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Applying Failure Modes and Effects Analysis to Public Health Models: The Breathe Easy at Home Program

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ABSTRACT

Failure Modes and Effects Analysis (FMEA) is a structured process used to identify and prioritize risks by ranking them based on severity, occurrence, and detectability. Historically, FMEA has been used within industries, including automotive and health care. This project explored the adaption of the FMEA template to a small public health program designed to improve asthma outcomes. The Breathe Easy at Home (BEAH) program is a multi-sector partnership that uses a web-based system to link clinical sites with housing code inspections and enforcement for patients with asthma.

In July and August 2014, an FMEA was conducted to uncover risks within the BEAH process, and failures were prioritized for corrective action. The FMEA team prioritized risk based on severity, occurrence, and detectability to apply the FMEA process to a public health program. The FMEA team developed an action plan to improve failure modes that received the highest rankings. To fit the needs of a relatively small public health program, Joint Health Commission and U.S. Veterans Administration rating scales were adapted. The FMEA process can be adapted to a public health systems evaluation framework in order to prioritize areas for improvement.

Keywords

Failure modes and effects analysis, asthma, quality improvement, public health

Cover Page Footnote

Dr. Murphy reports grants from Boston Public Health Commission during the conduct of the study; Dr. Reid reports grants from Robert Wood Johnson Foundation Public Health Services and Systems Research during the conduct of the study; and Dr. Sandel reports grants from Boston Public Health Commission during the conduct of the study. No authors report competing interests.

BACKGROUND

Failure Modes and Effects Analysis (FMEA) is a structured process used to identify and prioritize risks by ranking them based on severity, occurrence, and detectability. Historically FMEAs have been used to identify risks within industry such as automotive and space programs. The Joint Commission incorporated FMEA to prospectively evaluate and redesign processes that led to failures in the healthcare setting.¹ Despite being an effective evaluation tool for industries such as automobile and healthcare in Idealized Design of Medication Systems (IDMS),² there is little literature on using FMEA to evaluate public health programs.

Breathe Easy at Home (BEAH) is a multi-sector partnership that uses a web-based system to link clinical sites with housing code inspections and enforcement for patients with asthma. Healthcare staff refers patients through the website to Boston's Inspectional Services Department (ISD) for a home inspection. If violations are found, the responsible party, either the landlord or tenant, must correct them within a specific time period and a follow-up inspection is conducted to monitor compliance. Outstanding violations are forwarded to Boston Housing Court.^{3,4} This current project explored how the FMEA template can be effectively adapted to evaluate a public health program designed to improve asthma outcomes.

METHODS

In July and August 2014, an FMEA was conducted to uncover risks within the BEAH process, and failures were prioritized for corrective action. As part of a mixed-methods program evaluation, an FMEA team made up of physician, community health worker, inspector, inspectional services administrator, parent of a child with asthma (tenant), and housing authority representatives met four times to conduct the Breathe Easy at Home FMEA. Failures were prioritized for corrective action. All FMEA participants had direct involvement in the program and had in-depth knowledge of the program operations. During the first meeting, following the Institute of Healthcare Improvement matrix of defining failure modes, causes and effects, each potential failure mode was organized into a swim lane chart to map the BEAH process from referral to completion, specifically identifying what causes and effects were linked to the failure mode and which agency and position was responsible for which tasks (Figure 1).

The team met three more times to identify what needed to happen for each step within the process to be successful, what would happen if that step failed (failure mode) and what metric it would affect. Failure modes were then prioritized and ranked based on severity (how bad would it be if this happened?); occurrence (how often could this happen); and detectability (whether it will be known in time to mitigate the risks). The FMEA team developed an action plan to improve the failure modes that received the highest rankings.

Analysis. The team prioritized risks based on severity, occurrence, and detectability rankings. The Joint Health Commission recommends using a 10-point scale and the U.S. Veterans Administration recommends using a four-level approach.⁵ In order to fit the needs of this program, both scales were adapted maintaining mechanisms of each approach but redefining levels to reflect a public health framework and program specifics. For example, the Joint Health

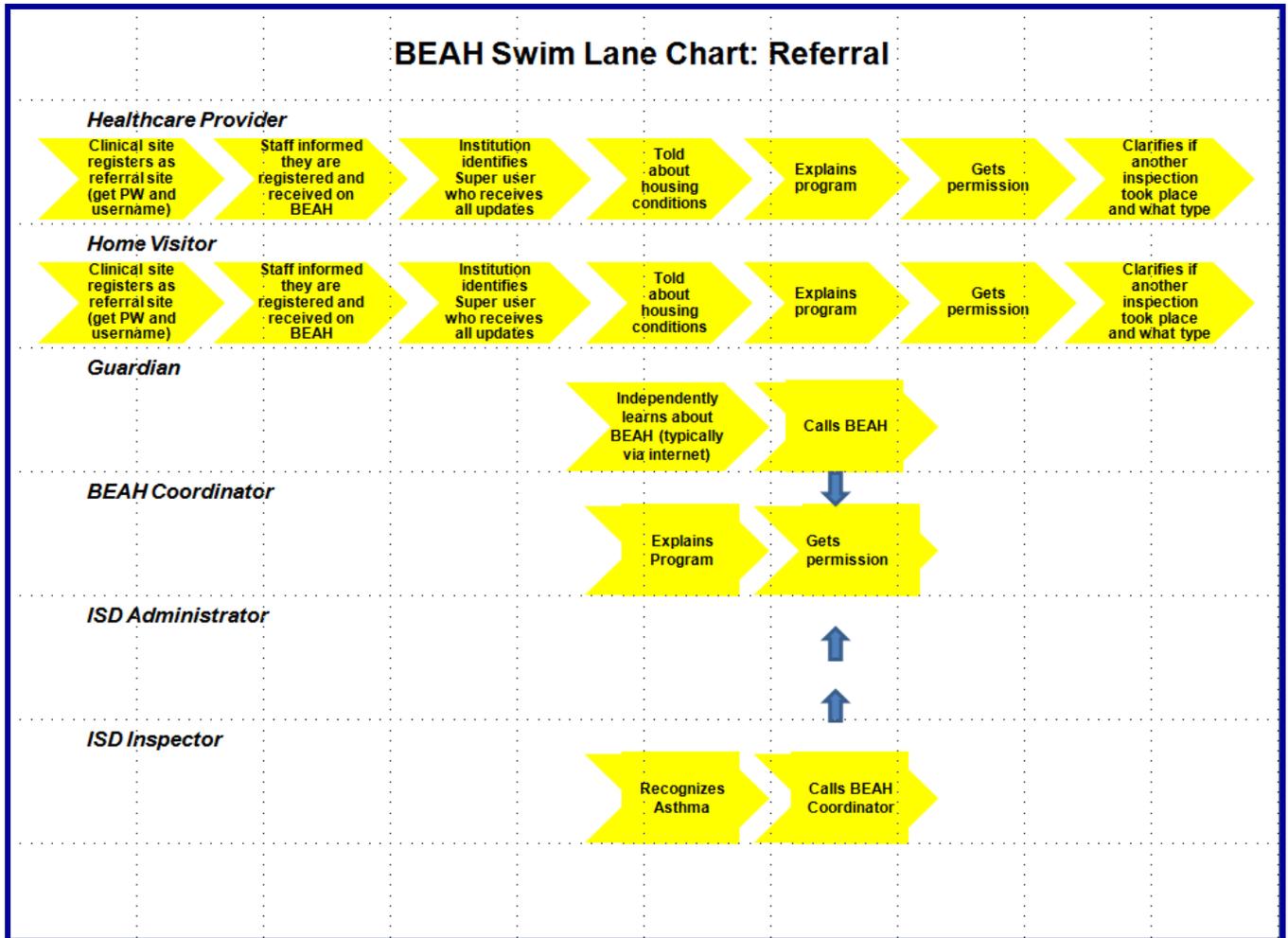


Figure 1: Swim lane chart example

BEAH, Breathe Easy at Home program; ISD, Boston’s Inspectional Services Department

Commission utilizes an occurrence rating from 1 to 10 where 1 means *failure is unlikely* (1 in >5 years) to *very likely or inevitable* (1/day). Given the relatively short tenant involvement in the program and small number of patients served, a ten point scale was not possible. Therefore occurrence was classified with four levels (remote [1]; uncommon [2]; occasional [3]; and frequent [4]) as recommended by the Veterans Administration. Remote failures were defined as unlikely to occur (once or twice during the 10-year history of the program); uncommon as possible to occur (once every 2–3 years); occasional (10–20 times a year); and frequent (up to 50 times a year).

The Joint Health Commission also classifies severity using a rating of 1–10: from *no severity at all* (would not affect individual or system) to *moderate* (significant effect with no injury) to *major injury to death*. There are a limited number of potential outcomes for BEAH and it is highly unlikely for severe injury or death to occur. We classified severity by utilizing four levels: minor event (1); moderate event (2); serious event (3); and catastrophic event (4) as recommended by the Veterans Administration.

The Joint Health Commission includes detectability, which this study did as well. Although, the Joint Commission approach classifies detectability using 10 levels, this study classified detectability using four levels: high (4); medium (3); slight (2); and impossible (1). Detectability was classified as impossible (no ability to detect problem); slight (after the fact, become aware and investigate); medium (proactively look for a problem); and high (problem is immediately self-revealing.) The FMEA team then calculated a combined indicator of risk known as the Risk Priority Number (RPN) by multiplying severity X occurrence X detectability. The higher the RPN the more essential to mitigate the risk.

The failures with the six highest RPN scores were prioritized. The FMEA team developed plans of action to prevent failures. The plans reflected the extensive BEAH systems knowledge among the team and required a method of measuring success. The team answered the following questions: *What failure mode needed to be addressed? What action could address this? What metric could be used to measure success in reducing the failure mode and how this metric will be followed over time?* For example a YouTube® video coaching clinicians to explain the BEAH program to their patients is designed to address a failure mode of clinicians poorly explaining the program to patients. Metrics of success could include monitoring the number of views of the video and number of referrals from the hospital. Some actions addressed multiple risks. In this case, the risks were combined and given a total RPN.

RESULTS

The team determined and scored 20 failure modes. For example, the highest failure mode was healthcare staff failing to know about patient's housing conditions.

The BEAH FMEA team then combined each individual failure mode into four main categories by consensus: staff education failure modes; parent education failure modes; changes to contact protocol failure modes; and changes to the website failure modes. Each of the four categories was then ranked based on their combined RPN score. The FMEA team utilized BEAH process knowledge to identify potential changes. Process changes were improving health care staff education improving patient education, changing patient contact protocol, and improving website (Table 1).

IMPLICATIONS

The failures identified within the FMEA process are guiding program improvements. Failures indicating the need to improve patient and health care education had the highest combined RPN score. To remedy these failure modes outreach materials are being updated, simplified, and translated, social media and YouTube® videos have been developed to market the program to different audiences. The second highest overall failure mode was related to client participation in the program. A new contact protocol providing text, email, or automated phone reminder options (in addition to the current phone call and letter) is being piloted with the goal of increasing enrollment and decreasing loss to follow up. Website modifications will include double entry and mandatory fields, in order to ensure that the correct information is received. Integration of data metrics regarding numbers of referrals, fulfilled appointments, and fulfilled follow-up appointments will provide information on the effectiveness of these remedies.

By using FMEA to prioritize risks, organizations can efficiently and systematically identify the most important problems within a program. The BEAH program can use established metrics to track the reduction of defined risks. The expert qualitative input of the FMEA team and the quantitative methodology could facilitate risk communication to multiple audiences including leadership, funding agencies, and others and allows for a more replicable program.¹ This serves as a case study on how the FMEA process can be adapted to a public health systems evaluation framework in order to prioritize areas for improvement. This case study also explores adaption of an FMEA process to a small public health program with risks that may not be applicable to industry or health care. Future studies will be needed to assess if this methodology does change program performance over time or can be replicated in other public health programs.

SUMMARY BOX

What is already known about this topic? Failure Modes and Effects Analysis (FMEA) is a structured process used to identify and prioritize risks by ranking them based on severity, occurrence, and detectability. Historically FMEAs have been used to identify risks within industry such as automotive and space programs.

What is added by this report? This project explored how the Failure Modes and Effects Analysis (FMEA) evaluation template can be adapted to a public health program designed improve asthma outcomes. Risks within the Breathe Easy at Home process were identified and prioritized based on severity, occurrence, and detectability to apply FMEA to a public health program.

What are the implications for public health practice, policy, and research? The FMEA process can be adapted to a public health systems evaluation framework in order to prioritize areas for improvement.

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Table 1: Actions to Address Failures sorted by Risk Priority Number (RPN). RPN is the total of Severity X Occurrence X Detectability.					
Action Taken	Failures Addressed	Severity	Occurrence	Detectability	SxOxD
Improve Health Care Staff Education	Staff must know of housing conditions	3.5	4	2	42
	Staff must be aware of BEAH	3	3	3	27
	Staff must clearly explain BEAH	2	4	3	24
	Staff must address parent concerns	3	2.5	3	22.5
	Healthcare site must be registered to refer to BEAH	3	2	3	18
TOTAL RPN		14.5	15.5	14	133.5
Improve Parent of Asthmatic Education	ISD Admin must reach family by phone	2.5	4	1	10
	Adult must be home to let inspector in	2.5	4	1	10
	Parent needs to consent	2.5	3.5	1	8.75
	Client needs to recognize inspection done	2.5	3	1	7.5
	Health Care staff must address parent concerns	3	2.5	3	22.5
	Staff must clearly explain BEAH	2	4	4	24
	Parents must give referral permission	3	1	1	3
TOTAL RPN		21	25.5	11	121.75
Change Inspectional Services Department Contact Protocol	Adult must be available for inspection	2.5	4	1	10
	Adult must be home to let inspector in	2.5	4	1	10
	ISD Staff must have correct information	1.5	4	1	6
	ISD admin must know about referral	3	2	3	18
TOTAL RPN		15	22	10	90
Changes to Breathe Easy at Home Website	ISD Admin must reach family by letter	3	4	3	36
	ISD Admin must reach family by phone	2.5	4	1	10
	ISD Staff must have correct information	1.5	4	1	6
	Adult must be home to let inspector in	2.5	4	1	10
	ISD admin must know about referral	3	2	3	18
	ISD Staff must log in to working system	2	2	1	4
TOTAL RPN		14.5	20	10	84