Contribution Analysis of a Complex System During Disruptions[1]

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Abstract: *The U.S. National Institute of Occupational Safety and Health (NIOSH) supports 11 regional centers to conduct research and outreach in agriculture, fishing, and forestry. The Southwest Center for Agricultural Health, Injury Prevention, and Education serves Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. The 2016–2022 evaluation used contribution analysis since it is effective in evaluating complex systems with diverse stakeholders and multiple projects, with partners working toward the same outcome over time. The evaluation responded to the disruptions in program implementation caused by the COVID-19 pandemic and to NIOSH modifications to key elements of contribution analysis procedures.*

Keywords: *occupational safety and health, agricultural health and injury prevention, COVID-19, evaluation practice*

Résumé : *Le U.S. National Institute of Occupational Safety and Health (NIOSH) soutient 11 centres régionaux pour mener des recherches et des activités de sensibilisation dans les domaines de l'agriculture, de la pêche et de la foresterie. Le Southwest Center for Agricultural Health, Injury Prevention, and Education dessert l'Arkansas, la Louisiane, le Nouveau-Mexique, l'Oklahoma et le Texas. L'évaluation 2016–2022 a utilisé l'analyse des contributions, car elle est efficace pour évaluer des systèmes complexes avec diverses parties prenantes et plusieurs projets, avec des partenaires travaillant vers le même résultat au fil du temps. L'évaluation a répondu aux perturbations dans la mise en œuvre du programme causées par la pandémie de COVID-19 et aux modifications apportées par le NIOSH aux éléments clés des procédures d'analyse des contributions.*

Mots clés : *santé et sécurité au travail, santé et prévention des blessures en milieu agricole, COVID-19, pratique d'évaluation*

The objective of this article is to present a case example of program evaluation using Contribution Analysis (CA). As such, it expands the published applications of CA and, hopefully, informs the challenges of applying CA (Dybdal et al., 2011; Lemire et al., 2012). Furthermore, the program(s) evaluated involved public health

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interventions, so the article illustrates the practical application of CA to address behavioural change (Michie et al., 2011). With this objective in mind, the article has been divided into six sections. The first section provides the context of the evaluation in terms of the funding agency and describes the first disruption caused by the COVID-19 pandemic. In the second section, the program evaluated—the Southwest Center for Agricultural Health, Injury Prevention, and Education (SW Ag Center)—is fully described. The third section describes how the CA used in the evaluation (Mayne, 2008, 2011, 2012a, 2012b, 2015, 2017, 2018a, 2019) differs from that promoted by the funder and, subsequently, reveals the second disruption. The fourth section details the response to the two disruptions: (a) how program implementation changed because of the COVID-19 pandemic and (b) how the evaluator (author) altered the CA to align with the funder's concept of CA. The latter is the case example, with details of the CA, including the key modifications made in response to the disruption. The fifth section offers a discussion of the disruptions and the overarching responses to them, with key lessons learned using CA that may render it more operational for evaluators. Finally, in conclusion, the sixth section notes signature features of the evaluation that reflect upon the SW Ag Center and, therefore, the quality of the evaluator's experience.

CONTEXT OF THE EVALUATION

The funding agency, the National Institute of Occupational Safety and Health (NIOSH), is an extramural program of the Centers for Disease Control and Prevention (CDC, 2014). NIOSH is federally funded annually in 5-year cycles to support research and education programs in occupational safety and health to promote agriculture, forestry, and fishing (AgFF) worker health and safety and improve workplace conditions to prevent illness and injury. NIOSH invests resources in 11 Agricultural Safety and Health Research Centers (Ag Centers) in furtherance of their agenda. Each Ag Center re-competes for NIOSH funding every 5 years. It is even more important that Ag Centers must demonstrate their efforts are evidence-based and contribute to the NIOSH mission of improving AgFF worker occupational health and safety.

In the 2016 proposal application request (for the 2016–2021 cycle), applicants were required to implement components covering (a) Administration, Planning, and Evaluation; (b) Research Projects; and (c) Outreach Education. Research projects were categorized as Research, Education/Translation, Surveillance, or Prevention/Intervention. Importantly, although the program announcements listed evaluation as one of the required administrative components, NIOSH did not provide substantive direction as to how the evaluation should be conducted.

Disruption: Global Pandemic

Early in the second quarter of Year 4 of the funding cycle, specifically 31 January 2020, the U.S. secretary of health and human services and the World Health

Organization (WHO) declared the novel SARS-CoV-2 virus a public health emergency. Officially named COVID-19 by the WHO in February 2020, the novel coronavirus outbreak was declared a pandemic on March 11, 2020. The CDC's incident manager, Dr. Nancy Messonnier, predicted "the disruption to everyday life may be severe" (CDC, 2023a), and by mid-March 2020, a U.S. national emergency was declared and states began to shut down to prevent the spread of COVID-19. Travel restrictions and social distancing mediation strategies were put into effect, and most states practiced those for at least a month. By May 2020, most states began phased reopening despite health experts warning it was too early. Cases and deaths continued to surge through the winter of 2020. The U.S. Food and Drug Administration granted emergency use authorization for the first of several COVID-19 vaccines in December 2020 with a roll-out to older adults and at-risk groups well underway early in 2021.

SW AG CENTER

The SW Ag Center was created in late 1995 at the University of Texas Health Northeast to serve Arkansas, Louisiana, New Mexico, Oklahoma, and Texas through research and outreach aimed at reducing injuries and fatalities among AgFF workers and their families. The mission of the SW Ag Center is to improve the safety and health of AgFF workers through research, intervention, and education projects. These projects build and leverage a network of strategic partners who represent the diversity of the workforce and the range of agricultural production in the region.

Although NIOSH did not require the use of logic models for program planning and evaluation, the SW Ag Center routinely incorporated them in the program development and evaluation process (Newbill et al., 2017). This process helped articulate the connection between the Center's goals and NIOSH objectives and ensured that the program components (e.g., Administration/Planning/Evaluation, Outreach, Research Projects, and Feasibility Studies) supported the Center's goals. As a result, within the SW Ag Center, the set of logic models is analogous to a family tree: centre-wide (parent), programmatic cores (children), and research projects (grandchildren).

For the 2016–2021 funding cycle, the SW Ag Center initiative supported the required components and an optional component of Feasibility/Pilot Studies/Emerging Issues (hereafter referred to as Feasibility Studies). The SW Ag Center maintained a professional administrative staff dedicated to Center operations. The director (PhD, full-time equivalent [FTE] = 56%), University of Texas, Tyler Health Sciences Center (UT, Tyler) faculty, provided oversight of key Center operations and represented the Center at the federal level; the program director (MBA, FTE = 85%) coordinated programs across the Center and with UT, Tyler Office of Sponsored Projects and actively collaborated with other Ag Centers and NIOSH in cross-centre projects; the outreach education coordinator (MPH, FTE = 85%) designed and lead activities to promote the marketing,

production, and dissemination of educational outreach products across various platforms; the Feasibility Studies director (PhD, FTE = 8%) sought and coordinated pilot studies of emerging issues conducted by new researchers. Also, the Center was guided by an External Advisory Committee (EAC) and an Internal Advisory Committee (IAC), which represented expertise in AgFF from each of the states served by the SW Ag Center.

Eight university-based Research Projects representing basic science, translation, intervention, and surveillance were funded for the 2016–2022 cycle, and each project was evaluated individually. Nineteen Feasibility Studies/Emerging Issues, composed of field-based studies of 1–3 years' duration across a variety of topics relevant to AgFF in the region, were evaluated as a block. The required components and the many diverse, multidisciplinary evidence-based research projects created a complex system of interrelated programs administered by the SW Ag Center that were evaluated using CA following John Mayne.

CA OF THE SW AG CENTER

Although a familiar approach to evaluation in Canada and Europe, CA is far less common in the United States. CA is especially suited to evaluating programs, like the Ag Centers, with multiple projects and partners working toward the same outcomes over a prolonged period (Patton, 2012). So it was a welcomed surprise when NIOSH held an online workshop on CA in June 2017 that followed the work of John Mayne (Avalos, 2017). Briefly, CA focuses on determining the contributions of a program to observed outcomes quite differently from that of finding cause in a random controlled trial. Contribution analysis aims to show a plausible, verifiable association between X and Y, not that X causes Y. Specifically, according to Mayne (2011),

> whether a reasonable person would agree from the evidence and argument that the program has made an important contribution to the observed result. (p. 62)

CA is an iterative process conducted following the steps outlined in many of Mayne's publications since 2001. The first critical step is setting out the attribution problem, which Mayne calls the intervention statement with supporting factors. These latter establish the assumptions—the causal links—required for the intervention to occur and provide the evidence for the contribution claims. Mayne (2019) shows that the best way to set out the attribution problem is to create a causal package to include an intervention *and* supporting factors/theory-of-change (TOC) assumptions that are sufficient to produce the intended outcomes. If the assumptions hold, contribution claims are justified, the intervention is determined to be a contributory cause, and a claim of impact can be made.

Subsequent to the NIOSH CA workshop and during the SW Ag Center annual advisory board meeting in 2017, the author proposed using CA for the

evaluation. The proposal was accepted immediately, and SW Ag leadership and Research Project principal investigators (PIs) dedicated several hours during the session to develop the SW Ag Center Intervention Statement, with seven supporting assumptions. The assumptions were grounded in the intervention ToC that establishes the program effects and assumptions behind those effects regarding how program activities contribute to intended outcomes (Mayne, 2011, 2012). The following intervention statement was adopted: *The SW Ag Center intervention aims to improve the safety and health of AgFF workers through 1) sponsoring original multi-disciplinary research, intervention, surveillance, and translation projects to identify and reduce risks relevant to AgFF and 2) raising awareness of safety and health practices among AgFF workers, business owners, and communities through an evidence-based outreach program.*

SW Ag Center supporting assumptions were:

1. [Sufficient] Funding for research and outreach initiatives.
2. Willingness of AgFF stakeholders to a) engage/participate and b) implement/adopt recommended, evidence-based practices.
3. Willingness of community-based champions to support Center research, outreach, and awareness campaigns.
4. Capacity of SW Ag Center to contribute to the development of educational resources that are accessible and adoptable.
5. Capacity of SW Ag Center to engage AgFF researchers in Center initiatives and in mentorship relationships.
6. Ability of SW Ag Center to identify and scientifically consider emerging issues in AgFF.
7. Ability of SW Ag Center to expand its sphere of influence through strategic partnerships.

Data collection proceeded iteratively along a ladder of evidence documenting what, where, and among whom intervention effects were observed. Critically, expectations of how observations are linked to effects were guided by assumptions integral to the ToC. This ladder of evidence, with causally linked assumptions, is the ToC. The analysis of the data collected to assess program effects led to understanding how and why the intervention contributed to program goals and objectives (Mayne, 2019). The evaluation ToC evolved into the Capability, Opportunity, Motivation and Behaviour (COM-B) model (Mayne, 2019; Michie et al., 2011) and then was further modified in 2020 in response to the NIOSH changes described next (see Figure 1).

Disruption: NIOSH Modifications to CA

As implied earlier, NIOSH required evaluation as a component of funding but did not provide guidance on how to conduct one. Unexpectedly, in late 2019, NIOSH raised the idea of an "Evaluation Capacity Building" initiative (CDC, 2023b), and all 11 Ag Centers were required to participate through the

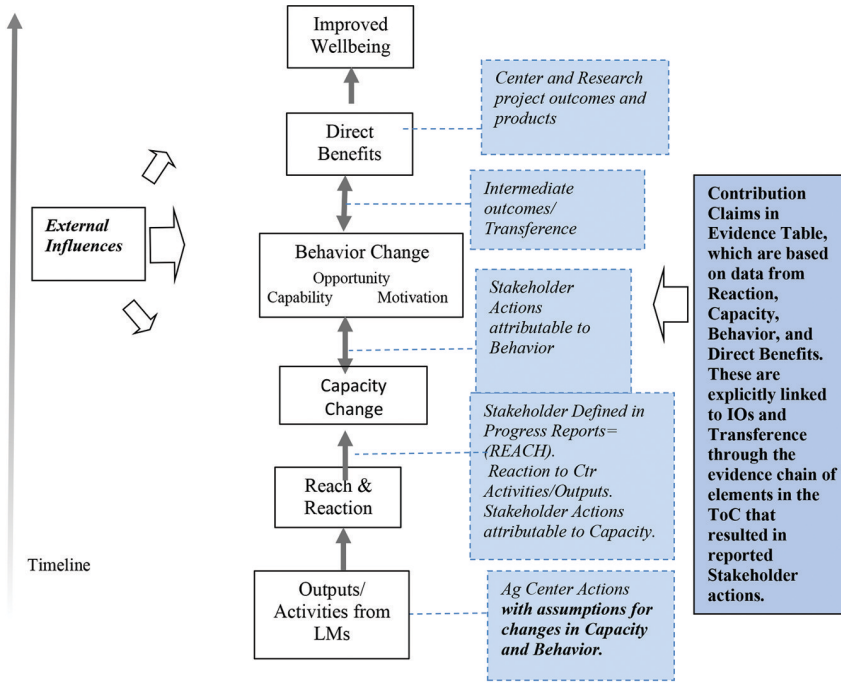

Figure 1. The COM-B-based theory of change with alignment to National Institute of Occupational Safety and Health Agricultural Safety and Health Research Center contribution analysis (right two columns)

Evaluation, Coordination, and Outreach group (ECO) each Center maintained to support cross-centre outreach primarily. The NIOSH approach used CA in a version approximating Mayne (see Downes et al., 2019, Figure 2) to assess cross-center topics (e.g., heat-related illness and tractor safety) that were part of national campaigns to promote AgFF worker health, in which most Centers had some experience either through outreach or research. The SW Ag Center was using CA in its evaluation but was the only Center doing so. Also, most Ag Center evaluators did not have experience with or were using CA in evaluation so had not created intervention statements "setting out the cause-effect issue to be addressed" as claimed by Downes et al. (2019, p. 4). NIOSH held a virtual meeting in March 2020 since in-person meetings were cancelled due to pandemic travel restrictions. Unexpectedly, the NIOSH CA had key modifications to accepted practice. Most critically, the intervention statement with assumptions was omitted and logic models replaced the ToC. These are necessary elements and without them, the NIOSH CA is not recognizable as CA. Furthermore, logic models are weak ToCs since the intervention assumptions linking activities and outputs and outputs to intermediate outcomes are missing (John Mayne, personal communication, October 2020). A highly detailed logic model, with causal

link assumptions that are the key to CA and needed for monitoring and evaluation (M&E), might work (see Patton, 2012). This idea was explored in the evaluation of the SW Ag Center, and is detailed next in presenting responses to the disruptions: first, the COVID-19 pandemic and then the NIOSH changes to CA.

RESPONSES TO THE DISRUPTIONS

SW Ag Center Response to the Global Pandemic

Responses to the pandemic began in January 2020/Year 4 and persisted through the end of the funding cycle in September 2022. NIOSH (a branch of the CDC) and Ag Centers across the nation responded by following federal public health guidelines. As previously noted, Ag Centers concentrate efforts on outreach and research. Outreach typically happens through evidence-based educational materials and products disseminated at regional and local AgFF venues. Most research projects are field- or community-based observational studies lasting 2–5 years. All that changed in 2020 in the federally mandated response to the COVID-19 pandemic. Universities shuttered, travel was restricted, and virtual meetings became the norm. Data collection across research projects was halted. Outreach efforts, typically done face-to-face, moved to digital and virtual presentations. NIOSH urged Ag Centers to divert outreach efforts and resources to COVID-19 awareness, education, and response among AgFF workers. The SW Ag Center improved, expanded, and enhanced digital technologies during the shutdown. Research projects (including Feasibility Studies) sponsored by the SW Ag Center stopped per federal mandates and then restarted with the reopening of the country. The greatest lasting impact was to the ongoing recruitment of subjects needed to fulfill study protocols and data collection for those projects slated to begin in Year 4. Easing of travel restrictions, re-opening of universities, and availability of vaccines provided unique opportunities and revealed the nimbleness of the Center and PIs. For example, some field-based research projects, with the support of the SW Ag Center, set up community vaccination clinics in their study site when contact was permitted, and data collection renewed. NIOSH, with a clear understanding of the inability of Ag Center researchers to finish their projects in the 5-year cycle, provided funding to all Ag Centers for 1 additional year of funding. By late Year 6, all projects had completed planned activities and accomplished specific aims.

Evaluation Response to the NIOSH CA: The Case Example

The SW Ag Center evaluator (author) tried to be responsive to the NIOSH's capacity-building plan as much as possible while retaining the integrity of CA. The author has considerable experience with logic models so could see a way to meld accepted practice using CA and the NIOSH approach that was outcome-driven. Toward this end, the ToC was modified to insert the language of logic models (outcomes) and the language of CA (assumptions). Additionally, data were aggregated into an Evidence Table advanced by NIOSH, with the modification that linked observed evidence to the intervention-supporting assumptions. This turned the

Evidence Table into the familiar evaluation matrix designed to order, describe, and explore data (Miles et al., 2014). NIOSH used the language of "Evidence Table," so it is retained here. The responses to NIOSH are detailed thoroughly to present the case example of the CA of the SW Ag Center and remark on improvements to the CA process for evaluating the science impact proposed by Downes et al. (2019).

As stated earlier, the spine of CA is ToC, which is a chain of evidence and assumptions supporting why the intervention is expected to produce stated outcomes and impacts. Following Mayne (2008, 2017), data target rungs in the ToC are the building blocks in the chain, and the ladder of evidence for the intervention is Reach, Reaction, Capacity Change, Behaviour Change (embedding Capability, Opportunity, Motivation), Direct Benefits, and Impact (Figure 1 left half). If the evidence supports the theory of change, then it is reasonable to assume the program contributed to impact and a contribution claim justified (Mayne, 2008, 2011, 2012a, 2012b, 2015, 2017, 2018a, 2019).

NIOSH (Avalos, 2017) offered examples of acceptable evidence in a CA: program records, stakeholder perceptions, and literature. The list suggests a variety of methods and sources that may be used as evidence. Table 1 presents the data gathered for the CA by TOC component and time in the evaluation cycle. As implied in Table 1, a CA is data-dense, which is understandable and necessary given the intent of attributing "cause" in the absence of experimental conditions. Sources of data were SW Ag Center administration, Research Project PIs, and various stakeholder groups, some of whom emerged during the 6-year cycle (e.g., Extension Agent Advisory Group, Strategic Partners). Data collection events followed the timeline presented the data matrix in Table 1. Details by source were as follows:

- PIs: To reduce the time burden on PIs, most data needed from the evaluation/CA were collected through reporting requirement events established by the SW Ag Center (e.g., annual Progress Reports, IAC quarterly meetings, and annual Advisory Board meetings). By Year 3, reports were standardized and included queries needed for the CA. This coordination of data collection remarks well on the partnership between the external evaluator and the SW Ag Center, and the responsiveness of the administration to evaluation needs and findings, as well as PI time demands. Recall that all PIs were university faculty with the routine demands for career advancement. Only the Challenge Assessment in Year 1 was an extra demand, which was soon replaced by queries in required annual reports.
- Non-PI Stakeholders: perception surveys and polls.
- Evaluator Activities: Case studies; perception survey/poll instrument development and implementation; data analysis and report preparation for routine meetings (IAC and Advisory Board annual meetings).

Figure 1 shows the alignment of NIOSH CA melded with a ToC with a logic model concept. The latter had outcomes (short, intermediate, and long

Table 1. Data collection matrix

Theory of Change	Methods & Sources	When
External Influences	1. Challenges Assessment 2. Monitoring of external events that may have a demonstrable influence on outcomes	1. Beginning/end of each year 2. Ongoing
Reach & Reaction	1. Contact database 2. Research & Feasibility Projects new collaborations lists 3. Center Portfolio 4. OutREACH log 5. Social media data sweeps including comments 6. See all capacity data & sources	1. Ongoing 2. Progress Reports (Yr 3+) 3. 2015 to present 4. 2016 to present 5. Periodic (discontinued after Year 2)
Capacity = Immediate/ Short-Term Outcomes	1. Needs assessment 2. New partners in contact database 3. Stakeholder perception survey follow-up from needs with a focus on contribution (materials and skills) & change 4. Ag Extension agent poll 5. Case studies of Research Projects & Feasibility Studies Program short-term/immediate outcomes in respective logic models	1. Nov.–Dec. 2017 2. Ongoing 3. Year 2 (Time 1) and Year 5 (Time 2) 4. Jan. 2020 (Year 4) 5. 1–2 yr + annual NIOSH required Progress Reports for Center Admin, Outreach, Research Projects, and Feasibility Studies
Behavioural Change = Intermediate Outcomes	1. Stakeholder perception survey follow-up from Yr 2 with focus on contribution (materials and skills) & change. 2. Ag Extension Agent Poll 3. Interview Research Project partners and Feasibility study PIs re: career experience, skills gain/ improvement 4. Case studies of Research Projects & Feasibility Studies Program	1. Yr 4 cycle (Time 2) 2. Jan 2020 3. Exit interviews 4. 3rd+ year of implementation Annual NIOSH required Progress Reports for Center Admin, Outreach, Research Projects, and Feasibility Studies.

Table 1. (Continued)

Theory of Change	Methods & Sources	When
	intermediate outcomes in respective logic models	
Direct Benefits of Intervention = Long-Term Outcomes	Case studies of Research Projects & Feasibility Studies Program intermediate/long-term outcomes in respective logic models	3rd+ year of implementation Annual NIOSH required Progress Reports for Center Admin, Outreach, Research Projects, and Feasibility Studies

Note. NIOSH = National Institute of Occupational Safety and Health; PI = principal investigator.

depending on the style) yet lacked assumptions for linking activities to outcomes that are necessary in accepted practice using any theory-based evaluation especially that of CA. A descriptive list of the components shown in Figure 1 as relevant to the CA of the SW Ag Center is as follows:

1. Activities/Outputs—These were the distinct types of implementation activities and expected outputs undertaken by the SW Ag Center and Research Projects as depicted in their respective logic models. NIOSH did not require logic models prior to the 2022 funding cycle. Regardless, the SW Ag Center had employed and trained its researchers in logic model use for decades. Each Research Project was required to create a logic model consistent with that of the SW Ag Center during the application process. Therefore, the logic model framework provided a cohesive, hierarchical approach to program planning, implementation, and monitoring (Newbill et al., 2017). Routine M&E of research projects and administrative cores during the program evaluation captured the challenges to completion (i.e., external influences).
2. Reach and Reaction—This rung comprised the stakeholder groups and their reaction to the intervention. Exactly *who* a stakeholder was varied across Research Projects (e.g., logging producers, shrimp fishers, and organic farmers) and Center targets across the region (e.g., Extension Agents, trade associations, and industry events). Stakeholder reaction evolved during the funding cycle to conform to NIOSH's CA to be *stakeholder actions* in response to Ag Center initiatives.
3. Capacity Change—Logically, a change in capacity leads to a change in behaviour. Capacity was assessed through measures of knowledge, attitudes, and perceptions with added questions around motivation and intentions; and through responses to opportunities to increase capacity (e.g., Outreach efforts supported by the Center and through community-based connections made by Research PIs).

4. Behaviour Change—The "COM" was nested within Behaviour Change illustrating the reliance on measures of Capability, Opportunity, and Motivation in interpretations of behaviour change (Mayne, 2018b, 2019; Michie et al., 2011). Behaviour change (both individual and workplace) was the greatest evidentiary challenge to the Ag Center evaluations. Observed changes in COM provided the evidence for credible interpretations of behaviour change. More succinctly, behaviour change was the combination of observed capabilities, motivation, and opportunities, and all interact with Capacities (discussed earlier) that may change with time.
5. Direct Benefits—Tangible, intermediate outcomes (IOs), to include transference of research findings to practical use (i.e., signage, fact-sheets, workplace change) and statements of benefits made by stakeholders.
6. Safety and Health Impacts—NIOSH stated the impact for the Ag Centers and was a long-term outcome not expected to be measured in 5-year cycles. Impact was not evaluated.

The Evidence Table and Contribution Claims

One of the challenges in using CA is organizing and ordering the vast amount of data collected and needed to make claims of attribution. The added challenge was melding CA's ToC change processes with logic model activities and outcomes. This was done using the evidence table formatted to report evidence of outputs and outcomes from program implementation activities for each level of the ToC (Table 2).

The table shows all evaluation data determined to be evidence for each ToC component, the source of the data, and the intervention assumption(s) supported by the evidence contribution claim. Essentially, the lines of evidence of program outputs and outcomes were linked to one or more of the seven intervention assumption(s) to establish contribution. Also, the process of constructing the evidence table afforded the opportunity to accomplish another key step in applying CA: create linkages to potential influential factors and discover, and then fill in, the gaps (Dybdal et al., 2011; Lemire et al., 2012). Table 2 is an abbreviated version of the evidence table built for the CA of the SW Ag Center. The full evidence table has over 35 unique data points (Newbill, 2022). A few notes that may help navigate the table include the following:

- Reach and Reaction evidence had a circular pathway that began with the SW Ag Center outreach of programmatic content and the reaction of stakeholders (who were reached) to that content and then the response of the SW Ag Center to stakeholder reactions.
- Capacity change occurred among both stakeholders and the SW Ag Center. For example, the involvement of regional Extension Agents as a

Table 2. Evidence table (abbreviated)

Theory of Change Level	Evidence	Sources	Contribution Claim: Linkage to Assumptions
REACH & REACTION	1. Advisory board composed of Extension Agents in the region created (2020) in response to Extension Agent Poll in which 62% had not heard of the SW Ag Center. Routine, virtual meetings are held.[a] 2. Outreach materials box mailed to Extension Agents in response to Ext Agent Poll asking *What resources would be helpful to you to promote the health and safety of producers on ag operations? Ag operations—the workplace?* 3. Dissemination of NIOSH- and SW Ag Center–sponsored research through education outreach materials, presentations, and workshops. 4. Outreach efforts aligned with needs assessment conducted early in the cycle (Oct.–Nov. 2017). 5. Outreach efforts persist through COVID-19 disruption through expanded use of digital and virtual technologies.	Admin, Eval Ext Agent Poll Admin OutREACH log Eval Needs Assmt; OutREACH log; Center Portfolio OutREACH log	Assumptions 1, 3, 4, 6, & 7 • All below: Interacts with Capacity and Direct Benefits-Transfer/Translation
	6. Feasibility study PIs engage new researchers in mentored projects, either graduate student or faculty collaborations.	Feasibility Projects Annual Update Reports	Assumptions 1, 5 & 7
CAPACITY CHANGE	7. Feasibility studies sponsor new researchers, who are often young scholars (new graduates or PhD candidates) or involved in such projects. [Stakeholder change] 8. Some feasibility projects involve emerging issues in AgFF. (Both Stakeholder & Center change)	Feasibility Projects Annual Update Reports	Assumptions 2, 4, 5 & 6 • Interacts with REACH and DIRECT BENEFITS
	9. Student participation in Research Projects, Feasibility Projects, and SW Ag Center internships leads to career/educational advancement. (Stakeholder) 10. Outreach materials box mailed to Extension Agents in response to Ext Agent Poll noted 3. (Both Ctr & SH) 11. Information sharing, expanding partnerships to include collaboration with the Texas Department of Agriculture, the Texas Farm Bureau, and NIOSH Regional ERC. (Both Ctr & SH)	Center Portfolio, incl Bibliography Admin; Eval Admin	Assumptions 1, 3, 4, 5, 6 & 7 • Interacts with REACH & REACTION and DIRECT BENEFITS Assumptions 3, 4, & 7

(*Continued*)

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Table 2. (Continued)

Theory of Change Level	Evidence	Sources	Contribution Claim: Linkage to Assumptions
	12. The Administrative Core and Outreach and the Research PIs provide updates to the program through annual progress reports submitted to NIOSH per funding requirements. (Both Ctr & SH) 13. Most Research Projects add data to respective fields to further research. Several Research Projects advance methods and data collection technologies in field settings through demonstrated success of use (logging, shrimp fishing, transportation AgFF-related accident surveillance). (Both Ctr & SH) 14. All Research Projects and Feasibility Studies create and/or promote with Center support effective approaches and strategies for communicating findings and potential impact of findings with target audiences. (Both Ctr & SH).	Admin; Eval Eval CA	Assumptions 1, 2, 4 • Interacts with Behaviour/Workplace Change • Interacts with DIRECT BENEFITS
BEHAVIOUR/ WORKPLACE CHANGE	15. Trends in Health and Safety Issues Reported by Extension Agents reported between Jan 2020 (Poll) and March 2021 (Time 2 Survey) find fewer agents responding "don't know" or "don't hear" when asked *What are the main health [safety next questions] you hear about from producers/workers in your area*. 16. Trend in stakeholder respondents' perceptions of the contribution of SW Ag Center resources to behaviour and workplace environment change increased substantially from the Time 1 Survey in 2018.	Eval Time 2 Survey Analysis and Trend Study	Assumptions 2, 3 & 7 • Interacts with DIRECT BENEFITS/IO
DIRECT BENEFITS			
Transfer/Translation	17. Dissemination of research results by students and PIs in professional meeting, publications, presentations, workshops, webinars, etc. 18. Center actively pursuing "research to outreach" initiative by engaging, encouraging, and supporting PIs in creation of outreach product based on their research project.	Center Portfolio, Outreach log	Assumptions 4, 6 & 7

(*Continued*)

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Table 2. (Continued)

Theory of Change Level	Evidence	Sources	Contribution Claim: Linkage to Assumptions
Intermediate Outcomes	19. Overall, the trend in perceptions of the SW Ag Center in effectiveness and resource value/use was up. The increase in the value of resource materials among respondents is attributed to gains in Disseminate and Both Use and Disseminate, as well as a decline in the proportion of respondents who found nothing of value to use or disseminate. 20. As of May 2022, all Research PIs with 3–5-year funded projects have completed all anticipated IOs, with most adding the creation of outreach material as appropriate. 21. Opportunity for dairy workers to receive COVID-19 vaccine (unintended outcome of Feasibility Project). 22. Opportunity for Vietnamese shrimp fishermen to receive COVID-19 vaccine and health clinic (unintended outcome Research Project in Galveston and RGV communities).	Eval CA; Feasibility Project Update; Research Project update	Assumptions All 7

Note. NIOSH = National Institute of Occupational Safety and Health; SW Ag Center = Southwest Center for Agricultural Health, Injury, Prevention, and Education; PI = principal investigator; AgFF = agriculture, forestry, and fishing; ERC = education and research centre; Ctr = SW Ag Center; SH = stakeholder; CA = contribution analysis; IO = ; RGV = Rio Grande Valley in Texas.

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leadership and advisory body to the SW Ag Center increased the capacity of both agencies.
- Behaviour change was narrowly awarded so the contribution claims are conservative. Specifically, change was attributed to shifts in perception over time as found in the Time 1 and Time 2 stakeholder perception surveys.

The evidence table is the bulwark of the contribution story yet is rather overwhelming. Table 3 distills it into If/Then logic statements (Hempel, 1966) of illustrative examples for intervention aims and assumptions. To mirror the form of logical argument (If p, then q), a To/By form is adopted here: The SW Ag Center efforts contributed TO (intended outcome)/BY (evidence of contribution). The "TO" statements are the SW Ag Center intervention aims and assumptions, and the evidence table (Table 2) supplies the "BY." The most explanatory and illustrative TO/BY findings are in Table 3.

Contribution Story

Credible contribution stories made from "causal" claims may assume many forms (see especially Mayne, 2008, 2012a, 2012b, 2015, 2018a). Yet, regardless of form, they must relate why it is reasonable to assume that program activities have contributed to observed outcomes. To provide a narrative of the illustrative evaluation findings in Table 3, the contribution story is written through the eyes of the SW Ag Center, with its dual emphasis on supporting original research and translating AgFF research into practical, educational outreach products. Also, what matters in the COM-B-based ToC are changes in capacity and behaviour (personal and workplace) so those are emphasized here.

NIOSH AgFF funding was maintained throughout a 6-year cycle, which included 1 additional fully funded year due to the disruptions to implementation caused by the global pandemic. Administration at both the SW Ag Center and within the university grants management office demonstrated uninterrupted support for 8 Research Projects, 19 Pilot/Feasibility Studies, and an array of Outreach initiatives. Funds supported the key components to improving health outcomes in AgFF workers: Research/Pilot studies and Outreach education. These two components are detailed separately next, with Research first since it is translated into educational outreach in the pathway to contribution. Each narrative includes evaluation findings from select projects that indicate changes in capacity and behaviour critical to verifying the ToC.

Research

Most of the research studies were conducted within communities, with one laboratory-based and another involved secondary data analysis. Community-based studies (e.g., shrimp fishermen, loggers, migrant workers, organic farmers) succeeded with industry support (i.e., access to sites) and with voluntary participation of local community leaders (e.g., recruitment and field-based data

Table 3. Illustrative Contribution Claims by Intervention Aims and Assumptions

Contributed TO/Outcome	BY/Evidence
Intervention Aims	
Sponsor original multidisciplinary research, intervention, surveillance, and translation projects to identify and reduce risks relevant to AgFF.	Admin core activities demonstrated uninterrupted support for 8 Research Projects and 19 Feasibility Studies. Projects represented the array of types: Basic/Etiologic, Surveillance, Intervention, and Translational. Annual progress reports submitted by Core projects demonstrated the accomplishment of specific aims, outputs, intermediate outcomes.
Raise awareness of safety and health practices among AgFF workers, business owners, and communities through an evidence-based outreach program.	Outreach Core activities sustained with pivot to virtual and digital in response to pandemic travel restrictions and uneven re-opening across the 5-state region. Stakeholder perception survey trend analysis found increased effectiveness, use and value of resources distributed by the SW Ag Center. R2p show transfer of often obtuse research findings to accessible materials that enable practical use.
Intervention Supporting Assumptions	
1. [Sufficient] Funding for research and outreach initiatives.	NIOSH funding maintained throughout 6-year cycle, which included 1 extra year fully funded due to the pandemic. Administration, with support of University Grant Management Division, highly proficient in adhering to operational budget, and in monitoring and coordinating expenditures.
2. Willingness of AgFF stakeholders to (a) engage/participate and (b) implement/adopt recommended, evidence-based practices. 3. Willingness of community-based champions to support Center research, outreach, and awareness campaigns.	Stakeholder perception survey trend analysis found increased awareness of worker/workplace safety and health practices and use of resources to improve such practices. SW Ag projects became a catalyst to improvement in access to: • health services: Docside clinic in Galveston, TX/RGV area; pop-up COVID-19 vaccination opportunities co-occur with start-up data collection; logging industry awareness of need to reduce

(*Continued*)

Table 3. (Continued)

Contributed TO/Outcome	BY/Evidence
	musculoskeletal stresses created during mechanized work. • safety measures: shrimp fishers value and use of personal floatation device; state departments of transportation expansion and use of AgFF accident surveillance methods. Community-based projects (e.g., shrimp fishermen, loggers, migrant workers, organic farmers) succeeded with industry support (access to sites) and due to participation of local community leaders (recruitment and field-based data collection).
4. Capacity of SW Ag Center to contribute to the development of educational resources that are accessible and adoptable.	Research project PIs required to create "research to outreach" product, with active support of SW Ag Center Outreach coordinator. Center portfolio presents the volume and venues of the professional contributions made during the 2016–2022 cycle. The provost report provides an overall summary of Center accomplishments.
5. Capacity of SW Ag Center to engage AgFF researchers in Center initiatives and in mentorship relationships.	8 multi-year, university-based research projects were funded, of which 2/3's supported graduate work leading to advanced degree. All 19 Feasibility/Pilot studies were mentored.
6. Ability of SW Ag Center to identify and scientifically consider emerging issues in AgFF.	Feasibility/Pilot Studies program (not mandatory) implemented, with dedicated PhD level faculty as coordinator. 19 projects on emerging issues in AgFF sponsored; all new researchers who were mentored by senior researcher.
7. Ability of SW Ag Center to expand its sphere of influence through strategic partnerships.	Center staff and PIs defined strategic in Yr. 6 at the request of the evaluator and provided list of current strategic partners.

Note. AgFF = agriculture, forestry, and fishing; SW Ag Center = Southwest Center for Agriculture Health, Injury Prevention, and Education; R2p = research-to-practice; NIOSH = National Institute of Occupational Safety and Health; RGV = Rio Grande Valley in Texas; PI = principal investigator.

collection). These projects became a catalyst for regional improvements in safety measures (capacity) and access to and utilization of health services (behaviour). For example, a pilot study with migrant shrimp fishers originally looked at slips, trips, and falls as major reasons that shrimp fishers experience fatal or non-fatal injuries. Yet, in talking to them, the PI learned that many shrimpers did not have access to primary health care. The study resulted in the Docside Clinic initially intended to be a one-time effort, but the need was so great it now occurs monthly. Currently, the clinic brings medical professionals to the docks to provide primary health care, such as check-ups, COVID-19 vaccinations, and an array of health screenings. A shrimper said, "Yes. You [Docside clinic] changed a lot. . . .I just hope you continue to come every month. I just hope that when I come and need anything, there's a doctor that can help me. That way at least something, there's a doctor on location that would help me a lot. Easy to talk to, access." Notably, because of the improvements achieved in the pilot study, the CDC awarded the PI funds for a 5-year, multi-site research project (2023–2028) to address health disparities in migrant fishers in the Gulf Coast of Texas and Louisiana.

Another example is the research project involving secondary data analysis of Texas Department of Transportation data on fatal and nonfatal crashes involving AgFF equipment in Texas roadways. Evaluation findings indicated that the study developed a model protocol that was adopted by State Departments of Transportation in the 5-state region. The analysis evolved into the SW AgCrash project, which currently supports standardized injury surveillance practices to identify injury risk factors and promotes transportation safety across the region.

Outreach

The evaluation found that outreach activities were sustained effectively with a pivot to virtual and digital platforms in response to pandemic travel restrictions and uneven re-opening across the region. It is worth noting that, at maximum, only three or four SW Ag Center administrators routinely performed outreach events. The content strategist (formerly titled outreach coordinator) completed most events alone or with the program director. Outreach events were conducted at both professional (e.g., conferences, trade associations, AgFF training events and conventions) and community venues (e.g., county extension events, state fairs, and local producers). Outreach materials (English and Spanish language) included monthly newsletters, fact sheets, webinars, and brochures targeting local issues and in support of national campaigns, and webinars. The pandemic response increased the Center's capacity to employ new virtual technologies and better alignment among content, target audience, and medium (i.e., YouTube, social media, and online courses). The evidence of changes wrought from outreach came primarily from stakeholder perception surveys conducted during the second (2018) and fifth year (2021). Trend analysis found (a) increased effectiveness, use and value of resources distributed by SW Ag Center and (b) increased awareness of worker/workplace safety and health practices

and use of resources to improve such practices. Testimonials provided another source for evidence of the contribution of SW Ag Center outreach to change:

> The ag center is my go-to resource for information when I am called upon to teach farm safety and injury prevention in the agriculture community. Not only do they provide me with timely, evidence-based information but they also supply the teaching resources to enhance my presentations. The videos and fact sheets are very helpful, whether my audience consists of older members of our state cattlemen's association or the youth of our local 4-H clubs. I am grateful for their support.
>
> (Independent Cattleman's Association of Texas, ATeamV Coalition, Save a Life Today Suicide Prevention)

> The Mental Health Safety training for our Arkansas FFA State Officers and staff was incredibly helpful in raising awareness [of] the needs which many of our FFA members may have. The pandemic has caused a great deal of isolation and anxiety for many, and the training has equipped our student leaders to be better prepared to identify their peers who may be struggling, and they have the tools they need to seek assistance if needed.
>
> (Arkansas FFA Foundation)

> My brothers attended your ATV Youth Riders Class and now they always wear the helmet they got.
>
> (Family member of ATV course attendee)

DISCUSSION

The 2016–2022 program cycle and evaluation began as planned. Research projects, both field-based and laboratory, were funded and well underway. All field-based projects had recruited participants and begun data collection, with at least half of the projected subjects secured. Data analysis of the limited sample with preliminary results presented virtually at annual EAC meetings proceeded. Outreach was robust with evidence-based educational materials and products disseminated at regional and local AgFF venues. Such venues included professional and trade association conferences, county extension events, state fairs, and AgFF training workshops. Then, the global pandemic occurred and disrupted everything, everywhere. The greatest lasting impact was on the ongoing recruitment of subjects needed to fulfill field-based study protocols and data collection for those projects slated to begin in Year 4.

The evaluation was less disrupted by the pandemic than delayed. The disruption was created by NIOSH whose evaluation capacity-building initiative using CA was undertaken in early 2020 at the beginning of the pandemic response. The effort was quite time-consuming for both Ag Center administration and outreach but also to evaluators, all of whom were invited to participate. Regardless, NIOSH did not normally deal with evaluation processes so the initiative would have been welcome if the NIOSH CA were methodologically sound.

Yet, the NIOSH CA was untethered from theory and unhinged from contribution claims established in an intervention statement.

Adaptation and nimbleness best characterize how the SW Ag Center and the evaluator proceeded. The SW Ag Center immediately switched to communication technologies, with a pivot to virtual; improved video presentations; and engagement of stakeholders using online, web-based platforms. The SW Ag Center and NIOSH, importantly, continued support of researchers both in time and resources, the latter enabled by the 1-year extension of federal funds. The SW Ag Center evaluator worked to embrace the NIOSH evaluation capacity-building initiative as much as possible while retaining the integrity of CA. Specifically, the CA adapted to become an *assessment of contribution* using logic models rather than contribution analysis following Mayne. The melding of the two approaches described arguably adopts the best of both: It allows the intervention statement to define the contribution claims and the logic model format to describe the pathways showing the causal sequence between activities to outputs to impact.

CONCLUSION

The idea to use CA for the evaluation in the 2016–2022 cycle was driven by the NIOSH workshop in 2017. The evaluator enjoyed a long collaboration with the SW Ag Center and had conducted a mixed-method approach to monitoring and evaluation since 2013. Allowing and granting use of it for the evaluation remarks highly on the support of the SW Ag Center to the evaluation and belief in the capacity of the evaluator. The CA would not have happened without leadership support and buy-in since much of the data obtained from PIs were included in routine reports required of them by the SW Ag Center. The subsequent modifications to the CA essentially produced a credible evaluation capable of making attribution claims based on a highly detailed evidence table that linked data from logic model activities and outcomes to assumptions of the benefits of the intervention—all elements that are key to CA (John Mayne, personal communication, October 2020).

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NOTE

1 In Memoria: In May 2019, the author delivered a paper on the contribution analysis of the SW Ag Center to the Canadian Evaluation Society. My primary intention for attending the meeting was to meet John Mayne. I tracked him down, and he graciously gave his time and thoughts and attended my presentation. We stayed in touch, and our last discussion focused on the merits of a CA without a theory of change. He unexpectedly died in December 2020. His legacy lives on.

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