Inquiry into the Use of Five Whys in Industry

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ABSTRACT

Purpose: This research seeks to understand the purpose five whys is used for in industry as well as what quality tools are used together with five whys.

Methodology/Approach: A survey was sent to organizations previously identified for an unrelated survey. The survey was sent to 98 organizations in Poland and 47 organizations responded. There were four respondents who reported being unfamiliar with five whys and their responses were discarded. The reported uses of five whys were assessed using a Chi-square goodness of fit test. The way in which five whys is used, either as a brainstorming tool or a method that requires investigation, and the purpose of five whys were compared to the intended use using a hypothesis test of two proportions. The quality tools used with five whys was then assessed using a Chi-square goodness of fit test.

Findings: Although more respondents use five whys as a root cause analysis (RCA) tool, the difference was not statistically significant. Respondents who used five whys with investigation used five whys as both a method for quality improvement and RCA more often than those who used five whys as a brainstorming tool without investigation. There was no statistically significant difference in using five whys for RCA and those who used five whys as a brainstorming tool reported using five whys for quality improvement more often. Although many different quality tools were reported, the Ishikawa diagram is by far the quality tool used the most with five whys.

Research Limitation/Implication: This paper used a survey that was limited to one region of Poland.

Originality/Value of paper: This paper provides the first insights into the use of five whys in organizations; as a method for quality improvement, RCA, or both.

Category: Research paper

Keywords: five whys; quality tools; root cause analysis; failure investigation

1 INTRODUCTION

This study seeks to identify the reasons five why is applied in organizations as well as which, if any, quality tools are typically used together with five whys. Five whys originated in the Toyota Production System (Gangidi, 2019) and is a basic tool that should always be used when performing a Root Cause Analysis (RCA) (Anderson and Fagerhaug, 2014), which is performed to find root causes to implement corrective actions (Dentch, 2017). As such, five whys are a method for diagnosis (Smith, 1994), which is essential for solving problems (de Mast, 2013).

Five whys is a method to determine the root cause of a problem (Boukendour and Brissaud, 2005) by repeatedly asking the question why (Fogle and Kandler, 2017) and is "used for drilling down into a problem" (Fonseca, Lima and Silva, 2015 p. 609). The root cause is the "failure mode of the lowest level why that can be eliminated to prevent the failure and in which control over the failure mode exists" (George, Ranjha and Kulkarni, 2021, p.698).

Five whys is also "A repetitive questioning technique for probing deeper to surface the root cause of a problem" (Christensen, Coombes-Betz and Stein, 2013, p.336). Five why is used to identify underlying causes and an example of underlying causes is given by Fogle and Kandler (2017) for a situation in with 15 out of 50 sensors failed a test. They failed the test due to too much moisture, which was the result of pin holes that let moisture in. The pin holes were the result of incorrectly performed welding.

The more obvious causes of a failure can be viewed as symptoms of the failure (McElroy, 2017). Declaring a failure cause to be the root cause without using five whys may result in addressing only a symptom and not the underlying root cause (Gangidi, 2019). The simplest way of performing five whys is to repeatedly ask "Why does this happen?" (Benbow and Brome, 2009, p.217) each time a question is answered.

Failures often have underlying causes beneath the noticeable causes. The noticeable causes of the problem are proximate causes and only correcting proximate causes may not ensure that a failure does not happen again. Using five whys can lead to the ultimate cause, which is the underlying cause for a problem, that if prevented, will ensure the failure cannot occur again. This is illustrated by a hypothetical example of a missing bolt hole due to a broken drill bit in an automatic system. The bit was broken because it was the wrong type of drill bit for the material being drilled. The drill bit was the wrong type because the manufacturing engineer did not check the type of material being drilled and this is the last proximate cause. The ultimate cause was a lack of a requirement to check the type of material to be drilled (Barsalou, 2017).

Although the method is called five whys, five is just a general guide and more than five whys may have been needed to find a root cause (Sandesh and Pawan, 2014). Use of five whys as a part of RCA solved an organization's main problem, resulting in a savings of over $32,000 per year at a manufacturing organization (Benjamin, Marathamuthu and Murugaiah, 2015).

Five whys can be used for both root causes and potential causes. A root cause is something that results in the problem, while a potential cause only results in the problem if the potential cause does happen. Actual root causes must be supported by evidence (Sarkar, Mukhopadhyay and Ghosh, 2013). Each additional why question becomes less superficial and more difficult to answer (Stamatis, 2003). However, once identified, root causes must be validated to ensure they are the correct cause (George, Ranjha and Kulkarni, 2021).

2 LITERATURE REVIEW

Five whys is a type of proximate cause strategy for RCA. A proximate cause strategy begins with an evaluation of the symptoms of the problem and then the investigator seeks to identify each underlying cause (de Mast, 2013). Five whys is well suited to identifying the cause of a failure through cycles of investigation and analysis (Barsalou, 2017). However, five whys can also be used for quality improvement, with multiple levels of theoretical causes identified for improvements. Here, multiple answers may be found, each with their own underlying causes. In such cases, it is possible that a few underlying potential causes are driving multiple problems (Anderson, 2007).

Five whys uses five iterations of asking why; however, five is more of a rule of thumb and more or less may be needed and there should be criteria for declaring the final why to be asked and the underlying root cause identified. Jing's criteria for stopping the cycles of asking why is to stop when a small investment can achieve a major improvement, when a few causes are found to have a major impact, or when a root cause is within an organization's ability to correct the cause (Jing, 2008). For example, an organization may not be able to correct problems with a purchased part out of a catalogue, but the organization does have control over where the purchase is made (Barsalou, 2017).

According to Vidyasagar (2016), the why question should be asked until a person, policy, or process is identified as the root cause. The relevance of the questions and answers to the original problem, the ability to control a root cause to prevent a reoccurrence, and the significance of the answers to the whys questions in regarding to the scope of the problem are additional criteria that can be used for declaring a final root cause when using five whys (Vidyasagar, 2016).

Five whys can be used as a standalone tool. However, five whys can also be used as a part of a problem solving methodology such as 8D reports (George, Ranjha and Kulkarni, 2021), where the use of five whys is a standard part of the 8D report approach to problem solving and five whys is used to "drill down" to find the underlying failure cause (George, Ranjha and Kulkarni, 2021, p.697) and A3 reports (Lenort et al., 2017). Five whys can also be used as a part of a Lean Six

Sigma Project as illustrated by Cheng (2017), who used five whys as a part of a Lean Six Sigma project together with a causal analysis to identify possibilities to implement optimizations.

Using five whys helps to ensure that an investigation into a failure is not stopped too early (Smith, 1998) and ensures depth to ensure superficial symptoms are bypassed and true root causes are found and understood (Shainin, 2011). Without five whys, a root cause may be declared to be human error, resulting in retraining to prevent an occurrence. However, retraining alone can't prevent a person from making the same mistake again. Five whys is needed to dig deeper to find a root cause that can prevent a reoccurrence once eliminated. For example, a distracted inspector was retrained to avoid passing failing parts in a visual inspection and the failure returned. Implementing a fixture in place of a visual control would have prevented a recurrence, even if an inspector was distracted (McElroy, 2017).

Serrat (2010) gives an example of five whys for an employee with an injured thumb. The thumb was injured because it was caught in a conveyor. Then thumb was caught in a conveyer because the employee was attempting to get his bag that was on the conveyer. The bag was on the conveyer because the employee used the conveyer as a table. The final solution to this problem was to provide a table for employee use.

Patyal, Modgil and Koilakuntla (2021) present an example of five whys that needed to go down six layers. The problem was customer complaints due to lumps in a product resulting from product being stored in sunlight because the product needed to cool to normal temperature resulting from a grinding operation using a specific chemical that was heated. The heated chemical was used so the product could be packaged sooner to meet manufacturing and sales objectives to meet an organizational goal for revenue.

In another example, a part was defective because a hole was too large and the hole was too large because the drill bit moved while drilling the hole. The drill moved because the drill fixture had play and the fixture had play because pneumatic clamps did not apply sufficient pressure. The pressure was insufficient due to variation in pressure at various locations in the production area (Benbow and Brome, 2009).

Five whys for dissatisfied website customers is presented by Anderson and Fagerhaug (2014). In this example customers are dissatisfied by lack of functionality caused by poor communication with customers due to time pressure that resulted from too many projects.

Five whys for the failure of a bridge lists corrosion of steel as the most obvious cause. This was caused by water collection resulting from debris clogging drain pipes. The drain pipes were clogged because maintenance was not performed on the drain pipes due to reductions in funding for maintenance (Scott, 2002). Another example of five whys is given by Gangidi (2019), who describes a fixture column that does not lock in two different tilt positions because of a screw jammed in the tilt mechanism. The screw fell because the retaining magnet on the screw was too weak because the magnet was in use beyond its intended lifetime.

Five whys is especially helpful for finding solutions to human error caused problems. For example, a package was shipped to the wrong customer because the wrong package was selected from storage due to an incorrect label. The label was wrong due to a supplier failure resulting from the operator who placed the label on the package selecting the wrong label. The wrong label was selected from a supply of finished labels. The solution to this problem was introduce bar codes for the automatic detection of incorrect labels (Gangidi, 2019).

A manufacturing organization example of five whys is presented by Sarkar, Mukhopadhyay and Ghosh (2013) who describe a production stop due to a grinding machine that cut an operator's finger after a part jammed. The jamming happened due to a damaged bearing mounting step that was unlubricated due to thick grease resulting from grinding particles in the grease that were not cleaned. In this case, lack of cleaning was the root cause.

Murugaiah, Benjamin, Marathamuthu and Muthaiyah (2010) describe the use of five whys to identify general improvements for a problem with sheet metal that was scratched. In this example, multiple potential causes were identified and corrected. Friction may have been due to forklift movement and sharp edges, The forklift movement could have resulted from both drivers who lacked experience and obstacles in the forklift's way. The sharp edges may have been due to metal on metal contact resulting from a lack of pads. Alternatively, scratches may have been due to friction at rollers caused by damaged rollers resulting from lack of maintenance due to no planned maintenance. Corrective actions for these problems included robotic arms in place of rollers, ensuring the forklift path is clear, and scheduled monitoring to detect sharp edges.

Chadha (2015) gives an example of the use of five whys due to customers complaining about out of specification parts. The parts were out of specification due to a process step being skipped due to inadequate repairs to a machine. The machine was not replaced due to the investment required because management did not want to spend money on an old machine that would eventually be replaced.

An organization applied five whys to the need for a new compressed air system. A new compressor was needed due to low pressure resulting from pipes that were not looped to move air in two directions because the usual way of setting up pipes was to run them from a main line. A lopped system was never considered because it was not known that it was needed and the possibility of a looped system was not previously considered due to expenses for a looped system (Perry and Mehltretter 2018).

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Another example of five whys pertains to a work place injury. An employee was cut by a knife due to the knife being left by a sink because the work area was not cleaned the day before. The work area was not cleaned because daily cleaning was not regularly conducted. The solution was the implementation of a documented requirement mandating regular cleaning (Williams, 2001).

Serrat (2010) recommends using a five whys worksheet, which consists of first defining the problem and then explain why it is happening. The first four answers are immediately followed by a new why question, leading down to the answer to the fifth why. Anderson and Fagerhaug (2014, p.51) present an even simpler template for five whys that consists of simply "why?" listed five times with each new why question below and to the right of the previous one.

Five whys should be conducted as a team activity. For example, one organization included plant managers, operators, and personnel from the maintenance department (Perry and Mehltretter, 2018). Five whys can also be combined with other quality tools.

There are many quality tools available with their own intended use (Starzyńska and Hamrol, 2013) to support an investigation. For example, there are the 7 quality tools consisting of the Ishikawa diagram, flow chart, check sheet, control chart, histogram, Pareto chart, and scatter diagram (Pyo, 2005) as well as affinity diagrams and matrix diagrams (Donauer, Peças and Azevedo, 2015) and these can be combined with five whys. For example, five whys is often used to gather with an Ishikawa diagram and supported by data-based tools to avoid finding an incorrect solution (Hopen and Rooney, 2014). Five whys can be used with an Ishikawa diagram to find the lower-level root causes (Force, 2012), with the Ishikawa diagram branches being expanded as each why question is answered (Mateos, 2021).

3 METHODOLOGY

A survey was used for data collection. The surveyed organizations were originally selected from a database of 372 organizations in a specific region with a quality management system for a previous study in 2013. The list of organizations was provided by a company that specialized in online databases. The 372 organizations were stratified by type of organization, such as manufacturing, production, or services, as well as three size classifications and two sources of capital, which were domestic or foreign. Representative sampling was used to ensure the organizations selected for the study were proportionally representative of the population of 372 in consideration of type of organization, size, and sauce of capital. The organizations in the survey represented a sample of 100 organizations from the database. However, three had closed since the original survey, so only 97 received the new survey.

There were 47 responses, which is a response rate of 48.5%. However, four respondents indicated they were unfamiliar with five whys and they did not complete the study, resulting in a total of 43 usable responses. There were 5 who reported being in consumer goods industries, 10 in the automotive industry, and 28 in other industries. The respondents' organizations ranged in size from less than 10 employees to over 500 employees. There were 16 respondents from organizations with over 100 employees, 13 respondents in organizations with 11-100 employees, 12 respondents in organizations with 101-500 employees, and 2 respondents in organizations with 10 or less employees.

The respondents were asked what their position was and 13 were managers. There were also 12 who reported being an engineer, and 12 who selected other. Director or president was selected three times and team leader was also selected three times. The respondents were also asked how many years of experience they had with quality tools. There were 13 with 11-20 years, 12 with 3-6 years, 10 with 7-10 years, 4 with two or less years, and four with 20 or more years of experience.

The respondents were asked "What do you use five whys for?" and the possible responses were "Both quality improvement and RCA," "Quality improvement such as process optimization" and "RCA, such as when investigating a quality failure" as well as "other."

To reduce the possibility of confusion regarding what was meant by quality improvement or RCA, an example was given as part of the response. The RCA response gave an example of investigating a quality failure and the quality improvement response gave the example of process optimization. The results are depicted in Table 1.

Table 1 – Reponses to "What Do You Use Five Whys for?"

Use	**Number of responses**
Both quality improvement and root cause analysis	16
Quality improvement such as process optimization	8
Root cause analysis, such as when investigating a quality failure	18
Other	1

A chi-square goodness of fit test was performed to determine if there was a statistically significant difference in the occurrences of the usage of five whys by determining if the occurrences differ from what would be expected due to random chance if there was no difference (Keller, Warrack and Bartel, 1994) with "other" removed. The results shown in Figure 1 have a p-value greater than 0.05; therefore, there was no statistically significant difference. However, the Chi-square goodness if fit test only considered use of five whys for quality improvement, RCA, and both quality improvement and RCA and did not consider direct comparisons between only two of the responses.

Observed and Expected Counts

Category	Observed	Test Proportion
Root cause analysis, such as when investigating a quality failure	18	0.333333
Both quality improvement and root cause analysis	16	0.333333
Quality improvement such as a process optimization	8	0.333333

Expected	Contribution to Chi-Square
14	1.14286
14	0.28571
14	2.57143

Chi-Square Test

N	DF	Chi-Sq	P-Value
42	2	4	0.135

Figure 1 – Chi-square Goodness of Fit Test for Use of Five Whys

What stands out is that most respondents who used five whys as both an RCA tool and a quality improvement tool tended to be those who used five whys with an actual investigation. Table 2 lists the use of five whys together with the purpose selected by the respondents.

Table 2 – Use for Five Whys and Purpose

Use	**Total**	**Quality improvement**	**RCA**	**Both Quality improvement and root cause analysis**	**Other**
Ask why five times and implement corrective actions to correct the answer to the final why	18	6	10	2	0
Investigate and determine the root cause; then ask why and investigate the cause of the root cause, repeating the process five times	25	2	8	14	1

Notes: RCA – Root cause analysis.

A hypothesis test of two proportions was to compare using five whys as a brainstorming tool or an investigation tool among respondents who reported using five whys for only quality improvement. A hypothesis test of two proportions is performed to determine if there is a statistically significant difference in two proportions at a given alpha level (Barsalou and Smith, 2018) and there was a statistically significant difference with a p-value less than the critical value of 0.05 using the normal approximation. However, the p-value was slightly over the critical value of 0.05 using Fisher’s exact test. Fisher’s exact test should be used when either the number of occurrences or non-occurrences is less than five (Barsalou and Smith, 2018), which is the case here. There is insufficient evidence to conclude that respondents who used five whys as a brainstorming tool reported using five whys only during quality improvement more often than respondents who reported using five whys with investigation (see Figure 2).

Method

p_1: proportion where Sample 1 = Event
p_2: proportion where Sample 2 = Event
Difference: $p_1 - p_2$

Descriptive Statistics

Sample	N	Event	Sample p
Sample 1	18	6	0.333333
Sample 2	25	2	0.080000

Estimation for Difference

Difference	95% CI for Difference
0.253333	(0.010981; 0.495686)

CI based on normal approximation

Test

Null hypothesis $H_0: p_1 - p_2 = 0$
Alternative hypothesis $H_1: p_1 - p_2 \neq 0$

Method	Z-Value	P-Value
Normal approximation	2.05	0.040
Fisher's exact		0.052

The normal approximation may be inaccurate for small samples.

Figure 2 – Test of Two Proportions for Use Versus Quality Improvement

Method

p_1: proportion where Sample 1 = Event
p_2: proportion where Sample 2 = Event
Difference: $p_1 - p_2$

Descriptive Statistics

Sample	N	Event	Sample p
Sample 1	18	10	0.555556
Sample 2	25	8	0.320000

Estimation for Difference

Difference	95% CI for Difference
0.235556	(-0.057925; 0.529036)

CI based on normal approximation

Test

Null hypothesis $H_0: p_1 - p_2 = 0$
Alternative hypothesis $H_1: p_1 - p_2 \neq 0$

Method	Z-Value	P-Value
Normal approximation	1.57	0.116
Fisher's exact		0.210

The normal approximation may be inaccurate for small samples.

Figure 3 – Test of Two Proportions for Use Versus RCA

A second hypothesis test of two proportions was performed to compare using five whys as a brainstorming tool or an investigation tool among respondents who reported using five whys for only RCA. They hypothesis test shown in Figure 3 has a p-value greater than the alpha of 0.05, therefore, there is no statistically significant difference.

A third hypothesis test of two proportions was performed to compare using five whys as a brainstorming tool or an investigation tool among respondents who reported using five whys for both quality improvement and RCA. The resulting p-value was less than 0.05, indicating there is a statistically significant difference (see Figure 4). Participants who use five whys with investigation use five whys for both quality improvement and RCA more often than respondents who use five whys only as a brainstorming tool.

Method

p_1: proportion where Sample 1 = Event
p_2: proportion where Sample 2 = Event
Difference: $p_1 - p_2$

Descriptive Statistics

Sample	N	Event	Sample p
Sample 1	18	2	0.111111
Sample 2	25	14	0.560000

Estimation for Difference

Difference	95% CI for Difference
-0.448889	(-0.691663; -0.206115)

CI based on normal approximation

Test

Null hypothesis H_0: $p_1 - p_2 = 0$
Alternative hypothesis H_1: $p_1 - p_2 \neq 0$

Method	Z-Value	P-Value
Normal approximation	-3.62	0.000
Fisher's exact		0.004

The normal approximation may be inaccurate for small samples.

Figure 4 – Test of Two Proportions for Use Versus Quality Improvement and RCA

The survey also asked respondents which quality tools they use together with five whys. The quality tools selected for the study were based on a previous study, which identified frequently used quality tools (Starzyńska 2014). Table 3 shows the responses, with 11 respondents stating Ishikawa diagram, three respondents stating check sheets, and two respondents answering FMEA. All other respondents selected more than one quality tool.

Table 3 – Combinations of Quality Tools Used with Five Whys

Tool combinations	**Count**
Ishikawa diagrams	11
Ishikawa diagrams, FMEA	7
Ishikawa diagrams, flow charts	5

Tool combinations	**Count**
check sheets	3
Ishikawa diagrams, FMEA, check sheets	3
flow charts, check sheets	2
FMEA	2
Ishikawa diagrams, flow charts, affinity diagrams	2
Ishikawa diagrams, flow charts, FMEA	2
flow charts, affinity diagrams, check sheets	1
Ishikawa diagrams, check sheets	1
Ishikawa diagrams, flow charts, check sheets	1
Ishikawa diagrams, flow charts, FMEA, affinity diagrams	1
Ishikawa diagrams, flow charts, FMEA, affinity diagrams, check sheets	1
Ishikawa diagrams, FMEA, affinity diagrams	1

Table 4 list the occurrences of the individual quality tools identified by respondents. The Ishikawa diagram was by far the mist identified quality tool. This was followed by the FMEA and then flow charts, check sheets, and affinity diagram.

Table 4 – Quality Tools Used with Five Whys

Tools	**Count**
Affinity diagrams	6
Check sheets	12
Flow charts	15
FMEA	17
Ishikawa diagrams	35

A Chi-square goodness of fit test was performed to determine if there was a statistically significant difference between quality tools used with five whys. The results in Figure 5 have a p-value greater than 0.05, indicating there is a statistically significant difference. The Ishikawa diagram is the quality tool most commonly used with five whys.

Observed and Expected Counts

Category	Observed	Test Proportion	Expected	Contribution to Chi-Square
Affinity diagrams	6	0.2	17	7.1176
Check sheets	12	0.2	17	1.4706
Flow charts	15	0.2	17	0.2353
FMEA	17	0.2	17	0.0000
Ishikawa diagrams	35	0.2	17	19.0588

Chi-Square Test

N	DF	Chi-Sq	P-Value
85	4	27.8824	0.000

Figure 5 – Chi-Square Test Results for Quality Tools Used with Five Whys

Figure 6 depicts expected values if all quality tools occurred equally versus the actual number of occurrences. The Ishikawa diagram occurred much more often than would have been anticipated if all tools were used equally. The affinity diagram, check sheets and flow charts were used less than would be expected. The FMEA occurred exactly as often as would be expected if all quality tools were used equally.

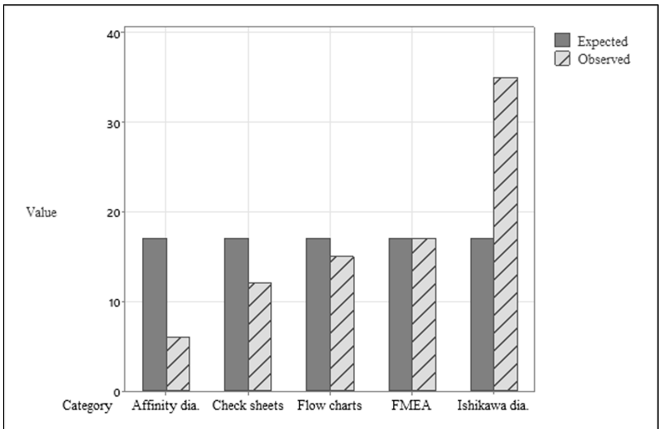

Figure 6 – Chart of Observed and Expected Values

Figure 7 depicts the contribution of each quality tool to the Chi-square value. The Ishikawa diagram had by far the greatest impact, due to being selected so much more often than other quality tools. This was followed by the impact of the affinity diagram, which was selected much less often than other quality tools.

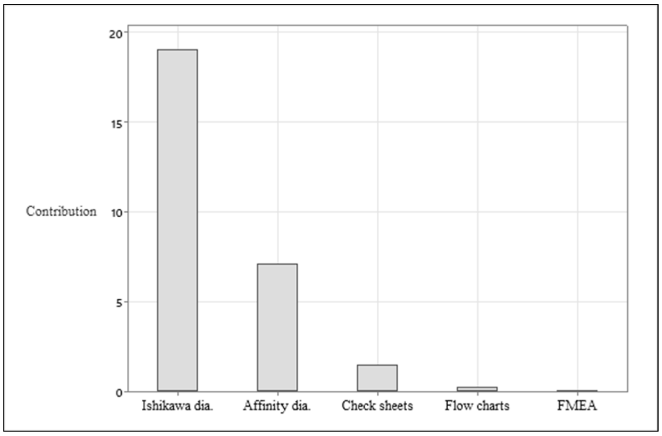

Figure 7 – Chart of Contribution to Chi-Square Value by Category

4 RESULTS

Many respondents who used five whys without investigation mostly reported using five whys for RCA, which implies they are finding root causes without actually investigating. This means that five whys, which can be useful for finding root causes, could be leading to incorrect results, potentially resulting in the reoccurrence of problems.

The respondents who use five whys with investigation reported using five whys for both RCA and quality improvement more often. Five whys is well suited to both RCA and continuous improvement. A basis for future study would be to determine those using five whys switch between five whys with investigation and five whys with only brainstorming when switching between RCA and quality improvement.

The Ishikawa diagram was used with five whys much more often than other quality tools. The Ishikawa diagram was followed by FMEA and the flow charts and check sheets. The affinity diagram was listed the least. However, the Ishikawa diagram was selected far more than other quality tools and this has a big impact on the Chi-square goodness of fit test results. Had the Ishikawa diagram not been one of the potential responses, it is possible that the remaining quality tools would not have had a statistically significant difference. What is clear from the results is that the Ishikawa diagram is the quality tool use the most with five whys.

5 CONCLUSION

Five whys is often used together with the Ishikawa diagram. This makes sense as an Ishikawa diagram can be used to list explanatory hypothesis. During an RCA, five whys can be used to dig deeper to find underlying causes that can then be listed as lower-level sub-branches in the Ishikawa diagram. However, it is essential that each cause listed is investigated and not just brainstormed when performing an RCA.

Five whys can be an effective tool for both RCA and quality improvement. However, if incorrect conclusions can be reached if five whys is used for RCA without an actual investigation.

Many quality problems in industry can be successfully addressed with the use of simple quality tools that do not require experts with advanced training (Easton 1995). The five whys together with an Ishikawa diagram provide simple and effective quality tools that do not require advanced training. However, organizations should consider a brief training session to ensure that employees understand the need to actually conduct an investigation when using five whys for RCA

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.