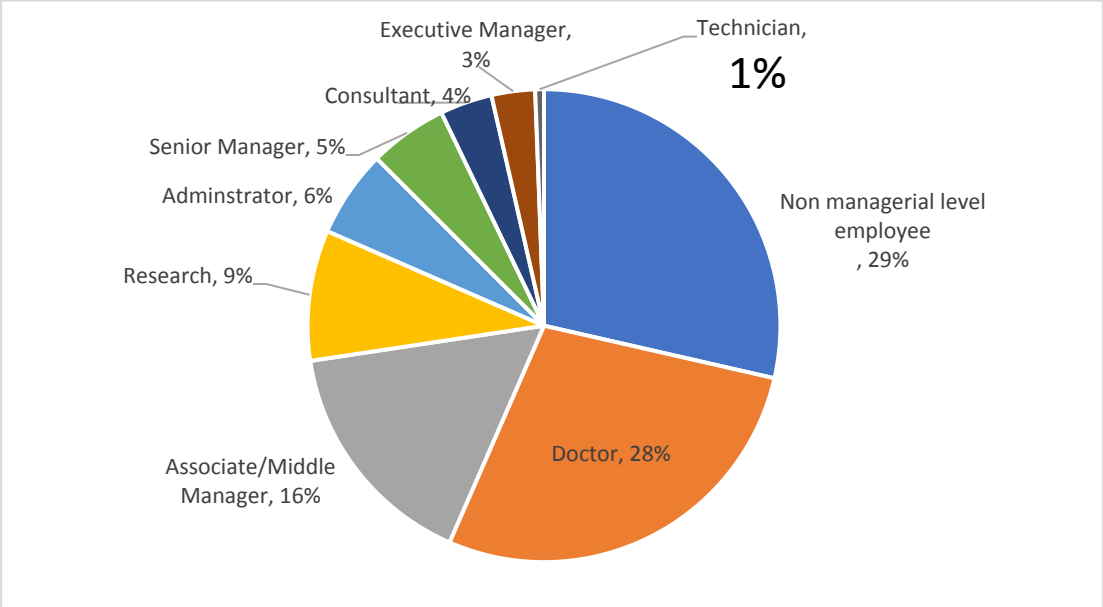


Figure 4: Roles of respondents within their healthcare organisations

The respondents were asked to identify which specific functional areas or departments within their healthcare facilities and hospitals in which they worked (Table 3). Many of the respondents classified themselves as either administrative (29%) or front line (22%) (in terms of working in hospital wards). A further 14% stated they word in Supply chain or purchasing roles (14%). The remaining 35% of respondents came from various supporting functional areas such as laboratory, pharmacy, radiography, ER, and operating theatres amongst others.

Table 3: Functional areas within healthcare organisations of respondents

Administration	29%
Hospital wards	22%
Supply Chain/Purchasing	14%
Pharmacy	5%
Ambulance	5%
ER	4%
Outpatients	4%
Medical Records	4%
Physiotherapy	4%
Stores/Warehouse	3%
Laboratory	2%
Operating Theatre	2%

Radiography	2%
Maintenance	1%

The first question in section 2 of the survey was to ascertain knowledge of the 7 Basic tools of QC in healthcare facilities. The question "*Have you been trained in the 7 Basic QC tools of Quality*?" was asked. 62% (104 people) responded that they had been trained while 38% (64 people) stated that they had not been trained in the 7 Basic QC tools (Figure 5).

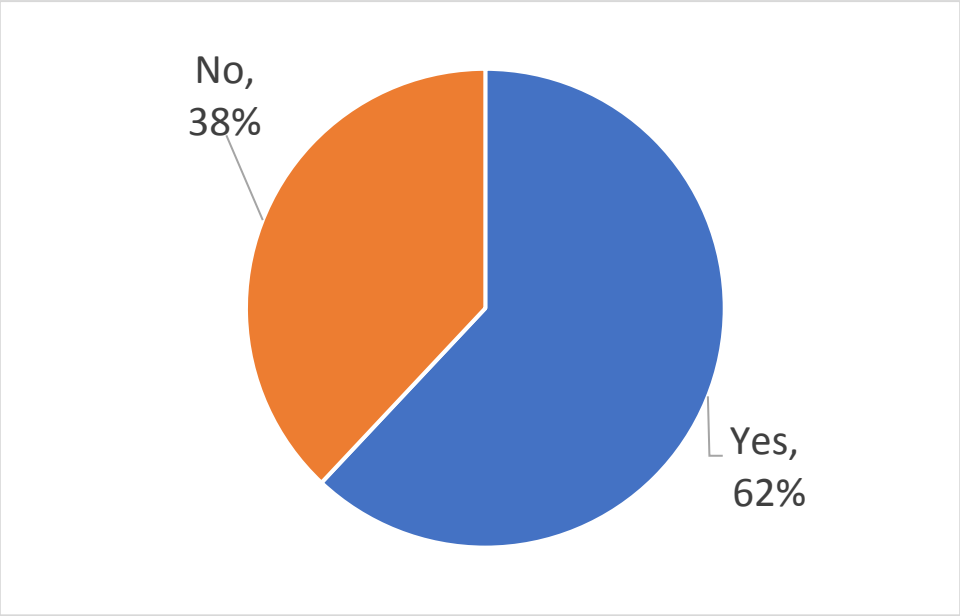


Figure 5: % of respondents trained in the 7 QC tools

The level of training in the 7 Basic QC tools in healthcare organisations overall was not as high as the training levels for the 7 Basic QC tools in manufacturing sectors which was over 80% in a research carried by Antony et al, 2021a, and Antony et al, 2021b. A further analysis was carried out to ascertain the breakdown in the level of training in the 7 Basic QC tools in private versus public healthcare facilities (Figure 6). Within the question of the 104 people who voted Yes to being trained, 69% were from the public sector and 31% were from the private sector. The levels of training in the 7 QC tools in public healthcare organisations was more than double that of training levels in private healthcare organisations.

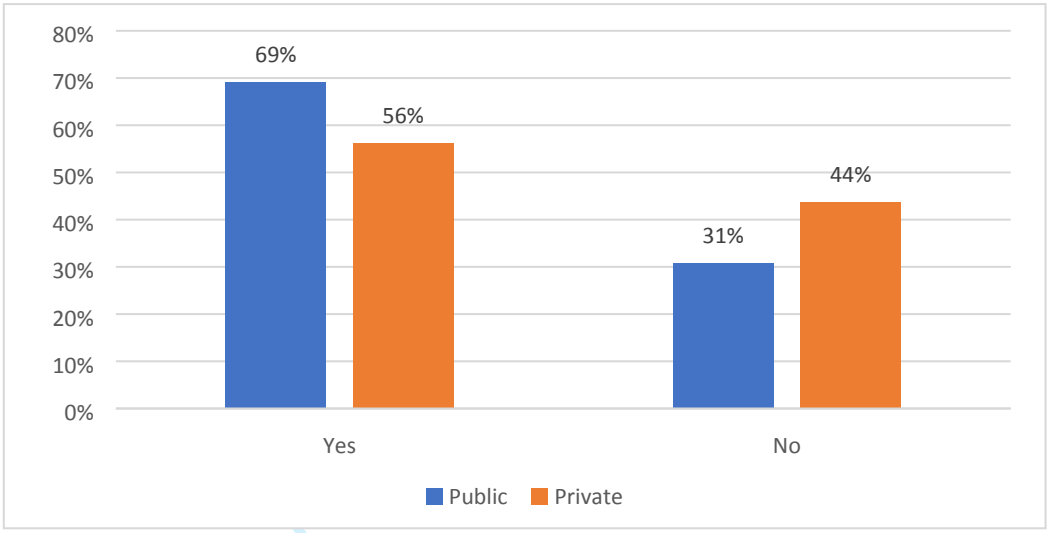


Figure 6: Public v's Private Training Levels

Respondents who replied "no" to the previous question and answered that they hadn't been trained in the use of the 7 QC tools were directed to exit the survey. The remaining 104 people who replied that they had been trained in the use of the 7 basic QC tools answered the remaining questions.

The next question asked was "*What % of people in your organisation have been trained on the 7 tools of Quality?*". 35% of respondents stated that under 30% of their organisations had been trained in the 7 Basic QC tools (Figure 7). 25% stated that between 31% and 40% were trained, 17% stated that between 41% and 50% and 13% stated that between 51% and 60% were trained in the use of the 7 QC tools. Consolidation of the first 3 categories in Figure 7 implies that there is 77% of people trained in 50% of healthcare organisations. Thus, there is a strong level of training and awareness of the tools and on quality improvement in these organisations.

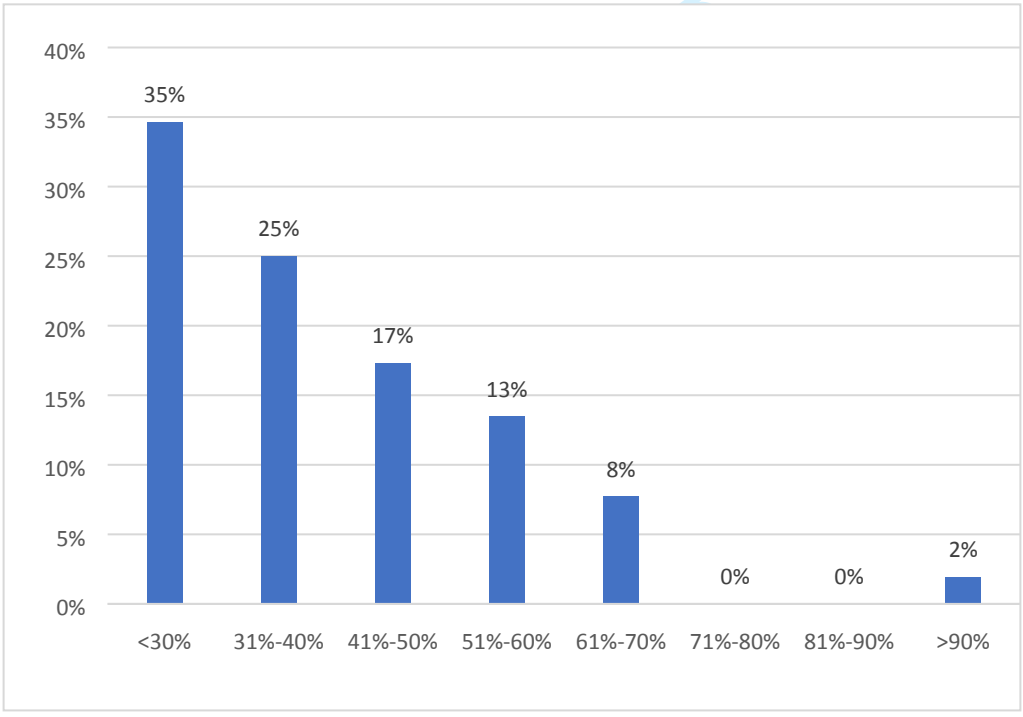


Figure 7: % of personnel in Healthcare facilities trained in the 7 Basic QC tools

In response to the question "*What percentage of quality problems in your current business can be tackled using the 7 "old" or basic tools of quality promoted by Dr. Ishikawa*?", the following results were highlighted. Only 3% of respondents stated that over 90% of their problems could be solved utilising the 7 QC tools. There is some evidence that the 7 QC tools can solve some level of healthcare organisational problems based on the aforementioned results. However, the results are nowhere near in agreement with Ishikawa's statement that the 7 QC tools can solve more than 95% of organisational problems.

A series of questions on tool usage and frequency of use was next asked. Respondents were asked "*What are the most used tools among the seven basic tools*?" and instructed to tick all that applied. The most commonly used tools were *Check Sheets (26.6%), Histograms (21.6%), Cause & Effect (21.3%) and followed by Control Charts (19.7%) (Table 4).*

It is not surprising to see the aforementioned tools as most commonly used. Check sheets and histograms are some of the simplest methods for collecting and determining trends and providing information for decision making (McQuater *et al.*, 1995) especially in busy healthcare environments. Cause and effect is a simple brainstorming tool and has been used in many healthcare situations and within cited case studies in the literature. Examples of cause and effect usage are many within the literature; utilised to brainstorm reasons for long laboratory testing time (Picarillo, 2018), used by Kumar, Ghildayal and Shah (2011) to root cause drivers for rising health care system costs and by Trakulsunti *et al.*(2020) in a study to root cause reasons for medication errors.

The least utilised tools were Pareto analysis (6.6%), followed by Scatter diagrams (3.2%) and stratification (1.1%). Scatter diagrams are used to help to detect and analyse a pattern relationships an independent variable and a dependent variable, and understanding if there is a relationship between them, whether weak or strong and positive or negative (Neyestani, 2017). Thus, as scatter diagrams are used to explore the relationship between two variables they may not be used on a day to day basis in a busy healthcare environment. Stratification analysis is a tool used to sort data, objects, and people into separate and distinct groups and revealing patterns that might not otherwise be visible when it's been lumped together. Studies where stratification has been cited in healthcare tend to be longer more statistically based studies of analysis on performance data. For example, stratification analysis was used in an evaluation of the quality of cardiovascular surgery care based on risk categories (Kawachi et al., 2002) and for developing a risk stratification tool for in-hospital mortality in heart failure (Fonarow et al., 2005). Pareto analysis has been discussed by Picarillo (2018) as an example for highlighting the reasons for medication errors but is probably more utilised in long term quality improvement and analysis than on tactical day to day quality improvement.

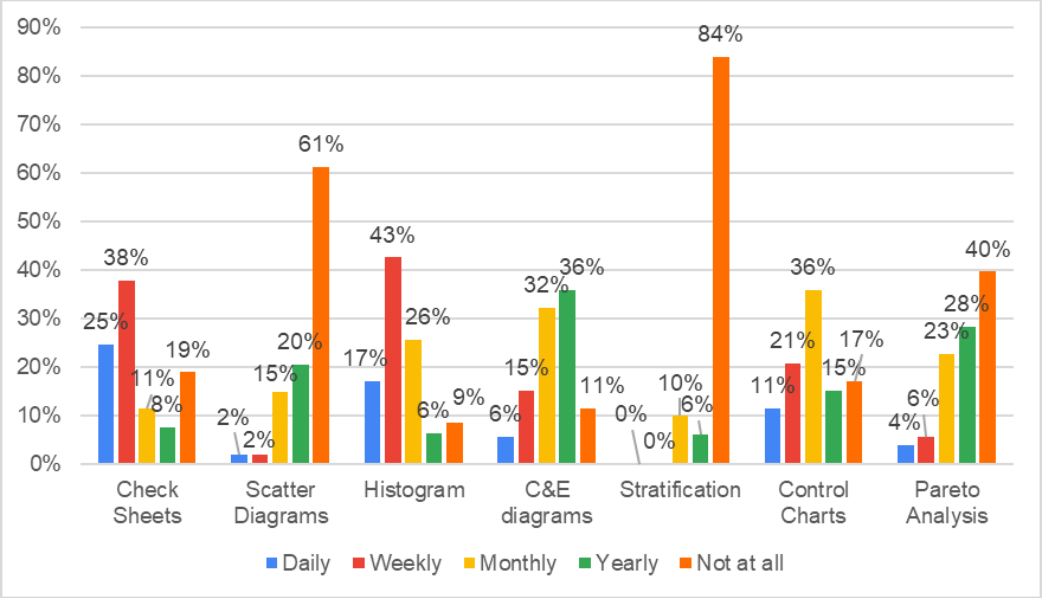
Table 4: % Frequency of tool usage of the 7 Basic tools in Healthcare

Tool	% usage
Check Sheets	26.6%
Histogram	21.6%
C&E diagrams	21.3%
Control Charts	19.7%
Pareto Analysis	6.6%
Scatter Diagrams	3.2%
Stratification	1.1%

The respondents were next asked "*How frequently are each of the 7 QC tools used?"* and given a list of choices ranging from daily, weekly, monthly, yearly use or not at all used. Check sheets, histograms and control charts were the three most utilised on a daily and weekly basis (Figure 8). This corelated somewhat with the findings from the previous question where check sheets, histograms, Cause and effect diagrams and control charts were all voted as the most utilised tools. However, C&E diagrams, control charts and pareto analysis had a high monthly and yearly usage suggesting perhaps their use in CI projects activity and analysis rather than day to day problem solving.

Control charts help determine the source of error from excessive variation by differentiating the common and special cause of variation, each requiring a different response from healthcare management (Seoh et al., 2021). As cited within the literature review there are several studies on the application of control charts in healthcare organisations. Histograms and checks sheets are simplistic graphical and visual tools and utilised as part of day to day administration and practice.

Stratification and scatter diagrams were the least utilised with 84% and 61% respectively stating that they were not utilised at all in many healthcare organisations. However the literature cites many studies on stratification usage in healthcare to study and stratify different patient groups with different risk factors (Glickman et al., 2007), (Funada et al., 2018). However, these studies would not be day to day activities or participated in by all functions; more so carried out as long term clinician and cross institutional data analysis and study to detect patterns and risk factors.



	Check Sheets	Scatter Diagrams	Histogram	C&E diagrams	Stratification	Control Charts	Pareto Analysis
Daily	25%	2%	17%	6%	0%	11%	4%
Weekly	38%	2%	43%	15%	0%	21%	6%
Monthly	11%	15%	26%	32%	10%	36%	23%
Yearly	8%	20%	6%	36%	6%	15%	28%
Not at all	19%	61%	9%	11%	84%	17%	40%

Figure 8: % Frequency of individual usage of the 7 Basic QC tools

The question "Do you apply these tools in other functions was asked?". Respondents were given a list of functions within healthcare facilities and asked to state where the tools were applied. This question helped disseminate further on where the 7 QC tools were applied functionally having gathered information on the frequency of use (table 5).

Within each department or functional area, check sheets were the most utilised of the 7 QC tools, followed by histograms and Cause &Effect diagrams. Stratification, scatter diagrams and pareto diagrams were the least utilised. The 7 QC tools were most utilised in *Accident and Emergency (A&E) or Emergency Room (ER), Outpatient , Operating theatres, hospital wards, administration, IT and Human Resources (HR)*. Considering medication and dispensing are a leading cause of death and exacerbated illness in hospitals (Trakulsunti et al., 2020) and have been the focus of many quality improvement projects (Trakulsunti & Antony, 2018) it is surprising to see the Pharmacy function not utilising the 7 QC tools more.

Due to the nature of administration, keeping patient records and protocols in healthcare it is not surprising to see check sheets as the most utilised. A study cited by Suman and Prajapati (2018) showed that most of control chart applications in Healthcare facilities is utilised in Theatre (Surgery), Emergency and Epidemiology departments. Tool usage is dependent on what tasks are required. This finding correlated with responses of the respondents who highlighted that the area which most utilised control charts was in the operating theatres.

Table 5: Frequency of usage of each of the 7 QC tools by functional or departmental area

Department	Check Sheets	Scatter Diagrams	Histogram	C&E diagrams	Stratification	Control Charts	Pareto Analysis	Frequency of dept usage (total)	Ranking
A&E	40	0	27	18	0	13	2	100	1st
Outpatients	30	1	18	10	0	7	1	67	2nd
Research/Clinical Trials	3	0	11	3	0	3	1	21	11th
Ambulance Services	11	0	3	6	0	7	0	27	9th
Facilities	5	0	3	5	1	3	1	18	13th
Admin	14	2	9	6	1	6	6	44	5th
HR	18	1	7	7	0	8	0	41	7th
Supply Chain & Logistics	11	3	5	6	1	6	2	34	8th
Hospital Ward	22	2	9	10	1	2	1	47	4th
IT	14	1	13	4	1	9	1	43	6th
Finance	5	1	5	2	0	2	1	16	14th
Customer Care/Quality Dept	11	1	7	6	1	7	1	34	8th
Radiography (X ray/MRI/CT)	6	1	4	4	1	3	1	20	11th
Physiotherapy	4	0	2	3	0	2	0	11	17th
Operating Theatres	21	3	5	10	2	17	1	59	3rd
Labs (Bloods/specimens etc)	12	1	1	4	0	5	1	24	10th
Maintenance	5	0	2	2	1	4	0	14	15th
Stores/Warehouse	8	1	3	3	2	2	1	20	12th
Pharmacy	8	1	5	3	1	4	1	23	10th
Doctors	5	0	3	1	1	1	0	11	16th
Records	11	0	1	2	0	1	0	15	15th
Frequency of tool usage (total)	264	19	143	115	14	112	22		
Ranking	1st	6th	2nd	3rd	7th	4th	5th		

The survey participants were asked to rank the top benefits of utilising the 7 QC tools. The top ranking benefits of utilising the 7 QC tools as answered by the respondents were; *encourages teamwork, aids in continuous improvement, improves patient and service quality, provide structure to problem solving, and helps determine the "true" root cause.* Aiding implementation of Six Sigma programs, reducing costs of poor quality, little statistical training required and reduction of prescription errors were the lowest ranked benefits. The focus on improvement through problem solving in terms of the benefits was a strong theme across the respondents. The results are elucidated in Figure 9.

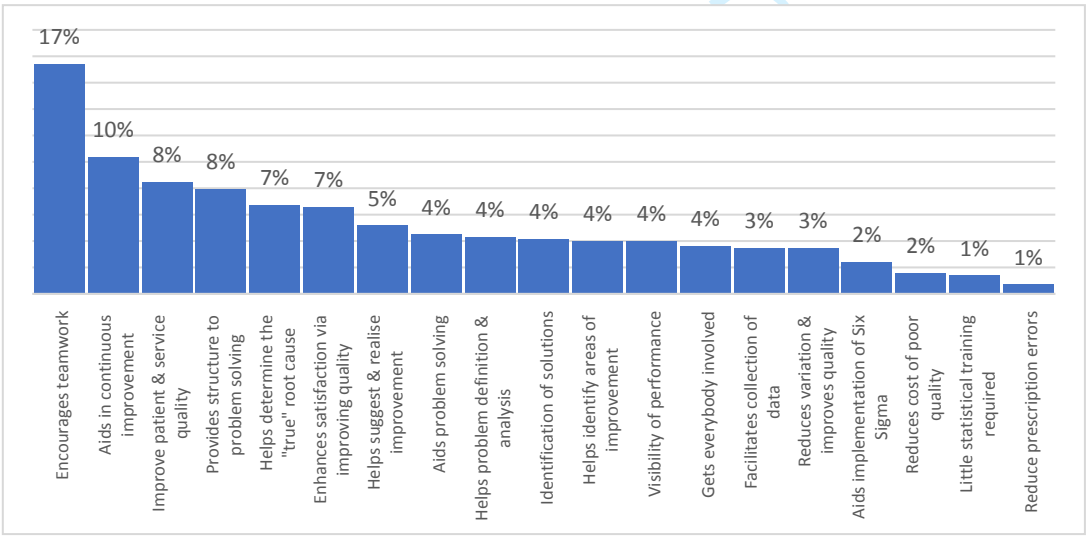


Figure 9: Benefits of utilising the 7 QC tools in healthcare facilities

The main challenges to using the tools were identified as *1. Lack of training in the use of the tools, 2. Lack of knowledge of the tools 3. Lack of understanding of the tools and not using the right tools at the right time (Table 6).* These findings aligned with previous research by Dale and McQuater (1998), Bamford and Greatbanks (2005) and (Tarí & Sabater, 2004) on the importance of training, knowledge and understanding in the use of the tools. Despite not using the right tool being identified as a key challenge it has not been researched or written about within the literature as extensively as other challenges to tool usage. McQuater et al. (1995b) did identify inappropriate use of tools and techniques as an obstacle to tool usage. Hagemeyer, Gershenson, and Johnson (2006) have suggested classification schemes for problem-solving tools that allow the user to select the right tool at the right time when problem-solving.

Other themes included *lack of understanding, lack of teamwork, lack of management support and lack of education.* Management commitment and team work approaches are the most vital components for tool usage to be potentially successful since it is impossible for one person to achieve improvement alone without a managerial involvement (Parmer & Deshpande, 2014). However, the respondents didn't cite management support and teamwork as the highest challenge. Without management supported and sponsored training and opportunities to use the tools in projects then tool usage is challenging. Interestingly no time to use the tools and no need for the tools were the least ranked challenges considering the healthcare sector can as a service sector can be very busy with unpredictable demands on services and time.

Table 6: Challenges to utilising the 7 QC tools in Healthcare facilities

Challenges	%
Lack of training	15%
Lack of knowledge of tools	12%
Lack of understanding	12%
Not using the right tools at the right time	12%
Lack of management support	10%
Lack of education	8%
Poor attitude towards quality	8%
No motivation or drive to apply the tools	6%
Poor communication	5%
Lack of teamwork	4%
Poor/bad organisational culture	3%
Only for use in certain areas	2%
Poor data collection methods	1%
No time to use	1%
No need for tools	1%
Other	1%

The top CSF's identified for utilising the 7 QC tools efficiently and effectively within healthcare organisations were next elicited. *Having a CI program (15%), having management support (14%) , sharing of success stories and benefits (13%), and communicating the benefits of tools (12%) were the top CSF's identified (Table 7).* Management support is also outlined as a CSF within the literature findings (Bamford and Greatbanks, 2005; Bunney and Dale,

1997). Having a CI program will encourage employees to use the 7 basic tools of QC for problem-solving and therefore it makes sense to see it as one of the most important CSFs.

In the previous question where no time to use the tools was ranked as the lowest challenge to using the tools there was a similar finding in this question. An opportunity to use the tools was ranked as the lowest CSF to using the tools by the respondents. This suggests that time and opportunity is not a barrier to the use and application of the 7 QC tools. This finding within a busy healthcare sector which has difficulties forecasting demand, inventory, personnel and resources depending on public health outbreaks is surprising.

Table 7: CSF's to utilising the 7 Basic QC tools in Healthcare facilities

CSF's	%
Having a CI program	15%
Management Support	14%
Sharing success stories and benefits	13%
Communicating the benefits of tools	12%
Companywide training	9%
Systematic & disciplined approach	9%
Opportunity to participate in problem solving	9%
Recognition and Reward	8%
A sense of urgency by the senior mgmt. team	6%
Opportunity to use the tools	4%

The last question asked within the survey was; *How often have you utilised the "wrong" or "incorrect" QC tool in a problem-solving situation*? Just slightly over half of the respondents (51%) stated that they had utilised the wrong tools less than 20% of the time (Figure 10). Zero respondents (0%) stated that they had used the wrong tools over 80% of the time. This is a positive finding considering that a similar study carried out within the manufacturing sector by Antony et. al (2021a) found that 35% of people had misapplied the tools over 80% of the time. The fact that there is a sizeable 37% of respondents stated that they utilised the incorrect tools between 20% and 39% of the time suggest training in the use of the tools could be strengthened. However, considering the fourth highest challenge identified to use of the tools in the healthcare sector in a previous question was not using the right tool at the right time there is evidence that tools are being applied incorrectly.

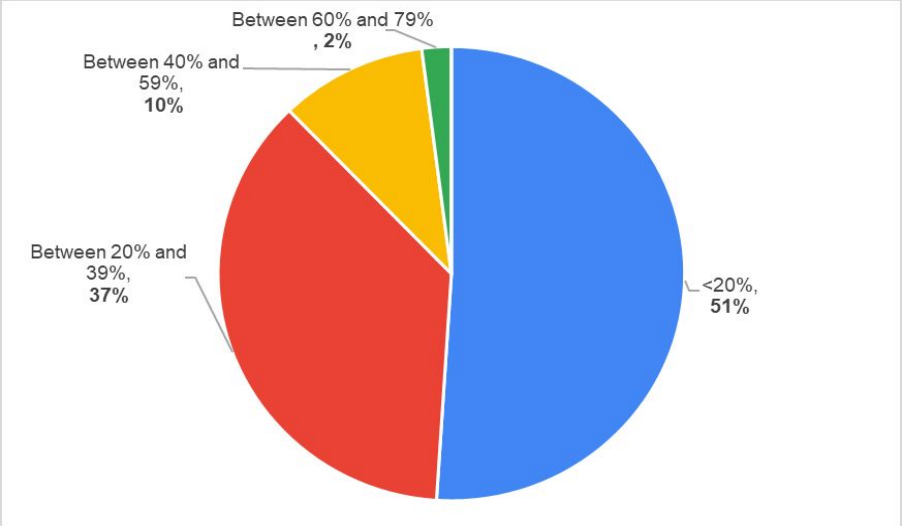


Figure 10: % of respondents who stated they have utilised the wrong or incorrect QC tool when problem solving.

Discussion

The 7 Basic QC tools as put forward by Ishikawa for QC are around for more than forty years. These tools are instrumental in problem solving and in continuous improvement programs. In terms of training and knowledge of the 7 Basic QC tools in healthcare organisations, 62% of respondents stated that they had been trained while 38% had not been trained (RQ1). The authors would like to make an argument here that the 7 basic tools of quality control are meant for all employees in a problem-solving setting and therefore organisations of the 21st century irrespective of their nature should be trained on these basic tools for problem solving and even quality related problems in a hospital setting. Quality must be everyone's responsibility and therefore these basic tools of QC must be taught to all employees and this will raise an increased awareness of problem-solving efforts using these powerful and basic tools.

35% of respondents stated that just under 30% of their organisations had been trained in the 7 Basic QC tools. While 25% stated that between 31% and 40% were trained, only 17% stated that between 41% and 50% were trained, with 13% stating that between 51% and 60% were trained in the use of the 7 QC tools. The authors are surprised to see the above statistics from our analysis as we would have expected a higher percentage to be trained on the basic problem-solving tools promulgated by Dr Ishikawa. Previous studies on the usage of the 7 QC tools in manufacturing organisations have found upwards of 80% of personnel trained in the use of the tools (Antony et al, 2021a, Antony et al, 2021b). This difference suggest that healthcare organizations do not perceive the need to train a large percentage of employees in 7 basic tools of QC as compared to manufacturing organizations. This could be because healthcare quality problem is more complex compared to manufacturing organizations. Take for instance, healthcare quality is also dependent upon the cooperation between patient and the service provider (Mosadeghrad, 2014). Such human oriented variability may be at times difficult to solve using 7 quality tools in a healthcare setting. Another perception is that perhaps healthcare organisations have a low maturity in the application of the basic tools of QC compared to manufacturing and moreover there is a lack of understanding of the benefits on the use of such

tools at the senior management and leadership levels in a healthcare environment compared to manufacturing.

Only 3% of respondents from healthcare organisations stated that over 90% of their problems could be solved utilising the 7 QC tools (RQ2). However positively, 24%, stated that between 71% to 80% of their problems could be solved by utilising the 7 basic QC tools. These figures contradicted Ishikawa's original statement that over 95% of organizational problems can be solved utilising the 7 Basic QC tools. However a similar global study carried out by Antony, McDermott and Sony (2021a) in the manufacturing sector also disagreed with Ishikawa's original statement.

Check sheets (27%), Histograms (22%), C& E diagrams (21%), and Control charts (20%) were the most utilised of the & QC tools in that order with Scatter diagrams, Stratification analysis and Pareto charts being the least utilised. *Check sheets, Histograms and Control charts were the three most utilised on a daily and weekly basis* (RQ1). Pareto Analysis use in healthcare would be very appropriate for problem prioritization and should be used in conjunction with cause and effect analysis to understand the potential causes of problems. The 7 QC tools were most utilised in the main *hospital treatment wards, Accident and Emergency (A&E) or Emergency Room (ER), Outpatients (OP) appointment clinics, Operating theatres, and hospital wards* (RQ1). Interestingly these areas would be seen by many as some of the busiest and stressful areas of hospitals for employees so the results demonstrate that there is a usage of the 7 Basic tools and an appetite for use of these tools to aid continuous improvement.

The top-ranking benefits of utilising the 7 QC tools as answered by the respondents were; *encourages teamwork, aids in continuous improvement, improves patient and service quality, provide structure to problem solving, and help determine "true" root cause* (RQ3). These benefits suggest that personnel in Healthcare see the value for the tools in improving the patient safety and service experience as well as structuring problem solving exercises.

The challenges to using the tools were identified as 1. *Lack of training in the use of the tools, 2. Lack of knowledge of the tools 3. Lack of understanding of the tools and not using the right tools at the right time* (RQ3). Within the literature lack of knowledge and lack of training have been described as key challenges to tool usage. However not using the right tools at the right time has not been studied extensively (Hagemeyer, Gershenson, and Johnson, 2006).

Having a Continuous Improvement (CI) program (15%), having management support (14%) , sharing of success stories and benefits (13%), and communicating the benefits of tools (12%) were the top CSF's identified. Just slightly over half of the respondents (51%) stated that they had utilised the wrong tools less than 20% of the time. Zero respondents (0%) stated that they had used the wrong tools over 80% of the time. This finding is aligned with the previous finding that not using the right tools at the right time was a challenge to tool application in the healthcare sector. There are cost and resource implications to utilising tools incorrectly as problem solving efforts have to restart. Adequate training and understanding in the use of the tools along with classification of tools in terms of when and how to apply can overcome this misuse (Hagemeyer, Gershenson, and Johnson, 2006).

Conclusions, implications limitations and future research directions

In this study the researchers investigated the accuracy of the statement that Dr. Ishikawa put forward in the 1970s and 80s that the 7 QC tools can solve 95% of quality related problems and provided evidence to refute this statement. This study, the first of its kind to investigate Dr. Ishikawa's statement in the healthcare sector and found that that only 3% of participants from European healthcare public and private organisations perceived that the seven tools of QC can solve over 90% of quality related problems. A key finding of this study is that 62% of respondents were trained in the use of the 7 basic tools of QC in the healthcare sector.

Interesting there were more professional from public organisations trained in the use of the 7 QC tools than in private organisations. Histograms, Cause & Effect diagrams and check sheets are the most used tools in the healthcare sector while the least utilised were Stratification and Scatter diagrams. This paper also revealed that the 7 QC tools were most utilised in Accident and Emergency (A&E) or Emergency Room (ER), Outpatients (OP) appointment clinics, Operating theatres, and hospital wards. There was a consensus that the tools are utilised across the main functional areas with healthcare facilities.

The study also demonstrated the consensus around the common challenges, benefit's, and CSF's to applying the tools in organizations which were common across sectors and across continents. One of the limitations of this research was that it was carried out in European healthcare facilities – and there is an opportunity to expand the study across global healthcare facilities. In addition, future studies should also compare the usage of 7 QC tools in both developing and developed country healthcare organizations. There is also an opportunity to study the use of the tools and their impact on hospital performance at operational and tactical levels in a longitudinal case study within a healthcare organisation. It is also suggested to undertake mixed method studies to understand the reasons behind variability of 7 QC tools in healthcare and other sectors. Such studies will help to explore the difficulties faced healthcare organizations in the effective utilization of 7 QC tools specifically with respect to each tool. The results of this study represent an important first step towards a full understanding of the applicability and usage of these tools in the healthcare sector.

Our findings have significant managerial or practical implications for managers of healthcare organizations who are seeking to eliminate quality problems. 7 QC tools are basic tools which help to identify and solve many quality problems. Our study suggests that there is some evidence that the 7 QC tools can solve some level of healthcare organisational problems. However, our study also found that most organizations do not train all their healthcare staff in these basic quality tools. Thus, managers should first and foremost take efforts to train most of the healthcare staff in these basic tools and help them in the execution of small and incremental projects which utilises the 7 basic tools. Efforts should also be taken to render vestibule training so that healthcare providers understand the importance of it and inculcate it as part of routine organizational activity. In addition, to training in these tools, a proper organizational culture should be created, as regards to usage of these tools. However, a culture of quality cannot be attained if people are equipped with the basic tools of quality improvement. Moreover, employees should take care of their own processes and solve process inefficiency and quality related problems using the basic tools. We suggest healthcare organizations, to create SOP and guides as regards to usage of each tool, so that employees can use it on a day-to-day basis to solve the quality issues. Another point to consider is that Pareto analysis, Scatter diagrams and

stratification were the least frequently tools found in our study. Managers should frame guidelines as regards to promote the usage of these, least frequently used tools, so that the benefits can be realised by the organizations. The authors were quite surprised to observe that Pareto analysis was not widely used in healthcare environment. In fact, it is one of the most powerful tools which can help managers and clinicians in identifying and prioritizing quality related problems which affect patient satisfaction and safety. The participation of all healthcare providers in quality improvement are becoming increasingly important so that healthcare systems are improved (Picarillo, 2018). Therefore, managers should encourage the use of these 7 QC tools in all departments of healthcare systems. Our study finds that the 7 QC tools are not used equally in all functional departments of healthcare. Thus, we suggest to managers to encourage all the functional departments of healthcare to use the 7 QC tools, by giving either monetary or non-monetary rewards to departments or team levels. Our study finds that the top challenges of using 7 QC tools are lack of knowledge of the tools, lack of training in the use of the tools, and not using the right tools at the right time. These challenges can be mitigated by designing managerial intervention programs in terms of training, and re-training the work force in specific 7 QC tools. Furthermore, such an intervention program will also help many employees with the reduction of incorrect usage of QC tools.

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8th June 2022

The Editor

TQM Journal

Please accept our article on ***" A study on the Ishikawa's original basic tools of quality control in Healthcare"*** for publication in the TQM journal. We propose the following referees who familiar with the area:

1. Dr Matthew Pepper

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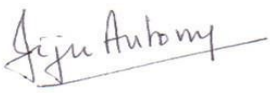
Best Regards,



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