MonashHealth

Informing best practice in the conduct of a Root Cause Analysis: A literature review

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Executive Summary

Background

In order to develop capability with leading and training others to conduct a Root Cause Analysis (RCA) at Monash Health and in other jurisdictions, a review of the literature was required to outline aspects of an RCA to inform best practice and evaluation of existing RCA training programs.

Objective

1. To review the evidence regarding the existing practices for conducting a Root Cause Analysis (RCA)?

Information of specific interest includes:

- Best practice features of an RCA
- Examples of tools used to facilitate an RCA

2. To determine what evaluations of existing RCA training programs report?

Information of specific interest includes:

- Details of training programs (format, content and context)
- Evaluation findings

Methods

A search for peer-reviewed literature and grey literature published in English from 2012 to present was conducted in PubMed database and the internet (Tables 1 & 2). Documents included were not limited to any particular healthcare disciplines or industry, or national setting, and screened according to the *a priori* inclusion criteria based on the PICOS framework (Table 3) by two reviewers.

Results

The internet and database search identified a total of 692 documents and a total of twelve documents were selected, one of which was a 2014 literature review examining the current literature specific to the conduct of an RCA [1]. In summary, the 12 documents included five review articles [1-5], 4 peer-reviewed journal articles [6-9], one government document [10], and two white papers [11,12]. Eleven documents were in healthcare settings and one document was in the aviation setting.

Best practice features of an RCA and tools used to facilitate an RCA

From the literature included in our report the following details emerged:

Content

- There are no standardised methods in the RCA process, and the process varied from 6-11 steps.
- Regardless of the number of steps in the RCA process, the main objectives were always to understand what happened, identify the root cause of failure, and recommend corrective actions to prevent future reoccurrence.
- There is a consistent approach to an RCA throughout literature. Organisations must adopt a system/process focus, and not blame individual(s) involved.

Context

- The RCA may be conducted by a multidisciplinary team, selected by senior management, led by an unbiased person trained in safety science methodology.
- The team may consist of 4-10 individuals, including senior leaders and administrators, and sometimes consumer/customer representatives. There is no consensus to whether the person(s) involved in the event should be involved.
- The RCA report should aim to communicate the results of the RCA and inform the relevant teams in the organisation.

Format

- The RCA may be conducted at time of minimal disruption to work flow (i.e. early morning or late afternoon).
- An RCA should commence immediately after the event in the form of a meeting or forum in a neutral location.
- The time frame for completion ranges from 1-4 hours to 45 days.

A variety of tools and techniques are available to assist in the RCA process and vary within and across industries. The review identified several tools to guide the process of examining a healthcare failure with the most common tools mentioned including the Fishbone (Ishikawa diagram), Five whys, Pareto analysis, Tree analyses and Run charts. An RCA matrix may help assist in selecting the tools and technique to be applied [12].

Evaluations of RCA training programmes

There were no RCA training programs that specifically detailed or evaluated RCA training in literature.

Limited evidence reported that the format of RCA training components may include both an individual as well as team approach, and delivered in the form of lectures. The content of RCA training may include reading assignments, worksheets and unique RCA cases. Students may be assessed via presentation or individual assignments according to a structured grading rubrics.

Two studies that reported the evaluation of the RCA training components within course curriculum by Pharmacy students highlighted a positive impact of RCA training in increasing students' ability to conduct an RCA [8], as well as revealed challenges students faced in the last step of RCA (i.e., communicating the findings with a disclosure plan) [9].

Limitations

There was no appraisal on the quality of evidence included in this review.

The scope of this review included evidence about existing practices for conducting an RCA and evaluations of RCA training programmes. This did not encompass the appropriate selection and/or application of various tools and techniques to facilitate an RCA, or address the limitations or pitfalls to conducting an RCA.

Conclusion

This review sought to report on what best practice features of an RCA include and to provide examples of tools used to facilitate an RCA. To this end the literature describes methods of conducting RCA are fraught with inconsistencies and subject to the industries and disciplines that the methods are being applied. Therefore we conclude that there are no standardised methods in the RCA process.

We have summarised the format, context and content of RCA processes, and the range of tools available to assist in an RCA across industry to help inform best practice in an organisation. The most common tools mentioned in the reviewed literature include the Fishbone (Ishikawa diagram), Five whys, Pareto analysis, Tree analyses and Run charts.

There was a lack of published literature that specifically detailed or evaluated RCA training. Limited evidence from the two studies describe the format, context and content of RCA training component as part of a Pharmacy course curriculum, and report a positive impact of RCA training in increasing students' ability to conduct an RCA.

Full Report

Background

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Table 1. Search databases

Information sources	***Date of search***
PubMed	12/04/2017
Google	11/04/2017

Table 2. Search terms

Search Terms in PubMed		***Results***
#	**Terms**	
1	"Root cause analysis" [All Fields]	732
2	"Critical incident analysis" [All Fields]	54
3	#1 OR #2	786
4	Limit 3 to publication date "2012/04/12" – "2017/04/10", English & Humans	292
Search Terms in Google		***Results***
"Root cause analysis" training OR evaluation OR tools OR technique "best practice" 2012….2017		400

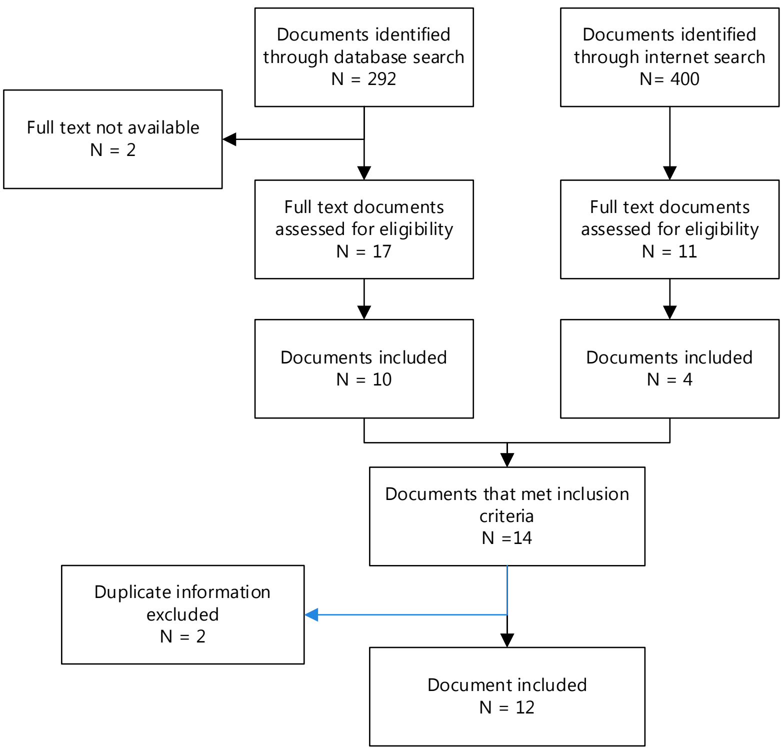
Table 3. Document eligibility criteria

Inclusion Criteria		
Setting	**Inclusion**	All industries
Intervention	**Inclusion**	Root Cause Analysis Root Cause Analysis training programmes
Outcomes	**Inclusion**	Best practice features Tools/Techniques Evaluation of training programme
Document Details	**Inclusion**	Human English White papers Peer reviewed literature Government documents
	Exclusion	Commentaries Editorials Non-human Non-English
Publication Date	**Inclusion**	2012 – 2017

Results

The search of medical database identified 292 citations of which 17 full text were retrieved and only ten met the inclusion criteria (Figure 1). The search of the grey literature identified 400 results, where only four documents met the inclusion criteria. After excluding duplicate information, a total of 12 documents are included and synthesised in this review (nine journal articles and three items of grey literature).

Figure 1. Search results and screening process used in the review



Document selection

The database search identified 292 documents.

The internet search identified 400 documents.

When a screening decision could not be made based on title and abstract alone, the full text was retrieved.

Twenty-eight full text documents were retrieved (17 journal articles and 11 items of grey literature). Two full texts were not available. (Figure 1)

A total of 14 documents were selected for this review (11 journal articles and 3 items of grey literature).

After excluding two publications that were duplicate information, a total of 12 articles were included in the review. (9 journal articles and 3 items of grey literature)

Narrative syntheses of results

Document selection

The internet and database search identified a total of 692 documents and a total of thirteen documents were selected, one of which was a 2014 literature review examining the current literature specific to the conduct of an RCA. [1] In summary, the 12 documents included five review articles [1-5], 4 peer-reviewed journal articles [6-9], one government document [10], and two white papers [11, 12]. The combined evidence was synthesised and summarised in Tables 4, 5 and 6.

"Best practice" features of RCA

There is a lack of peer-reviewed literature on the "best practice" methodology for conducting an RCA [1]. A summary of features of an RCA are highlighted in Table 4. The number of steps in the RCA process range from 6-11, and are detailed in four documents (Table 4) [2, 4, 5, 11]. There is also evidence of a novel approach to an RCA that was evaluated in hospitals in the United States [7], and suggestions on how to track and measure the effectiveness of the RCA process itself [3]. The literature included in this review reference three nationally available resources: National Patient Safety Foundation [4], National Patient Safety Agency [1, 11] and The Joint Commission [1, 2, 4, 5, 7].

Examples of tools used to facilitate RCA

There is a range of different tools used to conduct an RCA [1]. Table 5 gives an overview of the variety of tools and techniques available. Three documents describe the use of different RCA tools and techniques used in Healthcare [2, 3, 11], while an Aerospace report describe and discuss a wider range of techniques used in industries [12]. These four documents also discuss the application of the different RCA methods [2, 3, 11, 12].

Details of RCA training programmes and evaluation findings

There were no RCA training programs that specifically detailed or evaluated RCA training in literature. However, the evaluation of the RCA training components within course curriculum by Pharmacy students highlighted a positive impact of RCA training in increasing students' ability to conduct an RCA [8], as well as revealed challenges students faced in the last step of RCA (i.e., communicating the findings with a disclosure plan) [9]. Table 6 provides details on the context, content of training and evaluations of the RCA component of the curriculum.

In another evaluation of a novel approach (i.e. SWARM) to conducting an RCA, the authors revealed overall improvements in patient safety, and planned to integrate the approach into resident education [7]. One publication included in this review was a journal-based Continuing Medical Education (CME) activity that included teaching points and learning objectives for conducting an RCA in radiology [2].

Summary of Results

Summary of features for conducting an RCA

The reported features of an RCA are summarised and detailed below (Table 4) according to the three categories:

- Format of an RCA (this describes; when, how, where, how long)
- Context of an RCA (this describes; who leads, who is involved, who should be informed)
- Content of an RCA (this describes; objectives, approach, process, tools/techniques)

Table 4. The format, context and content of the features for conducting an RCA

Features	Summary	Details	
Format of RCA	• The RCA may be conducted at time of minimal disruption to work flow (i.e. early morning or late afternoon). • An RCA should commence immediately after the event in the form of a meeting or forum in a neutral location. • The time frame for completion ranges from 1-4 hours to 45 days.	When	• Immediately after the event [7] • Early morning or late afternoon [7]
		How	• Meeting [2] lasting for one hour [7] • Conversational forum [7] • Circular seating arrangement [7]
		Where	• Designated room in neutral location [7]
		How long	• Timeframe is dependent on scope of problem, quality of preparation and resources allocated [12] (Appendix 1 Figure 2) • Level 1 RCA (low impact): 1-4 hours • Level 5 RCA (high impact): 4-6 weeks or longer • Within 45 days [2]
Context of RCA	• The RCA may be conducted by a multidisciplinary team, selected by senior management, led by an unbiased person trained in safety science methodology. • The team may consist of 4-10 individuals, including senior leaders and administrators, and sometimes consumer/customer representatives. There is no consensus to whether the person(s) involved in the event should be involved.	*Who leads*	• Investigation Chair [12] or team coordinator [10] • Facilitator trained in safety science methodology [7, 10] who is unbiased [4] • Responsibilities of the lead are not limited to: • Arranging meetings, developing the framework, managing resources, leading the root cause analysis process, identifying corrective actions, and creating the final summary report [12]
		Who is involved	• Senior leadership involvement [2, 7, 12] • Multidisciplinary team of different professionals [4, 7, 10, 12] • Team ranges from 4-6 people [4, 7] to up to a maximum of 10 individuals [5, 12] • No consensus on whether people involved in the incident should be on the team [4, 7, 10]

	• The RCA report should aim to communicate the results of the RCA and inform the relevant teams in the organisation.		• May include patients or customer representatives [10, 12]
		Who should be informed	In a healthcare setting, the report should inform: • Health Service Executives • Safety, Quality and Performance team • Patient Safety Surveillance Unit • Office of the Chief Psychiatrist (for incidents involving mental health patients) [10]
Content of RCA	• There are no standardised methods in the RCA process, and the process varied from 6-11 steps. • Regardless of the number of steps in the RCA process, the main objectives were always to understand what happened, identify the root cause of failure, and recommend corrective actions to prevent future reoccurrence. • There is a consistent approach to an RCA throughout literature. Organisations must adopt a system/process focus, and not blame individual(s) involved. • A variety of tools and techniques are available to assist in the RCA process and vary within and across industries. A matrix may help assist in selecting the tools and technique to be applied.	*Objectives of RCA*	The goal of a RCA is consistent throughout literature [1, 2, 4, 10, 12] An RCA aims to: • Understand what happened • Identify the root cause of failure • Recommend corrective actions to prevent future reoccurrence
		Approach	It is important to note the following highlighted in literature: • Approach an RCA from different perspectives [12] • Conduct an investigation that is thorough and credible [2, 10] • Categorise events [1, 5, 6] • Confidentiality of process and reporting should be maintained [2] • Focused on the system and not the individual [5, 7, 10, 12] • A novel SWARM approach to an RCA is documented to have effective outcomes in incident reporting [7] • Five rules of causation are considered in an RCA [4, 5]
		Steps in the RCA process	The steps involved in an RCA process varied greatly. Steps identified include: • Organise a team [4, 5] • Identify appropriate RCA investigations [4, 11] • Gather information [11], interviews [2, 10] • Identify what happened [2, 5] • Mapping events [5, 11]

			• Determine causes (e.g., 5 whys) [2, 4, 5, 10] • Analyse information [2, 11] • Barrier analysis [11] • Generate list of solutions/recommendations/action plan to prevent reoccurrence [2, 4, 5, 11] • Design and implement “quick fix” interim changes [5] • Summarise, complete report and share it [2, 4, 5, 11] • Follow up of corrective action or recommendation [2, 4, 5, 10] • Measure outcomes, monitor changes, evaluate and document effectiveness of interventions [2, 4, 5]
		Tools and techniques	• The tools and techniques used in RCA were largely varied across literature and industry • Common tools used across industries include the fishbone (Ishikawa diagram), Five whys, Pareto analysis, tree analyses, and run charts • An overview of the different tools and techniques are found in Table 5 • An RCA matrix may help determine the appropriate RCA technique/tools to be used [12] (Appendix 1 Figure 3) • The application of RCA tools and techniques are discussed in depth in four documents [2, 3, 11, 12]. Appendix 2 Table 7 is an example of the pros and cons of RCA methods as discussed in an aerospace report [12]

Examples of tools used to facilitate RCAs

There are a number of tools used in RCAs. The most common tools mentioned across different industries include: the Fishbone (Ishikawa diagram) [2, 3, 5, 7, 10-12], Five whys [2, 3, 7, 10-12], Pareto analysis [1, 2, 7, 11, 12], Tree analyses [1-3, 5, 12] and Run charts [4, 7, 11, 12] (Table 5). RCA stacking is also described in industries, where a combination of methods are used [12].

Table 5. A variety of tools and techniques used in healthcare and other industries included in this report.

	Reference	**Polancich *et al.* [1]**	**Brook *et al.* [2]**	**Latino [3]**	**Charles *et al.* [4]**	**Shaqdan *et al.* [5]**	**Wagner *et al.* [6]**	**Li *et al.* [7]**	**DOH [10]**	**Ashmore *et al.* [11]**	**Duphily [12]**
	Document type	Review	Review	Review	Review	Review	Study	Study	Toolkit	Guide	White paper
	Application	Healthcare	Radiology	Healthcare	Medicine and surgery	Healthcare	Hospital	Hospital	Clinical incidents	Clinical audit	Aerospace
RCA tools/techniques											
Brainstorming			Y							Y	Y
Brainwriting			Y							Y	
Fishbone*			Y	Y		Y		Y	Y	Y	Y
Five Whys			Y	Y				Y	Y	Y	Y
Mapping tools										Y	
Nominal group technique										Y	
Pareto analysis		Y	Y					Y		Y	Y
Process mapping									Y	Y	Y
Run charts/Flow charts					Y			Y		Y	Y
HEAPS incident analysis									Y		
London Protocol									Y		
FMEA		Y		Y		Y			Y		
Tree analyses ^		Y	Y	Y		Y					Y
Barrier analysis		Y									
PRISMA		Y	Y				Y				
ACEA											Y
Cause mapping											Y
RCA stacking#											Y
CE diagram											Y
Opportunity analysis				Y							
Reality Charting (Apollo)					Y						Y

*Key: *also referred to as cause effect, or Ishikawa diagram; ^ this includes fault and logic, causal tree analyses; HEAPS – Human error and patient safety; FMEA – Failure modes and effects analysis; ACEA – Advanced cause and effect; # involves combining methods; CE – Process classification cause and effect; DOH – Department of Health, Western Australia*

Details of RCA training programmes and evaluation findings

Table 6 provides details on the context and content of training of the RCA component of a course curriculum as well as results of the evaluations by Pharmacy students.

Table 6. RCA training and evaluation as part of pharmacy curriculum

Context	• For 2nd [8] or 3rd year pharmacy students [9]
Format	• Teams of 5-6 students [8] • Individual effort [9]
Delivery	• 6 weeks x 2 hours lectures [8] • Lecture [9]
Content	• Reading assignments [8, 9] • 2 x unique cases assigned to each team [8] • RCA components obtained from textbooks [9] • Worksheet listing RCA steps and flow diagram [9]
Assessment	• 4-8 week written assignment [8, 9] • Presentation of case [8] or reflective narrative [9] • Structured grading rubrics for assignment [8, 9] (Appendix 3 Table 8) • Independent review of assignments by 2 reviewers [9]
Evaluation of training	• Overall performance on root cause analysis assignments was high [8]; majority of students were able to complete RCA components [9] • An evaluation of the course and assignments was performed by students [8, 9] o Students consistently rated the root cause analysis projects as positively contributing to their learning comprehension and ability to apply medication safety principles [8] o Approximately 98% of students agreed or strongly agreed that the root cause analysis assignments contributed to their learning [8] o 76% of students were challenged by the last step of RCA i.e., communicating the findings with a disclosure plan [9]

Limitations

There was no appraisal on the quality of evidence included in this review.

The scope of this review included evidence about existing practices for conducting an RCA and evaluations of RCA training programmes. This did not encompass the appropriate selection and/or application of various tools and techniques to facilitate an RCA, or address the limitations or pitfalls to conducting an RCA.

Conclusion

This review sought to report on what best practice features of an RCA include and to provide examples of tools used to facilitate an RCA. To this end the literature describes methods of conducting RCA are fraught with inconsistencies and variations and subject to the industries and disciplines that the methods are being applied. There are no standardised methods in the RCA process.

Several methods exist and universally seek to examine a healthcare failure by comprehensively understanding of an event, typically in a sequence of steps; to examine any gaps or failures that occurred during the steps; to ask ‘why’ the failure or failures occurred, and then, to critically explore and recommend action items to prevent the identified cause(s) from reoccurring” [1, 2, 4, 10, 12].

This review has summarised the format, context and content of RCA processes across industry to help inform best practice in an organisation. A large range of tools are available to assist in an RCA. The most common tools mentioned in the reviewed literature include the Fishbone (Ishikawa diagram), Five whys, Pareto analysis, Tree analyses and Run charts.

There was a lack of published literature that specifically detailed or evaluated RCA training. The limited evidence from the two studies identified describe the format, context and content of RCA training component as well as reported positive outcomes of an RCA training component that was integrated into course curriculum for 2nd and 3rd year pharmacy students.

References

1. Polancich, S., L. Roussel, and P. Patrician, *Best practices for conducting an RCA: Are there any?*, in *PSQH eNewsletter*. 2014.
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4. Charles, R., et al., *How to perform a root cause analysis for workup and future prevention of medical errors: a review.* Patient Safety in Surgery, 2016. **10**: p. 20.
5. Shaqdan, K., et al., *Root-cause analysis and Health Failure Mode and Effect Analysis: Two leading techniques in health care quality assessment.* Journal of American College of Radiologists, 2014. **11**: p. 572-579.
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10. Department of Health, W.A., *Clinical incident management toolkit 2015*, P.S.S.U. (PSSU) and P.S.a.C. Division, Editors. 2015: Perth.
11. Ashmore, S. and T. Ruthven, *Using root cause analysis techniques in clinical audit*. 2016, Healthcare Quality Improvement Partnership (HQIP).
12. Duphily, R., *Root cause investigation best practices guide*, Aerospace, Editor. 2014, National Systems Group: Chantily, VA.

Other resources excluded in the review:

13. The Joint Commission. Framework for conducting a root cause analysis and action plan. Download resources from: https://www.jointcommission.org/framework_for_conducting_a_root_cause_analysis_and_action_plan/

14. National Patient Safety Foundation. RCA^2: Improving root cause analyses and actions to prevent harm. Download resource from: http://www.npsf.org/?page=RCA2

15. National Patient Safety Agency. Download resources from: http://www.npsa.anhs.uk/

Appendix 1

Figure 2 and 3. RCA rigor (impact level) matrix and examples of methods used based on the impact level matrix. [12]

Severity
Time of Day and Who's Affected
< (Significance of Impact) >

Severity			
High • Major disruption / nonconformance and/or, • 100% may have to be scrapped, or reworked and/or, • Inoperable, loss of primary function and/or • Customer/Consumer dissatisfied and/or, • Above "Y" number of people	Level 3 RCA	Level 4 RCA	Highest Risk Items Level 5 RCA
Medium • Minor disruption / nonconformance and/or, • Between "X" and "Y" people and/or, • Portion may have to be scrapped or reworked and/or, • Operable but without all conveniences and/or, • Customer/Consumer inconvenienced	Level 2 RCA	Level 3 RCA	Level 4 RCA
Low • Minor disruption / nonconformance and/or, • Output may have to be sorted and a portion reworked and/or, • Less than "X" people and/or, • Noticeable to some customers	Lowest Risk Items Level 1 RCA	Level 2 RCA	Level 3 RCA
	Low • May find future isolated failures	**Medium** • Likely to find future failures with this and similar processes • Have seen before	**High** • Future failures with this and similar processes are inevitable • Have seen multiple times before

Recurrence
Process → System or Service
< Likelihood of the Event Recurring >

Instructions

1. Use the description of Low, Medium, High to assess your issue's Severity and Likelihood of Recurrence
2. Based on your issue's Severity and Likelihood of Recurrence, map to the corresponding Level of RCA
3. Using the color of your RCA Level to guide you, assess the requirements for that RCA tool

Figure 6. RCA rigor matrix.

RCA Level	Impact	Commonly used Data Collection & RCA Methods	Typical Analysis Span*	Output Artifacts (as required)
5	High-High	• KNOT Chart • Event Timeline • Process Mapping • Cause Mapping • Fishbone Diagram • Advanced Cause & Effect Analysis • Fault Tree Analysis	2 – 6 Weeks (or longer)	• RCA Findings and Conclusions • Validation and Measurement Strategy • Illustration of Root Cause Analysis • Company wide communications
4	High-Medium Medium-High	• KNOT Chart • Event Timeline • Process Mapping • Cause Mapping • Fishbone Diagram • Advanced Cause & Effect Analysis	4 days – 2 Weeks	• RCA Findings and Conclusions • Validation and Measurement Strategy • Illustration of Root Cause Analysis • User Community communications
3	High-Low Medium-Medium Low-High	• Brainstorming • Event Timeline • Cause Mapping • Fishbone Diagram	1 – 3 days	• RCA Findings and Conclusions • Validation and Measurement Strategy • Illustration of Root Cause Analysis • Affected people communications
2	Low-Medium Medium-Low	• 5 -Whys • Brainstorming • Fishbone Diagram	.5 – 1 day	• RCA Findings and Conclusions • Affected people communications
1	Low-Low	• 5 -Whys • Brainstorming	1 – 4 hours	• RCA Findings and Conclusions • Affected people communications

*** Analysis Span Time for completion of an effective RCA is dependent on:**
1) Scope of problem; 2) Quality of preparation; and 3) Resources allocated to RCA and problem resolution

Figure 7. Example of RCA methods by RCA impact level matrix.

Appendix 2

Table 7. Example of pros and cons of RCA methods discussed in an included document* [12]

RCA Method	Pro	Con
Brainstorming (Sec 8.2)	Good technique for identifying potential causes and contributing factors.	Is a data gathering technique not a classification and prioritization process.
Cause and Effect Diagram (Fishbone) (sec 8.3)	Consideration of many different items Ability to plan, execute, and record results for multiple investigative paths in parallel. Simple graphical representation of a potentially large and complex RCA. Most commonly method used in industry.	Inability to easily identify and communicate the potential inter-relationship between multiple items. Best suited for simple problems with independent causes.
Fault Tree Analysis (FTA) (sec 8.4.4)	Help to understand logic leading to top event. Many software tools available NASA has an FTA Guide.	Requires knowledge of process. Fault Trees are typically used as a trial and error method in conjunction with a parts list.
Advanced Cause and Effect (ACEA) (sec 8.4.3)	Good tool for complex problems with dependent causes. Diligent scrutiny of cause and effect relationships of key factors and their inter-relationships.	Requires thorough understanding of cause and effect relationships and interactions. Higher commitment of resources and time in comparison to more basic tools.
Cause Mapping (sec 8.4.2)	Can be large or small, depending on the complexity of the issue. Introduces other factors which were required to cause the effect to create a more complete representation of the issue. Allows for clear association between causes and corrective actions, with a higher likelihood of implementation.	Difficult to learn and use.
Why-Why Charts (sec 8.4.1)	A good tool for simple problems with dependent causes. Also well suited for containment.	Typically based on attribute-based thinking, rather than a process perspective. Not as robust as some of the more advanced tools.
Process Classification Cause and Effect (CE) Diagram (sec 8.5.1)	They are easy to construct and allow the team to remain engaged in the brainstorming activity as the focus moves from one process step to the next. They invite the team members to consider several processes that may go beyond their immediate area of expertise. Invite the team to consider conditions and events between the process steps that could potentially be a primary cause of the problem. They often get many more potential root cause ideas and more specific ideas than might otherwise be captured in a brief brainstorming session.	Similar potential causes may repeatedly appear at the different processes steps.

**The complete table can be found on page 25-26 of the Aerospace report [12]*

Appendix 3

Table 8. Elements assessed in RCA assignments as part of RCA training component [8]

Table 2. Major Elements Assessed in Root Cause Analysis Assignments and Associated Team Outcomes (N = 37)

Outcome	No. (%) of Teams That Achieved the Outcome	
	Assignment 1	Assignment 2
Error identification		
Group has provided a complete identification of the error	37 (100)	37 (100)
Group has provided a partial identification of the error	0	0
Group has not identified the error	0	0
Identification of error sources (key elements)		
Group has completely identified all sources of the error	32 (86)	35 (95)
Group has identified nearly all sources of the error	5 (14)	2 (5)
Group has identified a portion of the error sources	0	0
Group made no effort in identifying sources of the error	0	0
Evaluation of error sources (key elements)		
Group has completely evaluated all identified sources of the error	28 (76)	32 (86)
Group has partially evaluated identified sources of the error	9 (24)	5 (14)
Group has minimally evaluated identified sources of the error	0	0
Group made no effort in evaluating sources of the error	0	0
Strategies for error prevention[a]		
Group has identified error prevention strategies addressing all identified sources of the error	NA	28 (76)
Group has identified error prevention strategies addressing nearly all of the identified sources of the error	NA	6 (16)
Group has identified error prevention strategies addressing a portion of the identified sources of the error	NA	3 (8)
Group has not identified any error prevention strategies	NA	0
Potential problems with error prevention strategies[a]		
Group has identified potential problems with all error prevention strategies	NA	24 (65)
Group has identified potential problems with nearly all of the error prevention strategies	NA	10 (27)
Group has identified potential problems with a portion of the error prevention strategies	NA	3 (8)
Group has not identified potential problems with any error prevention strategies	NA	0

Abbreviations: NA = not assessed (ie, element was not assessed in assignment 1).
[a]Note: These elements were only assessed on the final root cause analysis assignment.