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Raising the (Roll)Bar

Exploring Barriers and Facilitators to Research Translation in US Public Health

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For my grandparents.

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Abstract

Background: In public health, implementation science work is crucial to protecting the safety and health of populations. Despite this, such efforts have been extremely limited within the specific public health field of occupational safety and health. The overall aim of this thesis is to examine the concept of research translation, the barriers and facilitators that researchers have faced in translating research to the worker environment, and the process of scaling up an evidence-based agricultural safety program. Additionally, this study will provide an opportunity to adapt the clinically based Consolidated Framework for Implementation Research (CFIR), as well as the Proctor Taxonomy (of implementation outcomes), to occupational safety settings.

The implementation research conducted within this dissertation is focused on a case study in agricultural safety. With an annual fatality rate seven times higher than the all-worker fatality rate, agriculture is one of the most dangerous occupations to work in. Though nearly all aspects of farming can be considered dangerous, tractor overturns claim the greatest number of lives. Rollover protective systems (ROPS) are 99% effective in preventing death and disability in the event of an overturn when used with seatbelts. The ROPS Rebate Program was developed in 2006 to encourage the installation of retrofit ROPS in New York State and has been shown to be effective in this goal and in the long-term goal of reducing overturn fatalities. After expanding to six additional states, the National Tractor Safety Coalition was formed in order to facilitate the scaling up of the ROPS Rebate Programs. The National ROPS Rebate Program (NRRP) was formally announced in June 2017, though implementation of it is currently ongoing.

Methods: This dissertation is composed of five sub-studies which applied a mixed methods approach. Sub-study I consisted of a scoping literature review. Manuscripts were identified through six databases to explore how research translation is discussed among the research community. In addition, the review aimed at assessing the T0-T4 model of research translation (first developed by the National Institutes of Health) as it applies to agriculture, forestry, and fishing safety and health and used knowledge gained through the review to make modifications to this model.

To apply the CFIR and Proctor Taxonomy to agricultural safety settings (sub-study II), a survey was developed to assess the relevance of the constructs included in each framework to the NRRP implementation. The final survey was distributed to members of the National Tractor Safety Coalition. Using

the results from this survey, quantitative and qualitative evaluation tools were developed.

Sub-study III utilized a repeat measure survey collected at four time points to capture changes in CFIR and Proctor constructs over time. Correlational analyses were conducted to compare each survey item to three outcome measures: state *progress* toward securing rebate funding for the Program, farmers *intakes* into the Program, and completed *retrofits*.

Thirteen individuals participated in qualitative research interviews for sub-study IV; nine of these individuals also participated in follow-up interviews. Interview guides were developed based on the survey results in sub-study III. Grounded Theory Situational Analysis was used to analyze each set of data.

Sub-study V was developed as a result of missing data from sub-studies III and IV. To conduct this analysis, media reports published about the ROPS Rebate Programs were collected. Discourse analysis for print media was used to assess the media reports in comparison to the ROPS Rebate Program trajectory in each state and nationally.

Results: Sub-study I led to the development of a modified T0-T4 research translation model, which takes into account the real-life challenges in moving proven innovations into widespread practice. The remaining sub-studies in this dissertation focused in the T3 phase of this model (widespread adoption). Sub-study II led to the identification of 21 CFIR and Proctor constructs that National Tractor Safety Coalition members believed would be important to the NRRP implementation. Sub-study III demonstrated that eight CFIR and Proctor constructs were highly correlated (rho ≥ 0.5) with at least one of the outcome measures (*progress*, *intakes*, or *retrofits*). Two primary themes were developed from the qualitative portion of the study (sub-study IV): 1) the implementation strategy evolved inconsistently across stakeholders, and 2) stakeholder engagement is a function of perceived feasibility and "small wins." Finally, sub-study V identified components of successful media strategies for implementation including diversity in actors and messages, timing, and frequency. In total, sub-studies III-V identified 27 CFIR and Proctor constructs that were relevant to the implementation of the NRRP, 10 of which were identified in more than one study.

Conclusions: This dissertation has served to examine, specifically, the implementation of the NRRP, and more generally, the field of implementation science as it applies to occupational safety and health. The methods applied in this study as well as the findings have resulted in: application of implementation frameworks to the field of agricultural safety and health,

assessment of the unique challenges associated with initiatives to scale up innovations, assessment of implementation from the perspective of the CFIR and Proctor Taxonomy, and assessment of the use of media advocacy as an implementation strategy. The knowledge gained through this research will be helpful in improving the implementation of the NRRP and in developing implementation science efforts within the specific public health field of occupational safety and health.

Abbreviations

ANOVA: Analysis of Variance

CFIR: Consolidated Framework for Implementation Research

NIH: National Institutes for Health

NRRP: National ROPS Rebate Program

NY: New York

ROPS: Rollover Protective Structures

US: United States

USD: United States Dollar (Currency)

Original Papers

This dissertation is based on the following five sub-studies:

I. Tinc PJ, Gadomski A, Sorensen JA, Weinehall L, Jenkins PL, and Lindvall K. 2018. From Lab Bench to Worksite: Understanding Implementation Science Efforts and Adapting the T0-T4 Model to Agriculture, Forestry, and Fishing. *American Journal of Industrial Medicine, 61*(1): 51-62. *(Permission for reprinting granted by John Wiley & Sons.)*

II. Tinc PJ, Gadomski A, Sorensen JA, Weinehall L, Jenkins PL, and Lindvall K. 2018. Applying the Consolidated Framework for Implementation Research to Agricultural Safety and Health: Barriers, Facilitators, and Evaluation Opportunities. *Safety Science, 107*: 99-108. *(Permission for reprinting granted by Elsevier.)*

III. Tinc PJ, Jenkins PL, Sorensen JA, Weinehall L, Gadomski A, Lindvall K. 2019. Key factors for successful implementation of the National ROPS Rebate Program: A correlation analysis using the Consolidated Framework for Implementation Research (CFIR). *Scandinavian Journal of Work, Environment, and Health.* Published online ahead of print. *(Permission for reprinting granted by the Scandinavian Journal of Work, Environment, and Health).*

IV. Tinc PJ, Sorensen JA, Lindvall K. Understanding stakeholder experiences implementing a National ROPS Rebate Program: A grounded theory situational analysis. *Manuscript under review.*

V. Tinc PJ, Sorensen JA, Weinehall L, Lindvall K. 2019. An exploration of ROPS Rebate Program media coverage: Strategies for implementation and sustainment. *BMC Public Health, 19*(1257). *(Permission for reprinting granted by BMC's Open Access Policy).*

1 | Introduction

In the US, the average working adult (approximately, those between the ages of 25 and 65) spends more than a quarter of his/her time at work (1). Thus, workplaces are a prime source of potential injuries, illnesses, and fatalities and an important target of public health initiatives.

Given the nature of agricultural work, workdays are often longer than among other occupational sectors, many farmers, workers, and their families live on the farm, and many farmers work long past the typical retirement age. These factors increase exposure to a wide variety of occupational hazards. In addition, economic challenges and strong cultural beliefs may result in challenges initiating and maintaining safer work practices among producers (2). With an estimated 1.3 billion workers worldwide and at least 170,000 agricultural fatalities annually, agriculture is among the most hazardous professions (3). In the US, the fatality rate is nearly seven times higher than the all-worker occupational fatality rate (24.0 per 100,000 full time workers versus 3.5 per 100,000 full time workers) (4). This rate is higher than in many countries, including those in the European Union (5). In addition to high fatality rates, agricultural workers also face a high risk of non-fatal injuries, though in many countries accurate estimates are not available (5). Current reports suggest that approximately 120,000 non-fatal injuries occur annually in the US agricultural population (6). However, this estimate is likely to be severely underreported, as it is based solely on injuries in which workers sought medical attention and the injury was documented as farm-related in the medical record (6, 7).

Though nearly every farm task can be considered dangerous, tractor overturns are the most frequent cause of death, and have been for much of the last century (8). A 2008 estimate produced by Meyers et al. reported that approximately 125 tractor overturn fatalities occur annually in the US (9). Further, the authors provided estimates for the number of nonfatal injuries requiring medical treatment (n=573), as well as events in which treatment was not sought (n=1,714) (9).

Though the loss of life and the increased emotional and physical burdens of disabling injuries are the most important public health outcomes to address, a wide array of consequences can occur after a tractor overturn event. Financially devastating medical costs, lost productivity on the farm and at home, and closed farms can take a toll on farm families, communities, and economies.

With increasing awareness of tractor overturn fatalities, US tractor manufacturers began the process of developing and testing engineered solutions in the 1950s. In 1956, the first rollover protective system (ROPS) was successfully tested and shown to prevent operator fatalities in the event of a tractor overturn (10). In the US, ROPS were first offered as optional equipment in the early 1960s; however, they did not become standard equipment on new tractors in the US until 1985 (10, 11). When used with a seatbelt, ROPS keep the operator in a "zone of safety," which prevents the tractor operator from being crushed by the tractor during an overturn (12). In doing so, ROPS have been shown to be 99% effective in preventing death and disabling injuries (12).

More than thirty years have passed since ROPS standards were implemented; however, nearly half (41-49%) of tractors in the US still lack rollover protection today (13, 14). Trends in retrofitting and overturn fatalities (8, 13-15) suggest that this problem is not likely to disappear without external efforts, as has been [anecdotally] discussed by agricultural safety professionals. These rates are compared to countries such as Sweden and Australia that reached close to 100% ROPS use and nearly eliminated tractor overturn fatalities by the 1980s and 1990s, respectively (16, 17). In the US, low ROPS prevalence rates are due, primarily, to the long lifespan of tractors, meaning that many tractors in use today were manufactured prior to the standardization of ROPS (14). Often, the financial status of the small and mid-sized farms, which make up 96% of US farms (18), makes it difficult to invest in new equipment with added safety features, or even safety upgrades for older equipment (2). In addition to those tractors that were manufactured prior to ROPS becoming standard equipment, some ROPS have also been removed from newer tractors, often to allow the tractor to be stored inside of low-clearance barns – an issue that has more recently been addressed with the introduction of manual and automatically-deployable folding ROPS kits (19). Though safety regulations regarding ROPS use exist through the Occupational Safety and Health Administration, the organization operates using a "small-farm exemption," which prevents regulatory oversight on [small and mid-sized] farms with fewer than 11 employees (2).

While numerous agricultural safety solutions such as ROPS have been developed, few have been widely adopted by the US farm population. Without widespread adoption of these innovations, their effects are limited. In a 2017 commentary written by researchers at the National Institute for Occupational Safety and Health, the authors explicitly stated that,

> *"there is a need to assess and document barriers and facilitators of institutionalizing and sustaining new recommendations, training, or*

technology leading to generalizable knowledge that in time should measurably improve the health and safety of workers (20)."

This dissertation takes the opportunity to begin addressing this concern by exploring barriers and facilitators related to scaling up a program that has been proven to increase the use of ROPS on farms, thereby reducing tractor overturn fatalities. Though this dissertation specifically focuses on implementing a Program to prevent tractor overturn fatalities, its primary goal is to increase our understanding of the field of implementation science, especially as it relates to occupational safety and health settings.

2 | Background

While ROPS can be retrofitted onto many older tractors, it has been difficult to take this step. Outside of the US, countries such as Sweden and Australia have passed legislation requiring the use of ROPS (16, 17, 21). Paired with informational campaigns and monetary incentives, these programs have reduced the number of annual overturn fatalities to near zero (16). Unfortunately, in the US, progress has been much slower despite many efforts directed at decreasing the number of unprotected tractors on US farms including education, incentives, and regulation.

This dissertation focuses on the implementation of the National ROPS Rebate Program (NRRP). In the coming sections, I will first introduce the initial efforts to reduce tractor overturn fatalities in the US. This will be followed by an introduction to the development of the ROPS Rebate Programs, which are the predecessors to the NRRP that is discussed throughout this dissertation.

2.1 Efforts to Eliminate Tractor Overturn Fatalities in the US

2.1.1 Educational Efforts

A simple Google search will reveal numerous fact sheets, handouts, websites, videos, and organizations that are available to help educate farmers about the dangers of operating tractors without proper rollover protection. While these materials are now easily accessible, educational campaigns surrounding ROPS have been available since long before the widespread use of the internet. Educational campaigns for many safety topics have been a go-to method for organizations like Cooperative Extension which was formally established in 1914 (22) and the National Institute of Occupational Safety and Health's agricultural research centers which were established in 1990 (23).

Though educational campaigns have been the most common strategy for increasing ROPS protection in the US, they rely on two assumptions: 1) target populations are unaware of the issue at hand and/or solutions to that issue, and 2) there are no barriers to change beyond awareness. In regard to ROPS, a 2006 study demonstrated that of farmers who had not considered installing ROPS, only 22% were not aware of the issue of tractor overturn fatalities or the benefit of ROPS (24). This indicates that few farmers would benefit from more education about the dangers of tractor overturns.

2.1.2 Financial Incentives

In 1979, the Virginia Farm Bureau launched a rebate program to help farmers install ROPS on their tractors. Over time, several additional rebate programs have started (25-27); however, many last for only a short time or retrofit only a small number of tractors. Because these programs have most often been facilitated by organizations such as Farm Bureau that do not conduct research, published evaluations of the programs have not been produced to explain these results. However; other research provides two possible explanations: the rebate amounts (typically between 300 USD and 500 USD) were not high enough (28) and other barriers (e.g. finding the appropriate ROPS kit) to retrofitting still existed (29).

2.1.3 Regulations

Though regulations have been successful in reducing tractor overturn fatalities outside of the US, such efforts have been less successful within the US. In the late 1990s, agricultural safety researchers at the University of Iowa developed guidelines and materials to promote the development of state regulations to increase the use of ROPS (30, 31). Unfortunately, these guidelines were not put into use, and as a result, ROPS regulations were not implemented. Had a particular state attempted to develop such guidelines, it is likely that significant pushback from the farm community would have prevented the regulations from being passed or implemented. This hypothesis is based on previous examples in which regulations that aimed to limit the exposure of farm children to safety hazards were blocked by farm activists who are deeply opposed to such regulatory action (32-34). Such opposition to regulations is likely the result of both a culture of independence on US farms (2), as well as a poor history of regulations leading to negative outcomes (e.g. decreased profits and increased expenditures) for farmers (2, 35).

2.2 The ROPS Rebate Program(s)

Despite efforts to increase the installation of ROPS on US tractors, little progress had been made by the early 2000s. Given the high number of fatalities from tractor overturns, researchers began to look at alternative methods for increasing ROPS installations. The following sections highlight the work that was done to develop and evaluate the ROPS Rebate Program in New York (NY) and subsequently expand the Program to additional states. As will be shown in these sections, while the Program research is grant-funded and the aims were decided upon by the research team (a "top-down" approach), intervention development was conducted in close collaboration with the target population and other relevant stakeholders, demonstrating a "bottom-up" approach to tackling tractor overturn fatalities.

2.2.1 Formative Research

From 2005-2006, 23 farmers, farm spouses, and adult farm children were interviewed to gain perspectives on risk perceptions, barriers, and motivators for installing ROPS (36). These farmers were located throughout NY, and operated small crop or livestock farms, as these commodities had the highest prevalence of unprotected tractors (36).

In addition to one-on-one interviews, a much larger-scale survey with a total of 562 farms was also conducted (24). These surveys included farmers representing a wider variety of farm commodities, with all participants residing in NY. This survey was formulated based on the Transtheoretical Model (37), and thus asked participants questions that would then allow them to be classified based on the Stages of Change: precontemplation, contemplation, determination, action, or maintenance. For example, participants who had never considered installing ROPS would be in the precontemplation category, while participants who had decided to install ROPS but had not yet taken action would be placed in the determination phase.

As a result of these two studies, several key findings were identified. First, the logistical factors related to installing ROPS on tractors were significant barriers: ROPS kits are difficult and time consuming to find and install and are often cost-prohibitive (29, 36). In addition, the research team found that many farmers did not believe that they themselves were susceptible to tractor overturns (despite the fact that most farmers know at least one other farmer who had experienced an overturn) (29, 36). The surveys demonstrated that approximately 75% of farmers were in the precontemplation phase when it came to the decision to install rollover protection on their older tractors (24). Despite the numerous barriers to retrofitting and the fact that most farmers were in the precontemplation phase, several motivators for installing ROPS were identified. In particular, farmers who had installed ROPS were generally safety conscious, often performed dangerous tasks with their tractors, or wanted to protect workers and family members that would be driving tractors (29).

2.2.2 Intervention Design

The formative research conducted in the early 2000s led to the design and launch of a social marketing intervention (38). Social marketing has been described as marketing to influence behaviors, and differs from traditional marketing in that it aims to benefit the public rather than corporations (39). In public health, this relates to encouraging target populations to make healthier and safer choices. In one particularly helpful description of social

marketing, the authors describe the target population as those who want to make the best decision, but need help doing so (40).

Social marketing interventions have two main components: 1) targeted marketing of the new behavior, and 2) reduction of barriers to behavior change. In this case, the research team focused on finding ways to make ROPS kits more accessible and affordable.

To develop the targeted social marketing messages, the barriers and motivators identified during the formative research phase were transformed into printed messages. These messages were tested in small focus group discussions with farmers and farm wives in New York (41). At the end of these focus groups, three of the 14 messages tested were selected for inclusion in the campaign. These messages used various tactics for getting farmers' attention and promoting the Program: humor, family protection, and farmer comfort and protection (41). Over time, the messages used in the Program have been updated; however, the core messaging tactics have continued to be reliable in encouraging farmers to retrofit. As the Program has expanded, the same tactics have been used successfully in other states.

2.2.3 Pilot Testing and Identifying Key Program Components

Once the basic premise of the ROPS Rebate Program was developed, a quasi-randomized control trial was organized to test various components of the proposed intervention (including a hotline for sourcing assistance, a monetary rebate, and the targeted messages) (42). This study compared four distinct groups:

1. Hotline, rebate, and generic messages
2. Hotline, rebate, and targeted messages
3. Hotline and targeted messages
4. No hotline, rebates, or messages (control)

The results of this study indicated that the complete package of sourcing assistance, monetary rebates, and targeted messages (group two) were most successful in encouraging farmers to install ROPS on their tractors (42). Thus, the ROPS Rebate Program was born. Specifically, this Program provides the following three components:

1. targeted social marketing messages;
2. a hotline and website for sourcing assistance; and
3. a 70% rebate toward the cost of retrofitting (including purchasing, shipping, and installing the ROPS kit).

Over time, this rebate scheme has been modified to meet the rising cost of ROPS; however, in initial trials, rebates were for 70% of the cost, up to 600 USD. This amount was based on a study in which farmers were asked what they would be willing to pay to install a ROPS kit (28).

With the success of the pilot test, the ROPS Rebate Program was fully implemented across New York using this format. The process that farmers follow to participate in the Program is shown in **figure 1**.

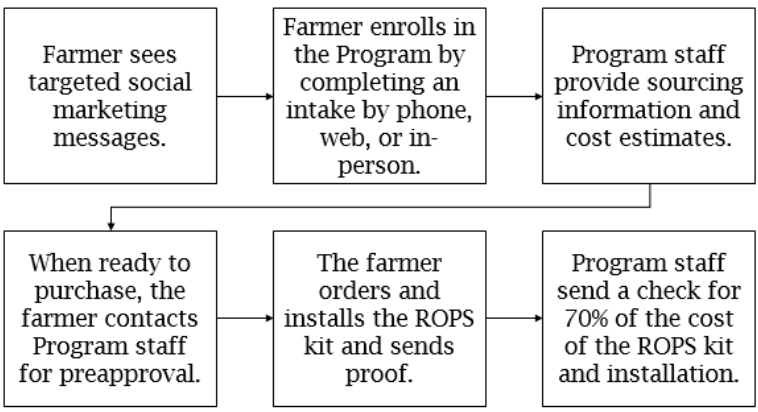

Figure 1: Process for participating in the ROPS Rebate Program.

2.2.4 Evaluation of the NY ROPS Rebate Program

Once expanded to reach all New York farmers, several evaluations were conducted (42-47). One study examined the logistical and safety aspects of allowing farmers to install ROPS on their own (without the work of a mechanic). This study found that about two-thirds of participants had trouble installing the kits (44). Many of the issues related to the ROPS kits themselves, which contained incorrect parts or unsuitable instructions. Though not discussed in the study article, the research team later worked with ROPS manufacturers to address these issues.

In addition to evaluating the intervention components and the feasibility of farmers self-installing ROPS kits, the research team also conducted a cost-effectiveness evaluation of the Program, which used data from the first 2.5 years of the intervention. Surveys with Program participants were used, as they asked individuals to report close calls, overturns, and other events in which they felt their lives were saved as a result of installing the ROPS kit on their tractors. This data was used to estimate the total cost of prevented injuries and fatalities, and was then compared to the Program costs. This

study determined that the Program would begin to save money after three full years, and that within 10 years, a savings of 1.9 million USD would occur as a direct result of the Program (43). Based on the cost-analysis of this Program, as well as the other evidence demonstrating its benefit, there was enough motivation to expand the Program further. Though true, research based on the NY ROPS Rebate Program did not end there. A 2018 update to the cost-effectiveness analysis of the Program demonstrated that the Program had in fact saved at least 17 farmers from fatalities or serious injuries due to tractor overturns and over four million USD in the first ten years (47). This is more than twice the projected savings estimated in the 2010 analysis (43). In addition, the 2018 analysis predicted additional savings of up to nearly 19 million USD for the tractors already retrofitted, assuming that those tractors remained in operation for 25 years after their respective retrofits (47).

2.2.5 State-by-State Expansion

As a result of the success in New York, the research team partnered with agricultural safety stakeholders in additional states to begin expanding the Program. Pennsylvania and Vermont, two of New York's neighbors, were among the first to join the Program. To ensure the fit of the messages and strategies used, an additional round of formative research was conducted in these two states. Similar to the work done in New York, farmers in Pennsylvania and Vermont were invited to participate in a round of telephone surveys to identify state-specific barriers and motivators for ROPS installation (48), as well as any sub-groups of farmers that were most in need (49). In addition, focus group discussions were held in each state to reassess the targeted social marketing messages based on regional preferences. In each of these studies, the research team found that, compared to farmers in NY, farmers in each other state had similar barriers and motivators for participating, and were motivated by the same types of messaging. The only differences were that farmers felt strongly that the messages needed to feature farmers and farmland reflective of their state.

By early 2011, ROPS Rebate Programs had launched in both Pennsylvania and Vermont. Around this time, New Hampshire also launched a ROPS Rebate Program based on the findings from these other states. Over the next several years, the ROPS Rebate Program was further expanded into three additional, individual states: Wisconsin (2013), Massachusetts (2015), and Minnesota (2016). In each of these states, the guiding principles identified through the research conducted throughout the previous decade were applied; however, as was suggested through the work in Vermont and Pennsylvania, Program materials were modified to appeal to farmers in each state or region.

In the midst of this expansion, the cost of ROPS kits increased significantly. These increases were likely due to the sudden increase of orders for ROPS kits. According to traditional economic principles, this should lead to a decrease in prices; however, these kits are specific to tractor models (of which there are nearly 1,000 with available ROPS retrofit kits) and are most often produced as orders are placed thus increasing production costs. The pricing increases spurred further work by the research team to determine how these pricing increases would impact participation in the Program. This study demonstrated a decrease in ROPS retrofits through the Program that coincided with the increase in ROPS pricing (46). As a result of these findings, the rebate scheme was modified to provide a higher rebate amount to participating farmers. This rebate scheme has been updated several times since the Program began. Currently farmers in most states are eligible for a 70% rebate with the stipulation that, when necessary, the Program pays beyond that 70% to ensure that farmers pay no more than 500 USD per retrofit.

2.3 Toward a National ROPS Rebate Program (NRRP)

This dissertation focuses on the implementation of the NRRP, which was born from the original seven ROPS Rebate Programs described. The expansion of the ROPS Rebate Programs into these additional states garnered enough interest to consider expanding it nationally. The successes of the Program (in both lives saved and cost-savings) were significant enough to move forward with this expansion (43). In order to ensure widespread support for this national initiative and to mobilize resources from many US organizations, the research team began searching for nationally-located partners who could assist with Program expansion. This involved a two-step process. First, a social networking analysis was conducted to determine which organizations or individuals were the most well-connected and best suited for contributing to such an effort (50).

Approximately 20 agricultural safety leaders from a variety of backgrounds were identified as potential partners for moving forward with a national-level Program. Despite collaboration between these and the resources that each could contribute, the group felt that the endeavor was not possible without greater support.

To close this gap, the group invited 60 stakeholders from nine agriculturally related sectors to participate in a two-day strategy session in 2014. This included manufacturers and dealerships, agricultural organizations, safety and health organizations, financial and insurance organizations, government, researchers, private corporations, the media, and farmers (51). The strategy

session followed the Future Search format (52), which involves stakeholder discussions rather than a focus on presentations. By doing so, all participants were equally represented and engaged in the meeting, which first examined the history of tractor overturns and ROPS followed by an overview of the current state of ROPS initiatives. The meeting concluded with participants documenting what they hoped to accomplish (related to tractor safety and ROPS) in the future, and committing to various actions to move closer to the group's common goals (53, 54).

The 2014 meeting was also the initial meeting of the National Tractor Safety Coalition. This committee, which includes those that were present at the meeting in 2014, as well as others who have joined since then, is responsible for overseeing the transition from state-based ROPS Rebate Programs to the NRRP, and is the primary study population represented in this dissertation.

Since the 2014 workshop, this group has worked together to move toward a NRRP, which was officially launched in June 2017 (55). The research related to this dissertation begins here and evaluates the launch of the NRRP from an implementation science perspective using the Consolidated Framework for Implementation Research (CFIR) (56) and Proctor Taxonomy of implementation outcomes (57).

3 | Conceptual and Theoretical Framework

3.1 Research to Practice in Agricultural Safety and Health

Implementation science can be defined in different ways, all of which generally refer to, "the study of what happens prior to, and after, adoption occurs, especially in organizational settings (58)."Adoption refers to the decision to "commit to and initiate an evidence-based intervention (59)." The field of implementation science has a long history, which began outside of public health and clinical medicine. More recently, the field has become more formalized and there has been a greater push to educate researchers and practitioners on this important work (60, 61).

In the agricultural safety and health research setting, "implementation science" is a term that is rarely, if ever, used. Instead, the vast majority of researchers and practitioners within the field refer to "research to practice" or "r2p." Unfortunately, despite the fact that research to practice is a term that is often used both within the agricultural safety and health research community and among those working in other fields, it can be challenging to identify a consistent definition.

In this dissertation, I define *research to practice* as the process of developing research innovations, ensuring those innovations are efficacious and effective, and putting them into use in real world settings. In clinical medicine and public health, this process can be seen in the National Institutes for Health's (NIH's) T0-T4 model of research translation (**table 1**). Though numerous implementation process models exist, the T0-T4 model is demonstrated here, and discussed in sub-study I because it is currently the most well-known implementation process model among occupational safety and health researchers.

In moving through the T0-T4 process, it is important that innovations must be proven efficacious and effective before focusing on widespread implementation of the innovation. Interestingly, although innovations can be proven to be effective in the lab or in a smaller pilot, many are not widely adopted. Implementation science, which can include effectiveness trials, largely fits into the later end of this process when innovations should be translated into practice through one of several methods (diffusion, dissemination, or implementation).

- *Diffusion*, which is defined based on Rogers' Theory of the Diffusion of Innovations, relates to the passive spread of innovations through a population (59, 62).

- *Dissemination* involves a more active approach to encouraging adoption; however is still fairly passive (59).
- *Implementation* requires the greatest resources and involves efforts to mainstream innovations (59, 63).

Table 1: Descriptions of the NIH T0-T4 translational research model stages (64). Originally published in Tinc et al., 2018 (sub-study I) (65).

	NIH T0-T4 Model
T0	• Identification of risk factors ○ Surveillance

T1	• Discovery to candidate health application
	  ○ Phase I clinical trial (assess safety)
	  ○ Phase II clinical trial (assess efficacy)
	  ○ Observational trial

T2	• Health application to evidence-based practice guidelines
	  ○ Phase III clinical trials (confirm findings in large population)
	  ○ Observational studies
	  ○ Evidence synthesis
	  ○ Guideline development

T3	• Practice guidelines to health practice
	  ○ Dissemination, diffusion, and implementation research
	  ○ Phase IV clinical trials (long-term safety)

T4	• Practice to population health impact ○ Outcomes research (monitoring of benefits, risks, and morbidity)

Depending on the situation and innovation, one of these methods may be more appropriate than others. For example, often when I discuss the lack of research related to implementation science in agricultural safety and health, implementation scientists will refer me to Everett Roger's study of hybrid corn seeds in Iowa farm communities – the basis for the Theory of Diffusion of Innovations (62), and thus, implementation science. In this case, the research innovation was a new type of corn seed, which would allow for greater productivity and profitability. As these outcomes were appealing and clear to most farmers, and few barriers to using the seeds existed, it required little effort to spread the seeds through diffusion. In his book, Rogers also discusses a case study related to a failed agricultural innovation – the N-Track soil testing system (62). Though not a safety or health innovation, some of the barriers which prevented successful diffusion of this innovation (including compatibility, observability, and unclear relative advantage compared to then-current soil testing methods) also play a role in safety and health initiatives (62). Given these, and other, barriers, more effort is needed (either using dissemination or implementation techniques) to facilitate widespread adoption in occupational safety and health settings.

There has been increasing interest in the field of implementation science in order to address a major gap in injury and illness prevention. On average, it takes 17 years for evidence-based programs to be fully implemented in clinical settings (66). A similar gap in translating evidence-based innovations into practice has also been reported across other sectors, including public health (and more specifically, occupational health) (67-69). As a result of this delay, end users experience an extremely limited or delayed benefit from the research that has been conducted and proven effective.

Numerous factors can contribute to the lag in putting innovations into practice. Limited monetary resources, challenges in obtaining stakeholder support, limited awareness of innovations, and separation of researchers and practitioners have been cited as important factors contributing to this gap (68, 70). In addition, an overall limited knowledge of processes that can be used for implementing innovations has impeded progress (69). In the agricultural safety and health field, these barriers to research translation are further amplified by the fact that 1) very few researchers or practitioners in this field are engaged in implementation science work and 2) there is little infrastructure supporting implementation science work (either research or practical applications).

3.2 The NRRP: An Implementation Opportunity

The NRRP implementation provides an opportunity to take a critical look at the factors influencing the widespread adoption of vital agricultural safety initiatives (i.e. the T3 phase of research translation) to see what works and what doesn't work. In doing so, this dissertation contributes to a greater understanding of implementation science by applying implementation frameworks to new areas of research (i.e. occupational safety and health) and assessing implementation factors in this field.

While this dissertation is focused in the T3 phase, the other stages of research have not been neglected. As was described in the background section of this dissertation, work has been completed in the earlier phases of research. **Table 2** provides a summary of the peer-reviewed literature published by our research team on this topic, which was described previously, and how each piece fits into the earlier stages of the T0-T4 model. Briefly, the T0 phase of research helped us understand the epidemiology of tractor overturn fatalities. In addition to the works presented in this table, much has been done in the T0 phase by researchers outside of our team (8, 9, 13, 15, 71-73). In the T1 phase of research additional formative research was conducted to understand methods that would be most helpful to farmers and a social marketing intervention was developed and pilot tested. The T2 phase of

research involved additional research to understand how the ROPS Rebate Program could be applied in different settings. Further, the Program expanded to a total of seven states. The works highlighted as T3 research were published prior to the start of this dissertation and provided a foundation for this dissertation by developing the National Tractor Safety Coalition.

Table 2: Research conducted on the ROPS Rebate Programs, based on the NIH T0-T4 Model.

Phase	Year	Title
T0	2006	Rollover protection on New York tractors and farmers' readiness for change (24)
T1	2006	Risk perceptions, barriers, and motivators to tractor ROPS retrofitting in the New York State farm community (29)
	2008	Encouraging farmers to retrofit tractors: a qualitative analysis of risk perceptions among a group of high-risk farmers in New York (36)
	2008	Evaluating tractor safety messages: A concept development project (41)
	2008	Encouraging the installation of rollover protective structures in New York State: the design of a social marketing intervention (38)
	2010	Cost-effectiveness of a ROPS social marketing campaign (43)
	2011	The social marketing of safety behaviors: a quasi-randomized controlled trial of tractor retrofitting incentives (42)
	2011	Results from inspections of farmer-installed rollover protective structures (44)
	2018	Rollover protective structures, worker safety, and cost-effectiveness: New York, 2011-2017 (47)
T2	2012	Prominent barriers and motivators to installing ROPS: an analysis of survey responses from Pennsylvania and Vermont (48)
	2013	Selecting target populations for ROPS retrofit programs in Pennsylvania and Vermont (49)
	2013	Increases in ROPS pricing from 2006-2012 and the impact on ROPS demand (46)
T3	2013	Building safety partnerships using social network analysis (50)
	2015	Creating a national coalition to address tractor overturn fatalities (51)
	2016	Implementing a national tractor safety program: Using "Whole System in a Room" to mobilize partners and implement solutions (53)

The ROPS Rebate Program has been proven effective at not only preventing fatalities, but also at saving money, making it a prime candidate for an implementation (or T3) effort, as described in an editorial published in the *American Journal of Public Health* in 2018:

"The [ROPS Rebate Program] study should serve as a model for implementation research in public health. Their investigation focused on a circumscribed problem; incorporated conceptual frameworks, mixed methods, and cost-benefit analyses; included multiple interventions in various combinations and focused on broad geographical swaths and subpopulations; combined sub-studies conducted by investigators from a wide array of disciplines; and involved a longitudinal time line, with funding secured over time. These elements are essential to amassing the kind of evidence needed to evaluate public health interventions with all of their 'moving parts,' (74)."

3.3 Consolidated Framework for Implementation Research (CFIR)

This thesis will use the CFIR to guide and evaluate the process of scaling up the ROPS Rebate Program into the NRRP. The CFIR was first published in 2009, after researchers at the US Department of Veterans' Affairs realized that many [then current] implementation frameworks were inconsistent with one another in their terminologies and failed to embrace the complexity of implementation studies (56). In addition, the authors (Damschroder et al.) sought to take prior frameworks a step further by not only explaining what works in implementation research, but also in what settings and, most importantly, why various strategies work (or don't work) (56).

In order to develop the CFIR, Damschroder et al. conducted a thorough review of the literature and worked to standardize terminology and combine constructs from various models, frameworks, and theories. The authors indicate that their literature search was not exhaustive; however, also clarify that they were able to reach saturation (i.e. they came to a point in which additional theories, frameworks, and models did not add new information) (56).

In developing the final CFIR framework, the authors reviewed a total of nineteen other implementation frameworks. Upon this review, the authors consolidated and combined like constructs into focus areas called domains. In total, the CFIR consists of five domains (*characteristics of individuals, inner setting, outer setting, intervention characteristics*, and *process*).

Characteristics of individuals refers to factors related to the people involved in implementing an innovation. These individuals are generally part of the *inner setting*¸ a domain that describes the implementation group, the interactions between actors in that group, and related non-human factors.

The *outer setting* refers to individuals, organizations, or factors that may be impacted by or have an impact on implementation, but are not directly involved. As the name suggests, *intervention characteristics* relate to how an innovation is presented. This includes both core intervention characteristics, which remain the same over time, as well as periphery intervention characteristics that may change over the course of the implementation. Finally, *process* refers to the process of implementing an innovation, and all of the factors that contribute to it. In total, these five domains incorporate 26 constructs and 14 sub-constructs that help describe and define the domains (56).

Though the domains of the CFIR are distinct from one another, they are also closely intertwined, and together, paint a complete picture of the implementation process.

The CFIR has been widely referenced in the literature (75, 76). A 2016 literature review provided an important overview of the wide variety of research that can be conducted using the CFIR (75). The framework, which was initially developed based on qualitative research can be used for qualitative, quantitative, or mixed methods studies. In addition, the CFIR can be applied before, during, or after implementation and may be used to guide all parts of implementation planning, data collection, analysis, or reporting. These reasons, as well as the wide array of constructs covered by the CFIR, were considered in selecting this model for use in this study.

3.4 Proctor et al.'s Taxonomy of Implementation Outcomes

Though the CFIR itself fully depicts implementation science theory and process, it fails to include key outcome measures demonstrating implementation success. In 2009, Proctor et al. published a taxonomy of implementation outcomes arranged by domains and constructs (77). In 2011, a follow-up manuscript was published further explaining and defining these outcome measures, which include three domains and 18 constructs (57). Similar to the CFIR, these domains and constructs were developed based on a review of implementation literature and the outcomes typically measured by study teams (57).

According to Proctor et al., *implementation outcomes* refer primarily to the ability to physically implement an innovation, and provides measures of how well that was done; *client outcomes* relate to customer service endpoints; and *service outcomes* relate primarily to quality assurance measures in clinical settings.

Though the Proctor domains and constructs are described as outcomes by the authors (57), throughout this study, most have been viewed as implementation factors much like the domains and constructs described by the CFIR. For example, the constructs *acceptability* and *appropriateness* (both *implementation outcomes*), among others, are relevant measures of innovations themselves. Such outcomes can be used to monitor changes in the innovation over the course of the implementation period, and the impacts of those changes on implementation. For this reason, the exclusion of such constructs from the CFIR itself could be considered a shortcoming of the Framework.

3.5 Combining the CFIR and Proctor Taxonomy

In order to fully explore the implementation of the NRRP, the CFIR and Proctor Taxonomy have been combined and used as one throughout this dissertation. While the included Proctor constructs may reasonably be classified under CFIR domains, they were considered in their pre-defined domains in order to maintain the structure of the CFIR and Proctor Taxonomy.

One Proctor domain, *service outcomes*, was excluded from this study because it relates to issues primarily faced in clinical settings (and thus is difficult to adapt to occupational settings). Further, sub-study II aimed to select and limit the number of specific CFIR and Proctor constructs that were formally included in evaluation activities (sub-studies III and IV), as will be described in section 5.7.

Table 3 shows all domains and constructs of the CFIR, as well as the two Proctor domains assessed in this study (*implementation outcomes* and *client outcomes*) and all related constructs. For the purposes of this dissertation, both CFIR and Proctor constructs and sub-constructs will be all referred to as constructs. As is appropriate throughout this dissertation, domains and constructs will be labeled based on the framework(s) that they refer to (CFIR, Proctor, or both).

Figure 2 is an adaptation of Damschroder et al.'s diagram of CFIR domains and how they interact (58); this version also includes the two Proctor domains applicable to this study.

Given the comprehensive nature of the CFIR, especially when paired with the Proctor Taxonomy, this framework appears to be a natural fit for this study, with many other implementation frameworks represented within it. However, alternative implementation frameworks were also candidates for this study.

Table 3: CFIR (56) and Proctor (57) domains and constructs.

Domain	Constructs
Characteristics of Individuals	• Knowledge and beliefs about the intervention • Individual stage of change • Self-efficacy • Individual identification with the organization • Other personal attributes
Inner Setting	• Culture • Implementation climate (tension for change, goals and feedback, relative priority, compatibility, learning climate, organizational incentives and rewards) • Networks and communication • Readiness for implementation (available resources, leadership engagement, access to knowledge and information) • Structural characteristics
Outer Setting	• Cosmopolitanism • External policy and incentives • Patient needs and resources • Peer pressure
Intervention Characteristics	• Adaptability • Complexity • Cost • Design quality and packaging • Evidence strength and quality • Intervention source • Relative advantage • Trialability
Process	• Engaging (champions, formally appointed implementation leaders, external change agents, opinion leaders) • Executing • Planning • Reflecting and evaluating
Implementation Outcomes[1]	• Acceptability • Adoption • Appropriateness • Feasibility • Penetration
Client Outcomes[1]	• Sustainability • Satisfaction

[1]The implementation and client outcomes domains are Proctor outcomes domains.

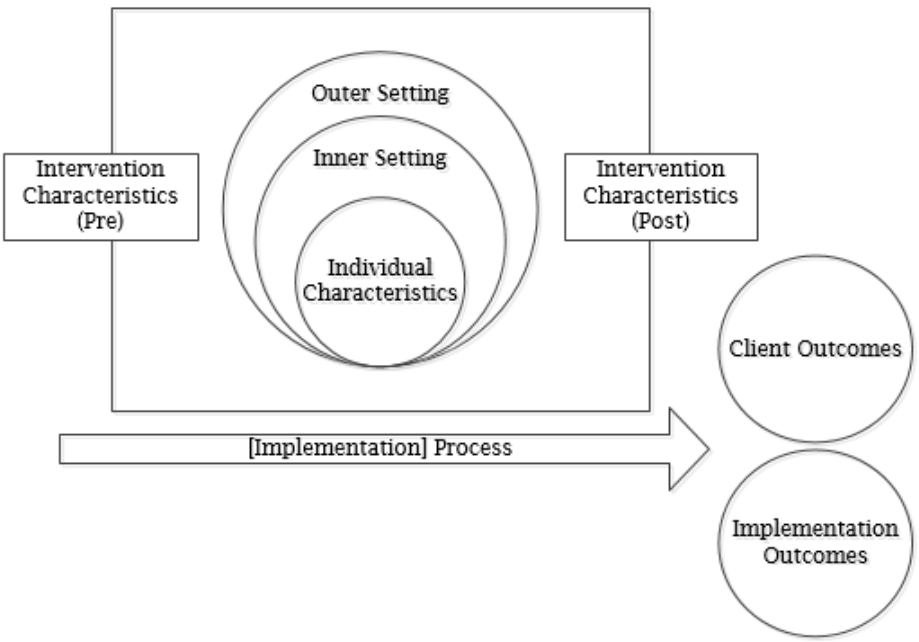

Figure 2: Visualization of the CFIR (56) and Proctor (57) domains and their interactions with one another.

In particular, the Theoretical Domains Framework, which was developed similarly to the CFIR (78), may also have provided the foundation for a quality implementation study. The difference between the two; however, led to the use of the CFIR, which focuses on organizational implementation factors (56), instead of the Theoretical Domains Framework, which focuses on individual implementation factors (78).

Though the CFIR and Proctor Taxonomy are well-known and utilized in clinical settings and public health, no examples of these frameworks applied specifically in high risk occupational safety settings such as agriculture could be found. Thus, this dissertation will serve not only to meet the aims laid out in the next chapter, but also to explore the use of the CFIR and Proctor Taxonomy in new areas of study.

4 | Study Aims

The overall goal of this study is to examine the concept of research translation, the barriers and facilitators that researchers have faced in translating research to the workplace, and the process of scaling up an evidence-based safety program (the ROPS Rebate Program). Additionally, this study will provide an opportunity to adapt the clinically based CFIR and Proctor Taxonomy to the specific public health field of occupational safety and health. The following specific aims guided the research:

1. Determine how agriculture, forestry, and fishing safety and health researchers discuss research translation (sub-study I);
2. Explore and propose alternative ways of discussing research translation within the agriculture, forestry, and fishing safety and health sector (sub-study I);
3. Adapt the CFIR and Proctor Taxonomy so that they may be used to guide and evaluate the implementation of the NRRP (sub-study II);
4. Develop (sub-study II) and implement (sub-study III) tools to measure changes in CFIR and Proctor constructs at the time that the NRRP is launched, and for 18 months after;
5. Evaluate the level of success of the NRRP implementation using three outcomes (*progress, intakes,* and *retrofits*), and identify which components of the CFIR and Proctor Taxonomy contribute to these outcomes (sub-study III);
6. Explore stakeholder (National Tractor Safety Coalition member and non-member) experiences of why and how the various CFIR and Proctor constructs impacted the research translation effort and contributed to the measured outcomes (sub-study IV); and
7. Explore how media coverage influences implementation and sustainment of the NRRP (sub-study V).

Study Aims	Paper	Data Source	Analysis Type	Mixed Methods Approach
Aims 1 and 2	Paper I: Adapting the T0-T4 implementation science model to occupational health and safety in agriculture, forestry, and fishing: A scoping review	Literature (n=14)	Scoping Literature Review	qual
Aims 3 and 4	Paper II: Applying the Consolidated Framework for Implementation Research to agricultural safety and health: Barriers, facilitators, and evaluation opportunities	Quantitative survey with Coalition members (n=54)	Descriptive Statistics	quan
Aims 4 and 5	Paper III: Key factors for successful implementation of the National Rollover Protection Structure Rebate Program: A correlation analysis using the Consolidated Framework for Implementation Research	Quantitative surveys with Coalition members at four time points (n=34, 32, 37, and 38, respectively)	Correlational Analysis	QUAN+QUAL
Aim 6	Paper IV: Understanding stakeholder experiences implementing a National ROPS Rebate Program: A Grounded Theory Situational Analysis	Qualitative interviews with Coalition members and non-members at two time points (n=13 and 9, respectively)	Grounded Theory Situational Analysis	
Aim 7	Paper V: An exploration of Rollover Protective Structure Rebate Program media coverage: Strategies for implementation and sustainment	News media (n=357)	Discourse Analysis for Print Media	QUAL

Figure 3: Multiphase research questions and data analysis methods.

5 | Research Methodology

5.1 Mixed Methods Research Design

The CFIR and Proctor Taxonomy, which were jointly used as the theoretical framework of this dissertation, were developed based on qualitative research methodologies. While this aspect is certainly important, it was decided that the research conducted for this dissertation would involve a multiphase mixed methods design (79, 80). Using this study design, several different methods of data collection (using both qualitative and quantitative inquiry) were utilized to answer separate, but related, research questions. Though each sub-study presents strictly qualitative or quantitative results, the aim of this cover story is to bring those together in a productive and meaningful way in order to bolster our understanding of the full results. For example, while quantitative approaches may conclude that a certain phenomenon is occurring, qualitative research can help explain why it is occurring, thus providing more detail to modify interventions and implementation strategies. The multiphase research questions and methods used in this dissertation are outlined in **figure 3**. This figure also highlights the mixed method approaches taken to answer each research question. As can be seen, the primary studies in this dissertation are sub-studies III (quantitative), IV (qualitative), and V (media assessment). Each of these manuscripts builds upon the prior one. These connections will be described within the following sections.

5.2 Study Timeframe

The data presented in this dissertation were collected between 2015 and 2018, following a schedule determined by the transition of the seven individual ROPS Rebate Programs to the NRRP, which is available to farmers in all 50 states. The initial transition to the NRRP was a two-step process, which took place between March 2017 and June 2017. In March 2017, a "soft" launch of the NRRP took place. The soft launch is defined as the point at which branding and technical aspects of the Program were transitioned from individual, state-based programs to a single nationwide program. This was followed by a "hard" launch in June 2017, at which point the NRRP was formally announced during the International Society for Agricultural Safety and Health annual conference in Logan, Utah (55).

Data collection for sub-studies I and II were completed prior to the soft launch of the NRRP in order to prepare for the data collection related to sub-studies III and IV. Thus, the literature review conducted for sub-study I was completed between 2015 and 2016, and the data collection and analysis for sub-study II took place during the fall and winter of 2016. Data collection for

sub-study III began with a baseline measurement at the time of the soft launch of the NRRP (March 2017). This was followed by three additional data collection points, each six months apart. Six month intervals were used in order to reduce recall bias among responders. The interviews used in sub-study IV were conducted after the second and fourth surveys included in sub-study III (October 2017 and October 2018). Retrospective data collection for sub-study V took place in the summer and fall of 2018 after the first set of interviews (sub-study IV) were analyzed. **Figure 4** shows the timeline for this dissertation compared with the launch of the NRRP.

5.3 The Intervention and Implementation Strategy

This dissertation relies on two vital study components: the *innovation* and the *implementation strategy*. In implementation science research, the *innovation* relates to the "thing" that is to be put into practice. This "thing" should have been previously deemed efficacious, and effectiveness trials should be completed prior to or in conjunction with implementation studies. In this case, the NRRP is the *innovation*. Within this Program, there are three core components (as described in detail in section 2.2):

1. NRRP website and hotline assistance,
2. financial incentives, and
3. social marketing to promote the NRRP to farmers.

Through the NRRP, all states have access to the website and hotline assistance. Financial assistance is available in those states where specific funding has been allocated, as well as through a small pool of national-level funding. Social marketing messages are only available in states in which there is ample funding for rebates.

Along with these core components are several peripheral components of the NRRP, including specific rules and guidelines about who may participate and what restrictions there are for participation. After launching the Program in seven states (New York, New Hampshire, Vermont, Pennsylvania, Massachusetts, Wisconsin, and Minnesota), it became evident that these pieces required flexibility in order for the Program to be adaptable to new regions.

The *implementation strategy* refers to the methods used to put the "thing", in this case the NRRP, into practice. This study uses a scale up approach, meaning that the goal is to develop a single national-level Program based on prior efforts. This is compared to spreading innovations, which is defined by multiple small, localized implementation efforts (81).

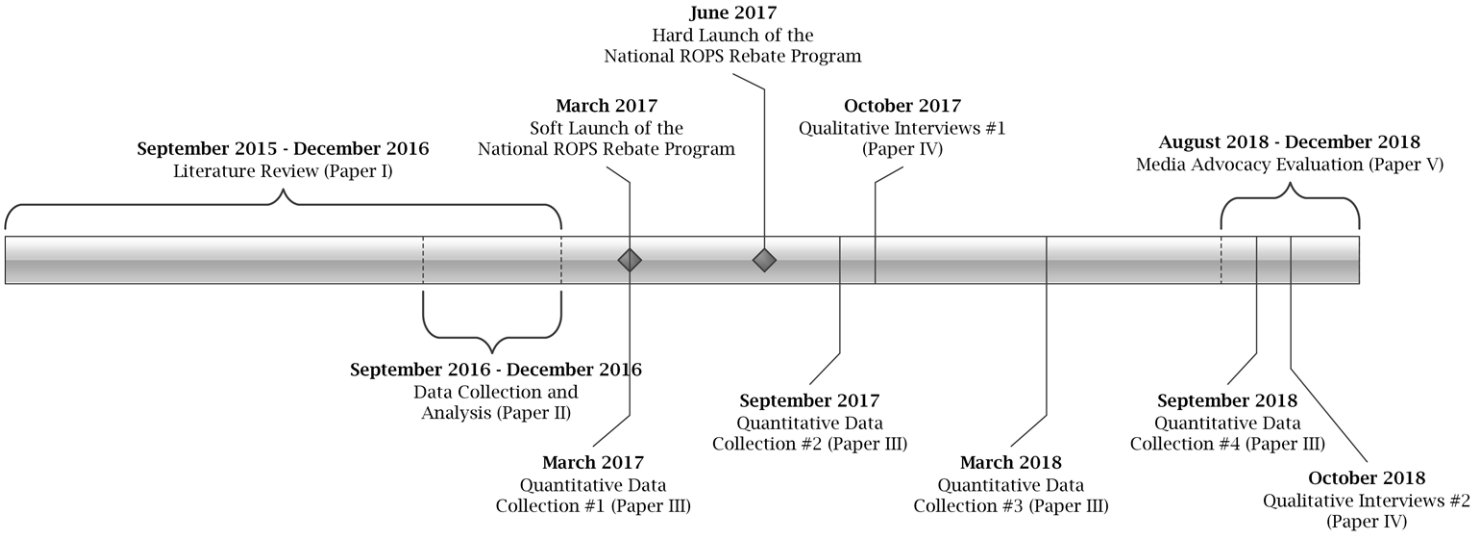

Figure 4: Dissertation timeline relative to the NRRP launch.

Though the program is already formally known as the NRRP, full implementation will not be achieved until all states have sufficient funding to meet the demand for ROPS.

In planning for the NRRP implementation and preparing the grant application, the NRRP was intended to be implemented through the use of a formal media advocacy campaign. This would have allowed the use of various media sources to spread information about the burden of tractor overturns and the need for the NRRP to stakeholders in states where farmers are at higher risk for tractor overturns. According to a literature review conducted by Powell et al., which identified commonly used implementation strategies, this strategy would have been classified as a form of *training and educating stakeholders* (82). However, given the pushback that was received from media partners who did not believe in the feasibility of involving journalists in the implementation, this strategy was modified. This change took place in late 2015, shortly after the study grant began but before the research presented in this dissertation began. Instead, efforts focused on "low hanging fruits;" in other words, those states that displayed some interest in providing state-allocated funding for the NRRP (for example, Maine, Ohio, and Oregon). Over time NRRP staff worked one-on-one with champions in these states, often National Tractor Safety Coalition members (described more under section 2.3), on securing funding. This involved using the Powell et al. strategy of *developing stakeholder interrelations* to identify and make the appropriate connections between farmers, non-farming stakeholders, and potential funders in each state or region. In addition, these connections were used to *train and educate stakeholders* about the NRRP and its benefits. In many cases, these efforts led to initiatives to support legislators in creating policy to fund the ROPS Rebate Program (*changing infrastructure*). Despite this progress, passing and implementing policy does take time. Thus, no new states were funded within the study period (September 2015 through August 2018).

5.4 Study Population and Data Sources

5.4.1 Study Population

In terms of the study population, this dissertation focuses, primarily, on the National Tractor Safety Coalition, as this group is responsible for the implementation of the NRRP. As described in section 2.3, the National Tractor Safety Coalition was organized in an effort to mobilize resources for the NRRP and includes approximately 60 stakeholders from nine sectors. These sectors include manufacturers and dealerships, agricultural organizations, safety and health organizations, financial and insurance organizations, government,

researchers, private corporations, the media, and a small number of farmers (51). In terms of how the CFIR and Proctor Taxonomy were conceptualized for this study, the National Tractor Safety Coalition is included in the *inner setting* (**table 4**). In addition to these individuals other *inner setting* factors include the processes, policies, and events of these individuals.

Table 4: Conceptualization of the CFIR and Proctor domains in terms of the NRRP implementation project.

Domain	NRRP Application
Characteristics of Individuals	• Individual members of the inner and outer settings (listed below)
Inner Setting	• NRRP staff • National Tractor Safety Coalition steering committee • National Tractor Safety Coalition • Processes, events, and policies of the National Tractor Safety Coalition and the NRRP
Outer Setting	• Non-National Tractor Safety Coalition stakeholders • Farmers • Processes, events, and policies external to the National Tractor Safety Coalition and the NRRP
Intervention Characteristics	• State-based ROPS Rebate Programs (pre-implementation) • NRRP (post-implementation)
Process	• Securing funding for and expanding the ROPS Rebate Programs to the NRRP
Implementation Outcomes	• Of the NRRP
Client Outcomes	• Of farmers

Two main groups are represented in the *outer* setting: non-National Tractor Safety Coalition stakeholders and farmers, as well as the policies, practices, and events related to these individuals. In addition to National Tractor Safety Coalition members, non-Coalition stakeholders are also considered part of the study population in sub-study IV. This was done in order to gain perspectives of those who chose not to participate in the National Tractor Safety Coalition, but who are connected in some way to the NRRP implementation. Though the study is designed to benefit farmers, they were not highly represented in the research conducted for this dissertation. Previous work related to the development of the ROPS Rebate Programs was conducted in close collaboration with farmers (29, 36, 38, 41, 42) (see table 2 in section 3.2). The work conducted for this dissertation; however, was intended to scale up the state-based Programs, as it had already been determined that the Program was favorable to and being used by farmers.

Thus, the implementation research was focused on the process of mobilizing upstream support for expanding these Programs. While farmers are involved in the National Tractor Safety Coalition and the implementation of the NRRP, this involvement is often minimal (e.g. sending a letter to their government representative) and often takes place through organizations such as Farm Bureau and Cooperative Extension, which are formally represented on the National Tractor Safety Coalition. Given this structure, farmers are not involved in the day-to-day activities of implementation that this study focused on; only one farmer was personally involved in the National Tractor Safety Coalition during this study. Thus, limited survey data was collected from this group for sub-studies II and III, and farmers were not included in the interviews conducted for sub-study IV. However, it is important to note that some of the participating stakeholders who represent various organizations on the National Tractor Safety Coalition also consider themselves to be part-time, active farmers.

5.4.2 Data Sources

The various sub-studies included in this dissertation utilize both primary data collected from the study population, as well as secondary data sources. Sub-study I relies solely on published research papers pertaining to research translation in the agriculture, forestry, and fishing safety and health sector. Sub-study II focuses exclusively on surveys collected from National Tractor Safety Coalition members. Sub-study III utilizes a mixture of data, including repeat measure surveys with National Tractor Safety Coalition members and data collected though the NRRP hotline. The data collected from the NRRP hotline includes three outcome measures: 1) *progress* toward securing rebate funding, 2) NRRP *intakes*, and 3) completed *retrofits* (to be described further in section 5.8.2). Sub-study IV is based on interviews conducted with both National Tractor Safety Coalition and non-Coalition stakeholders. Finally, sub-study V utilizes news media reports that have been published about the ROPS Rebate Programs since 2006.

5.5 Composition of this Dissertation

As indicated, this dissertation is comprised of five sub-studies. The methodology for each of these sub-studies will be presented in the following sections in the order that the studies were conducted. Because sub-studies III and IV are closely intertwined (both evaluating the NRRP implementation; one quantitatively and one qualitatively), these sub-studies are described together. The results (described in section 7) of each study are presented in a similar fashion, with a final section highlighting the combined results of sub-studies III-V.

5.6 Understanding the Research to Practice Gap (Sub-study I)

Initially, a scoping literature review (83, 84) using qualitative analytical methods was intended to help understand what was already known about implementation science in occupational safety and health settings. Throughout the study, it transformed into somewhat of a gap analysis, as it served to highlight the fact that few studies had progressed to widespread implementation.

5.6.1 Study Design

Though the NRRP focuses solely on agricultural populations, ideas and practices for improving worker safety are often shared between different occupations. Most often, agriculture is discussed along with forestry and fishing work. Given this, the literature review focused on all three occupations. In addition, construction and mining were also included in an initial review phase as prior collaboration and discussions with researchers in those areas had suggested that an abundance of research translation work was occurring in those settings.

In conducting the review, the PIECES methods of systematic reviews was followed (85). This process guides researchers in the Planning, Identifying, Evaluating, Collecting, Explaining, and Summarizing stages of literature reviews, and sets authors up to meet formal reporting standards, such as PRISMA. Though a guide for systematic reviews was used to structure the review, the study culminated into a scoping literature review. Compared to systematic reviews, which are more common, scoping reviews allow researchers to explore broadly defined topics and limit the scope over the course of the review (86). Further, scoping reviews can be used more effectively to map out what is already known about a topic, which was more aligned with the research objectives, versus comparing specific study results (as is done in systematic reviews) (86).

In starting the review process, I worked closely with an information specialist familiar with occupational safety and health research. Primarily, this collaboration served to identify the databases and search terms that would be most appropriate for this study. In the end, six online databases were selected for the literature search: PubMed, Scopus, Web of Science, Medline, Psychinfo, and ProQuest Dissertations. Having selected these databases, a handful of search terms were trialed to ensure that the official searches would result in the right type of references (i.e. those related to research translation in the occupational safety and health settings described previously). Based on these trials, combinations of terms were found to be most efficient. Thus, moving forward a combination of a topical term (e.g.

research translation), occupational safety or health, and an industry-related term were used. Industry definitions were developed using the North American Industry Classification System (87).

5.6.2 Data Collection

In conducting the first review, the following inclusion and exclusion criteria were used. First, in order to be included in the study, references were required to discuss research translation in agriculture, forestry, fishing, construction, or mining safety and health. Second, any literature format was acceptable, including grey literature. Third, all literature published on or before July 20, 2016 was eligible. Articles were excluded if they did not meet the appropriate North American Industry Classification System industry definitions for the sectors involved, did not focus on occupational safety or health, or were not available in English.

Upon completion of all database searches, 6,527 references were identified. Duplicate references were removed, resulting in 2,169 unique references. Titles and abstracts of these references were reviewed to determine which should be included in the study based on the criteria outlined previously. To complete the title and abstract appraisal I, along with an additional reviewer, evaluated all of the references individually. The list was then compiled and we worked together to resolve discrepancies and determine whether or not references should remain in the study.

After the title and abstract review was completed, I conducted full text reviews on the remaining titles. When necessary, supervisors and research team members were asked to review and provide feedback on specific references. Most often, this involved discussions of whether or not references met the definition of 'translational research.' During this phase, it became clear that not all articles/references defined and used 'translational research' in the same way. This was particularly problematic when evaluating review articles and summaries. To help eliminate discrepancies as a result of this issue, the authors determined that only original research should be included in the study. Once all texts had been reviewed fully for inclusion in the study, a single reference from the construction sector remained (see **figure 5** for the process flow chart). Upon review of the bibliography of this reference, it appeared that no other studies met the criteria required for this review.

In examining the references identified through the initial review, it became very clear that not only were there few examples of widespread research translation in these occupational settings, but research translation was not clearly or consistently defined among occupational safety and health researchers. Thus, it was difficult to gain a clear perspective on challenges

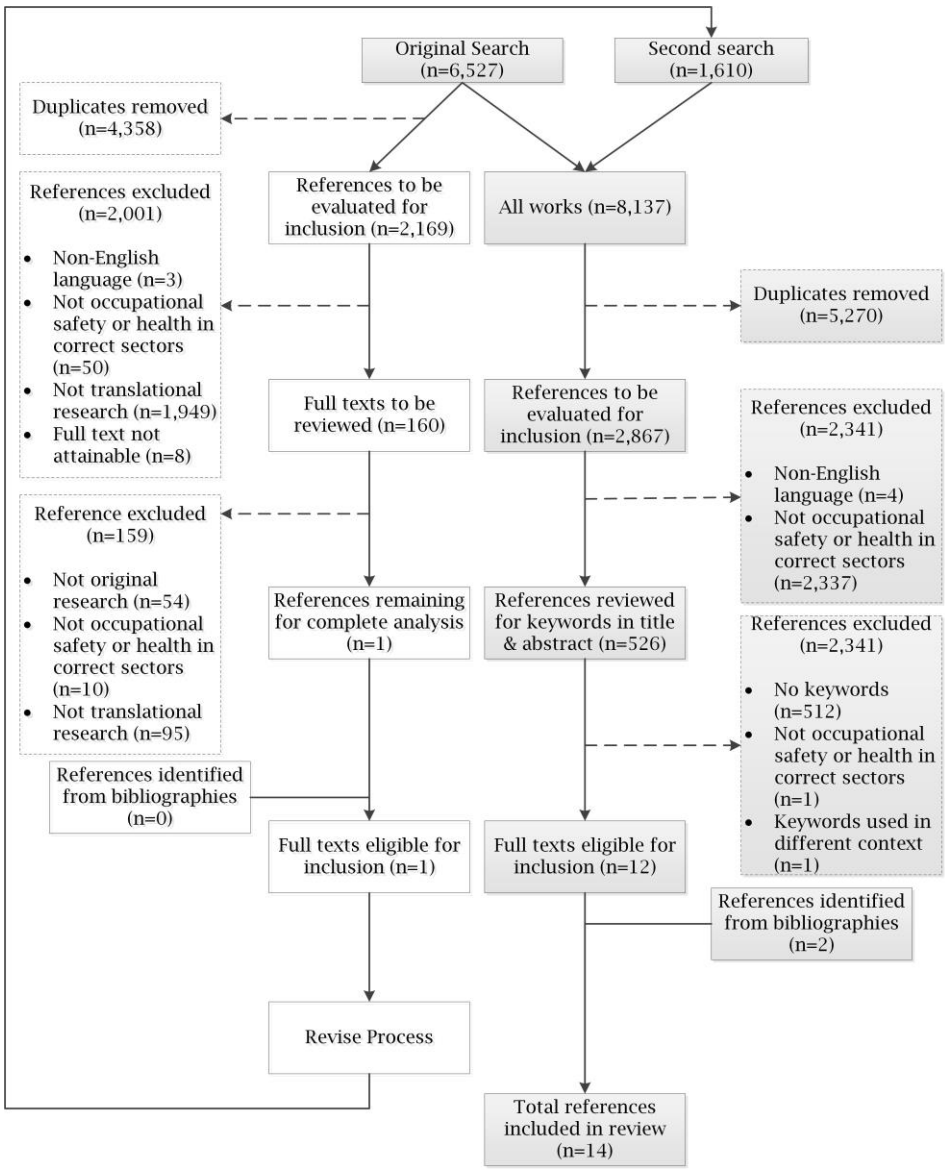

Figure 5: Literature review process.

and opportunities faced by the research community, particularly when considering specific stages of research translation. To address this, the study aims were modified to more broadly understand research translation efforts in agriculture, forestry, and fishing safety and health. In addition, the literature also served as a starting point for adapting the T0-T4 research

translation process model used by the NIH (**table 1** in section 3.1) (64) to occupational safety and health settings.

Though originally an unanticipated aspect of the study, this revision aimed to provide a structure for categorizing and evaluating research to practice progress in agriculture, forestry, and fishing which in turn increases consistency and clarity in discussing such efforts. After examining the findings of the initial literature review (which returned only one reference), it became clear that this would be a necessary step for framing the remainder of the sub-studies in this dissertation. The T0-T4 model was specifically selected for adaptation to this setting due to its reputability among agriculture, forestry, and fishing safety and health researchers. Though its' specific use is rarely documented in published manuscripts about agriculture, forestry, and fishing safety and health (only one such publication could be found at the time (88)), conversations with other researchers have demonstrated that this is the most well-known implementation science process model among this group.

In addition to modified aims, additional search terms were included to widen the scope of implementation science articles that were returned. The final list of search terms is shown in **table 5**. Searches (at this stage, as well as in the initial search) were conducted using combinations that included one search term from each category.

Table 5: Literature review search terms. Modified from Tinc et al., 2018 (sub-study I) (65).

Category 1	Category 2	Category 3[a]
• Research to practice • Translation research • Diffusion of innovation • Evidence-based medicine • Research design • Research translation • Scale up[b] • Implementation science[b]	• Occupational safety • Occupational health	• Agriculture • Farm* (Farms, farming, farmers) • Forest* (Foresters, forestry) • Logg* (Logging, loggers) • Fish* (Fishing, fisheries, fishermen, fishers) • Commercial fish* (Commercial fishing, commercial fisheries, commercial fishermen, commercial fishers)

[a]Terms in category 3 are listed as, "truncated search term* (all related search terms)." In conducting literature searchers, asterisks indicate that the term is truncated and that all complete terms should be searched.
[b]Search terms added after the initial literature review.

Because the new aims would have likely expanded the number of results identified, it was also decided that only studies relating to agriculture, forestry, and fishing would be used.

In modifying the search terms and scope of the study, an additional 1,610 citations were identified for potential inclusion. Including results from the original search, this brought the total number of unique citations to 2,867. Of these, 2,337 were not related to agriculture, forestry, and fishing research (this number was rather high due to the original inclusion of construction and mining research), and four were not available in English; thus, these were removed.

The remaining 526 articles were reviewed. References that had one of the topical search terms in the title or abstract were retained for the final analysis (n=12). This decision was made in order to capture as many citations as possible, as many would not have otherwise fit the definition of research translation that had previously been defined. In addition to these 12 manuscripts, two additional ones were identified from the bibliographies for a total of 14 included references.

5.6.3 Data Analysis

The final 14 references were analyzed using NVIVO qualitative data analysis software (89). Texts were coded in-vivo, and categories were developed to reflect the phase of research being described. These category headings remained close to the original text and included phases such as prioritizing needs, pilot testing, diffusion, dissemination, and implementation, among others. Once these categories were developed, they were matched with the appropriate phase of the T0-T4 implementation process model. Finally, the results of this study and the knowledge gained through conducting it were used to revise and expand the NIH T0-T4 model so that it is more tailored for occupational safety and health research, particularly for agriculture, forestry, and fishing populations. In doing so, this new model also helps measure progress (or lack thereof) toward improving end outcomes in agriculture, forestry, and fishing. The results of this sub-study were used as a starting point for sub-studies II through V. In particular, the process model proposed was used to frame prior research on the ROPS Rebate Program as well as research for this dissertation, which is focused in the T3 phase.

5.7 Adapting the CFIR and Proctor Taxonomy to Agricultural Safety Settings (Sub-study II)

The remainder of this dissertation is focused on trying to more fully understand how to move innovations from the T0-T2 phases into the T3

phase of research, as defined by the model presented in sub-study I. That is, the remainder of the dissertation focuses on examining the process of scaling up the ROPS Rebate Program to the national level. In order to evaluate the implementation of the NRRP using the CFIR and Proctor Taxonomy, it was first necessary to ensure that the constructs and domains were appropriate for agricultural settings. Further, because the CFIR and Proctor Taxonomy are so comprehensive, it was necessary to limit the scope of the evaluation to only those constructs that appeared most important for the implementation of the NRRP.

In order to adapt the CFIR and Proctor Taxonomy to this particular research setting, surveys were developed to collect feedback from National Tractor Safety Coalition members on which constructs, or implementation factors, were likely to have the greatest effect (either positive or negative) on the launch and sustainability of the NRRP.

5.7.1 Construct Selection Survey Development

In developing the construct selection survey instrument, an attempt was made to remain as close as possible to the CFIR and Proctor Taxonomy so that the results could later be compared to those of other studies utilizing the same frameworks. As such, the original survey instrument was more complex than was intended.

Six National Tractor Safety Coalition members provided feedback on the survey instrument via Think Aloud interviews (90). While traditional pilot testing could have been used, Think Aloud methods allow for a more in-depth discussion of sample materials, and provide the basis for researchers to understand why something is occurring. This is contrasted to more traditional pilot testing methods, in which a researcher may see that issues have come up, but may not have the opportunity to discuss the cause of the issues with participants. During this pilot test, in particular, the Think Aloud method meant that participants were asked to verbalize their approach to answering various questions (i.e. the factors that were considered and the thought process that got the participant from the question to the answer).

In this case, using Think Aloud to pilot test the survey instrument proved vital in ensuring that participants and researchers had a similar understanding of the survey questions. Though there were issues with complexity, one of the biggest challenges was framing the survey questions in such a way that National Tractor Safety Coalition members with diverse backgrounds were led to reflect upon the complexities of the real-world scenario. In initially describing the thought process behind responding to the questions, participants tended to view the world as somewhat static; what

was true at the time of the discussion would hold true over time in their minds. As such, the primary focus for participants tended to be on the constructs that were perceived as lacking at the time of the Think Alouds, rather than factors that were most important for moving forward with the implementation. This could pose an issue, as opinions, priorities, and behaviors (individual and organizational) could change over time, thus leading to potential challenges that were not an issue at the time.

During the Think Aloud interviews, I took time to revise unclear questions with participants. In the end, this helped connect the dots between the questions I was asking and the questions that the participants were responding to.

Once the Think Aloud interviews were complete, significant revisions were made to the survey instrument. These revisions went a long way in making the survey more user-friendly to non-researchers as well as researchers in different fields (e.g. engineering). In the final version of the survey, participants were asked to rate how important they felt different factors (constructs) were to the implementation process. The final version of the construct selection survey can be found in **appendix 1**.

5.7.2 Data Collection

The construct selection survey was distributed to all National Tractor Safety Coalition members using various modes: email, mail, and telephone. A sample of the schedule that was used for each survey is below.

Day 1: Survey link emailed to National Tractor Safety Coalition members.
Day 8: Survey mailed to non-responders.
Day 15: National Tractor Safety Coalition members emailed, thanking those who have responded and reminding those who have not to complete the survey.
Day 22: Follow-up phone calls made to non-responders or follow up emails sent to stakeholders whose phone numbers were not available.
Day 29: Survey closed.

All web-based surveys were entered directly into one of two web-based survey platforms. From October 2016-September 2017, Survey Monkey, a widely available survey website was used (91). In October 2017, Bassett Healthcare Network obtained a license for Research Electronic Data Capture (REDCap), a survey database system developed by Vanderbilt University for securely collecting research data (92, 93). Thus, the surveys conducted after this time point were collected through REDCap. Mailed surveys were entered into the

survey database upon receipt of the paper copy. No surveys were conducted over the telephone, though participants were given the option.

The mixed-mode survey design adapts the methods recommended by Dillman in *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method* (94). Distribution of surveys in multiple formats provides several benefits to both the participants and the researchers. First, participants have several options for completing the survey, and can thus use whichever format they are most comfortable with. Second, because survey invitations arrive in multiple ways, participants are more likely to see and pay attention to the requests. Finally, because the reminders are only given to non-responders, the more resource-intensive survey distribution methods (mailings and telephone calls) are reserved for a smaller number of participants.

5.7.3 Data Analysis and Construct Selection

Once collected, construct selection survey data was analyzed for the National Tractor Safety Coalition as a whole. For each CFIR and Proctor construct, the average score was calculated based on survey responses, which ranged from 1 (not at all important) to 5 (extremely important).

Using the average scores as a starting point, the constructs were then considered first individually by three researchers (including myself), and then as a group. Final selection was based on consensus between the three of us.

While the constructs could have been selected solely on the average scores (determined by National Tractor Safety Coalition members), this may have resulted in some important oversights. In preparing to work through this process, the main concerns were with 1) constructs that the study funders were likely to have found to be relevant, and 2) constructs relating to the National Tractor Safety Coalition itself, which had required tremendous resources to build and maintain. The constructs selected through this process were used as the foundation for sub-studies III and IV.

5.8 Evaluation of the NRRP Implementation using the CFIR and Proctor Taxonomy (Sub-studies III and IV)

Sub-studies III and IV aim to evaluate the NRRP implementation in terms of the CFIR and Proctor Taxonomy, as it was adapted to this setting in sub-study II. As indicated previously, these sub-studies took a QUAN→QUAL mixed methods approach, in that the quantitative survey undertaken for sub-study III led to the development of the qualitative interviews described in sub-study IV. This process is shown in **figure 6**.

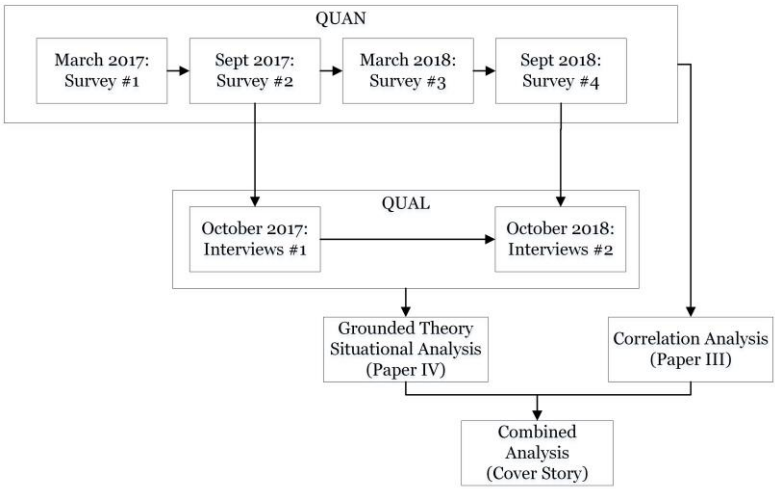

Figure 6: QUAN-->QUAL data collection and analysis process for sub-studies III and IV.

5.8.1 Study Design

The 21 constructs selected in sub-study II were evaluated to determine the best ways in which to capture data: repeat measure surveys, interviews, or data collected through the standard hotline processes.

Both repeat measure survey questions and qualitative interview questions were developed based on recommended measures for each construct (95). Surveys were developed using mainly Likert-scale questions and covered 15 CFIR and Proctor constructs that could be measured quantitatively. In the first part of the survey, participants were asked to rate their level of agreement with various statements. Each statement related to one of the constructs identified in sub-study II. The second part of the survey focused largely on stakeholder engagement. First, participants were asked about their perceived roles on the National Tractor Safety Coalition and in the implementation of the NRRP. Then, participants were asked how often they participated in activities related to each of those roles (from "not at all" to "more than one to two times per week"). The final two questions asked partners to reflect on which organizations or individuals should be involved in the implementation process and were asked during the first and third surveys only. The complete survey instrument can be found in **appendix 2**.

The interview guides were developed, initially, to focus on those constructs that could not be easily measured quantitatively. Based on sub-study II, the interview guide used for the first round of interviews (**appendix 3**) was broadly focused on a variety of CFIR and Proctor constructs.

In addition, data collected during the surveys and anecdotal information related to current events were also used to shape the interviews. The initial interview guide incorporated a total of 16 CFIR and Proctor constructs (including six constructs that were not measured quantitatively). As will be discussed in section 7.3, the follow-up interviews (interview guide provided in **appendix 4**) focused more on questions raised in the surveys and interviews, and emphasized questions about stakeholder engagement and related constructs. The follow-up interviews specifically discussed 17 CFIR and Proctor constructs, including eight that were not measured quantitatively or specifically asked about in the first round of interviews. All interview guides were discussed and revised with two supervisors who have qualitative research experience, as well as a program evaluator with a background in implementation research. Though the interview guide was developed using recommended questions for the CFIR and Proctor Taxonomy, participants were encouraged to discuss their responses more broadly to ensure that any relevant implementation factors were considered.

In addition to the survey and interview questions, two constructs were measured through the NRRP hotline processes. First, farmer *satisfaction* with the NRRP was measured through telephone surveys with every fourth NRRP participant. Since the original ROPS Rebate Program began in 2006, the Program has maintained a 99% *satisfaction* rate among participants. Second, *penetration* (*implementation outcomes*) was measured through three outcomes measures that are relevant to sub-study III and will be discussed in section 5.8.2.

Using the surveys, interviews, and passive data collection together, sub-studies III and IV help us understand which implementation factors (represented by CFIR and Proctor constructs) lead to increases in the three outcome measures described in section 5.8.2 (*progress*, *intakes*, and *retrofits*). This process is shown in **figure 7**.

5.8.2 Quantitative Data Collection (Sub-study III)

Surveys were distributed to all members of the National Tractor Safety Coalition using the same mixed-mode survey methods as were described for sub-study II. The first survey took place in March 2017, with follow-up surveys in September 2017, March 2018, and September 2018. Each survey asked participants to reflect on the six months prior (i.e. September through February or March through August). Multiple surveys were used in order to track any changes in construct measures over time. Changes in construct measures were then compared to changes in the NRRP, including increased or decreased progress in certain areas of the country. Each “survey item” represents one of

the CFIR or Proctor constructs; four of the 14 constructs included in the survey were measured using two or more survey items.

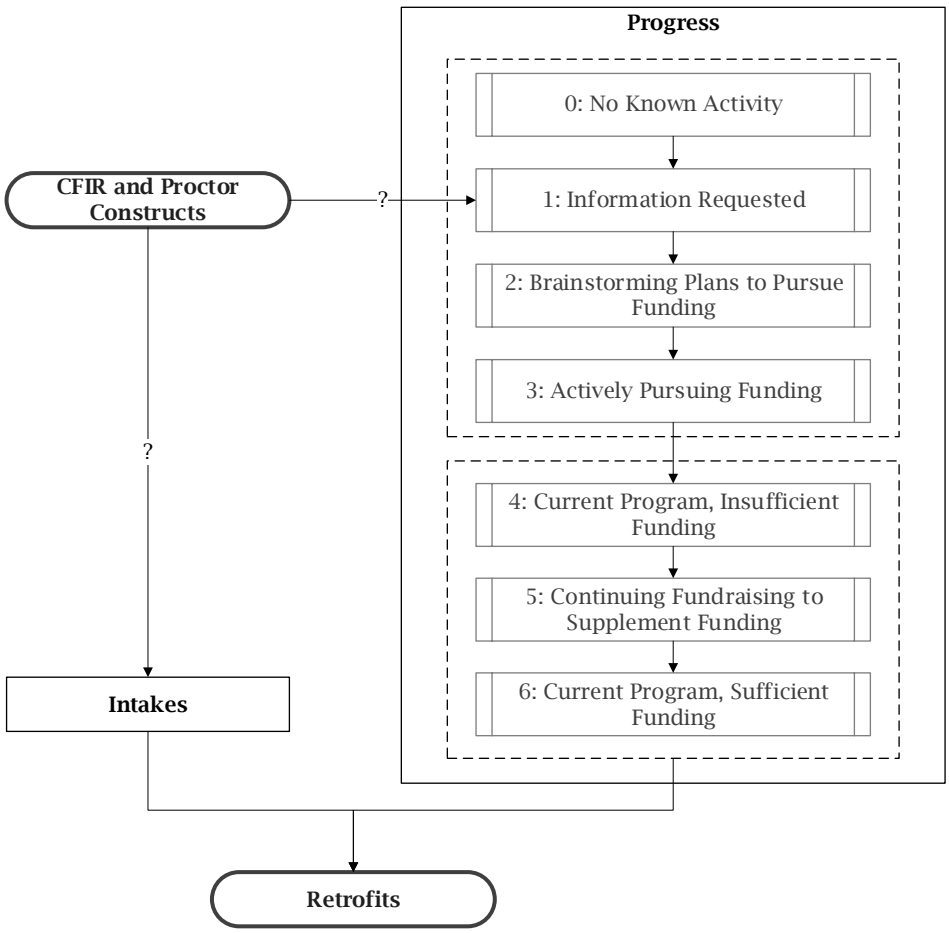

Figure 7: Depiction of the fundraising process and its relationship to CFIR and Proctor constructs, intakes, and retrofits.

In addition to those CFIR and Proctor constructs included in the surveys, penetration was measured through three outcome measures that are relevant to sub-study III. These measures are collected by NRRP hotline staff as part of the day-to-day activities First, the term *progress* refers to a states' headway toward obtaining state-allocated funding. These scores were between zero and six, with zero representing "no known fundraising activity" and six denoting "current program with ample funding," (**figure 7**). These *progress* scores were based on NRRP records including meeting notes, emails, and requests. Each

state received a score corresponding to each of the four survey periods previously described.

Intakes, which are defined as the number of individuals who sign up for the NRRP but have not yet retrofitted their tractor, and *retrofits*, which are defined as the number of individuals who complete retrofits through the NRRP, were also obtained from NRRP records. The date used to chronologize *retrofits* was the date that the individual first enrolled in the NRRP.

These three outcome measures were selected because they represent different phases of the process. *Progress* can be considered a short-term outcome in that it demonstrates stakeholders' engagement and success in moving toward full implementation of the NRRP. Similarly, *intakes* is a relatively short-term outcome that indicates our ability to appeal to farmers and engage them in the NRRP. Finally, *retrofits* can be considered a medium-term outcome. This measure reflects three things: 1) stakeholders' actions toward implementing the NRRP, 2) farmers initial interest in the NRRP, and 3) staff ability to retain participants throughout the retrofit process. The long-term outcome of interest, reduced tractor overturn fatalities at the national level, is not evaluated in this study because 1) the NRRP is not yet fully implemented, and 2) once implemented, several years' worth of data would be necessary to determine impact. Though this can't be done on a national level at this point, tractor overturn data is collected from participants annually and thus far has been used to demonstrate success in reducing overturn fatalities in New York (43, 47).

5.8.3 Qualitative Data Collection (Sub-study IV)

Maximum variation sampling was used to identify interview participants spanning the various stages of *progress* toward state-allocated funding, *engagement* with the National Tractor Safety Coalition, and *professional roles*. In selecting participants, every effort was made to capture a variety of audiences and perspectives of the implementation. The eligible participants thus included both National Tractor Safety Coalition and non-National Tractor Safety Coalition members. In the first round of interviews Canadian informants were included to provide an outside perspective of the NRRP implementation. Participants were recruited via email. In this initial email, the purpose of the study, expectations of participation (two 30 to 60 minute interviews approximately one year apart), and information to facilitate the informed consent process was provided to participants. Conference calls were scheduled with individuals who agreed to participate. Before each interview, interview guides were shared with participants so that they had time to reflect upon the questions before the interviews. Non-responders were contacted two additional times: once via telephone and once

via email. If at that point the individual still did not respond, another participant was selected.

Initial interviews began as individuals responded to requests; thus, some interviews took place before all participants had agreed. In conducting these interviews, it became clear that there were few individuals who could be considered highly involved in the NRRP implementation, despite including those who served on the steering committee. To address this, one of the implementation leaders who is not on the research team was included as a substitute for a non-responder. Initially this individual had not been selected to participate due to his close working relationship with the research team. Instead, initial attempts were to contact those who were likely to have more diverse viewpoints from the research team.

In preparing for follow-up interviews, participants were again contacted via email to schedule an interview time. Canadian partners were not included in these interviews, as the topics covered specifically related to engagement in the NRRP implementation. Because the NRRP is based in the US, engagement in its implementation was not an option for these individuals. In addition, one participant was not able to be contacted for follow-up, as the individual's email address and telephone number were both disconnected.

In the first round of interviews (fall 2017), a question related to stakeholders' perception of the *cost* of the intervention, was added to clarify survey data that suggested *cost* was not important to the implementation of the NRRP. Based on results from the surveys as well as the initial interviews, follow-up interviews (fall 2018) focused heavily on stakeholder engagement and predictors of it. As previously described, this is particularly important due to the diverse resources that each stakeholder brings to the table, and the limited ability to implement the NRRP without such collaborative relationships (this is described in section 2.3). Because the interviews followed an emergent design, memos were used to summarize key concepts of each interview. This way, as new ideas were brought up, they could be incorporated into subsequent interviews. For example, after several first-round interviews, it became clear that stakeholders were supportive, but not willing to engage in the implementation. In order to better understand why this might be and how it could be addressed, a question was added to the interview guide that asked participants to discuss another project they had been engaged in and how and why they were involved. Both first and second round interviews lasted approximately 30 minutes each. All interviews were audio-recorded and transcribed verbatim for analysis.

5.8.4 Quantitative Data Analysis (Sub-study III)

Initially, the intent was to compare changes in CFIR and Proctor constructs and ROPS outcomes (*progress*, *intakes*, and *retrofits*) across three intervention and one control region, as well as over time. These regions were: 1) the seven original ROPS Rebate Program states (New York, Vermont, New Hampshire, Massachusetts, Pennsylvania, Wisconsin, and Minnesota), 2) states that secured funding for the ROPS Rebate Programs over the course of the study period, 3) all other US states, and 4) Canada as a control region. The intervention regions differed in their access to ROPS rebate funds (which was largely state-based) and associated exposures to social marketing messages to encourage farmer participants. Because the social marketing messages are used to promote the NRRP to farmers, use of such messages prior to obtaining funding could provide a sense of false advertising and distrust of the NRRP. All three intervention regions had access to the hotline component of the intervention. Canada, on the other hand, served as a control, with no access to any part of the intervention.

As of the end of the study period, no new states had secured state-allocated funding for rebates, thus eliminating one of the planned intervention regions (region 2). While some states had moved up in *progress* scores, securing funding can take an extended period of time, and this did not occur within the 18 month period that this research focused on. In addition, after developing the survey instrument, it became clear that stakeholders not involved in the implementation (i.e. Canadian partners) would have difficulty responding to the questions due to the nature of them, therefore eliminating the control group (region 4). As a consequence, in order to ensure a sufficient sample size, the decision was made to base the analysis on ten US-based intervention regions instead (**figure 8**).

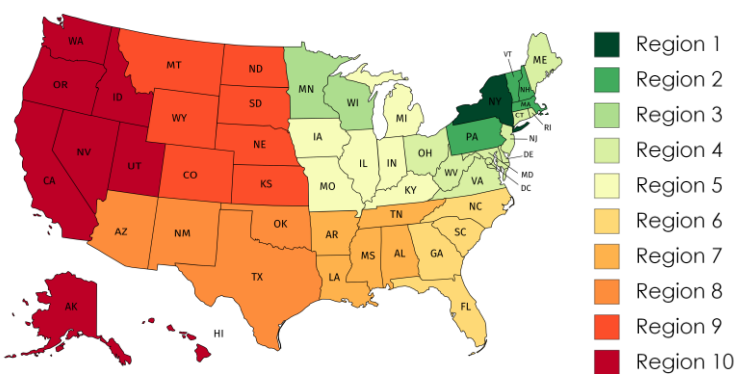

Figure 8: Map of intervention regions. Regions are divided based on geography and the presence of National Tractor Safety Coalition members. Originally published in Tinc et al., 2019 (sub-study III) (96).

All ten regions were included in the implementation strategy and had access to the website and telephone hotline for the NRRP. The ten regions were constructed based on 1) access to state-allocated funding and implementation of associated social marketing messages and 2) geographic location. First, New York was established as its own region due to the fact that the ROPS Rebate Programs had been established in this state and all state Programs and the NRRP are facilitated out of this state. The second and third regions were established based on having pre-existing funding and were divided based on geography: Vermont, New Hampshire, Pennsylvania, and Massachusetts formed the second region and Wisconsin and Minnesota formed the third. Because each of these three regions already had state-allocated funding for the ROPS Rebate Program, they also were able to implement the targeted social marketing messages which promote the NRRP to farmers.

The remaining seven regions were formed based primarily on geography. However, because not all 50 states have a National Tractor Safety Coalition member residing in them, it was important to ensure that at least one National Tractor Safety Coalition member resided in each region at each survey collection point. None of the states in these regions had secured state-allocated funding at the time of this study, and thus were not able to utilize the targeted social marketing messages.

Data from each survey time point was downloaded from the survey platform (either Survey Monkey or REDCap) and uploaded into SAS for analysis. Four by 10 mixed ANOVAs were used to compare changes in survey items, *progress* toward state-allocated funding, *intakes* into the NRRP, and completed *retrofits* between intervention regions and over time periods. No significant differences were seen for the effects of time (alone) or region by time. Thus, survey item scores, *progress*, *intakes*, and *retrofit* data were each aggregated across time periods within each region. These aggregate values were used to calculate correlations between survey items and the three outcome variables using Spearman's Rho.

5.8.5 Qualitative Data Analysis (Sub-study IV)

Once the initial interviews were completed, Grounded Theory Situational Analysis was used as the overarching analytical framework (97). Grounded Theory Situational Analysis was used as a way to incorporate and think about the various aspects of the implementation environment impact the NRRP. This helps to frame the analysis in such a way that factors besides individual discourse are considered.

First, I inductively coded interviews line-by-line. These codes were then combined with like codes to form categories, which were then further classified based on the situational elements described by Clarke (97):

- *Individual human actors:* Significant people in the situation.
- *Collective human actors:* Particular groups and organizations.
- *Non-human actors:* Relevant material "things."
- *Discursive constructions of human actors:* Language describing people.
- *Discursive constructions of non-human actors:* Language describing "things."
- *Major issues and debates:* Usually contested views in the situation.
- *Political:* Governmental aspects and politicized issues at any level.
- *Economic:* Financial aspects.
- *Temporal:* Historical, seasonal, crisis-based, or trajectory aspects.
- *Sociocultural:* Culturally-based and symbolic elements.
- *Spatial:* Related to physical spaces.

Using these codes, categories, and situational elements, several mapping exercises were used to better understand the data. Messy maps were used to describe how categories were connected. An example of a messy map focused on manufacturers is shown in **figure 9.** In practice, messy maps are created first by laying out all codes, and then connecting any related codes to a particular category or player. To enhance readability of **figure 9**, codes that were not connected, either directly or indirectly, to manufacturers were removed from this figure. Several messy maps were developed, each highlighting connections to one specific category or player.

In addition to messy maps, several positional maps were also developed to understand what gaps remained in the data. Positional maps, such as the one shown in **figure 10,** place participants on two axes to compare ideas about related issues.

Messy and positional maps provide the researcher with different ways to visualize the data. Once started, the researcher then refers back to the written transcripts and codes to further enhance the maps and to identify both key trends and gaps in the data. Once at this stage, I worked with two of my supervisors (who have experience in qualitative research) to review the coding and mapping processes. In addition, I collected feedback on the results from the leader of our evaluation team (who has implementation experience) and the ROPS hotline staff. In this study, the follow-up interviews were used to answer some of the questions that remained after processing the data in this way.

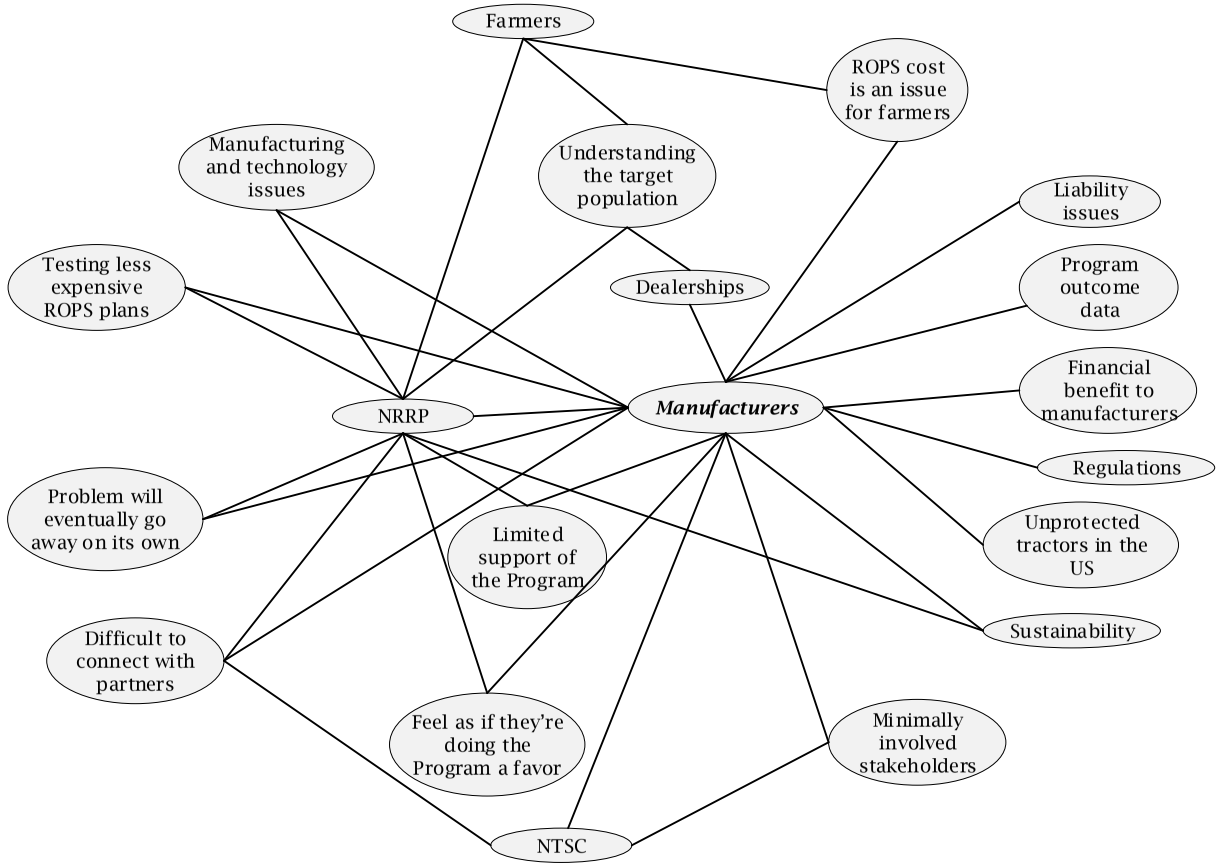

Figure 9: Example of a messy map focused on manufacturers. Elements not related to manufacturers have been removed for clarity.

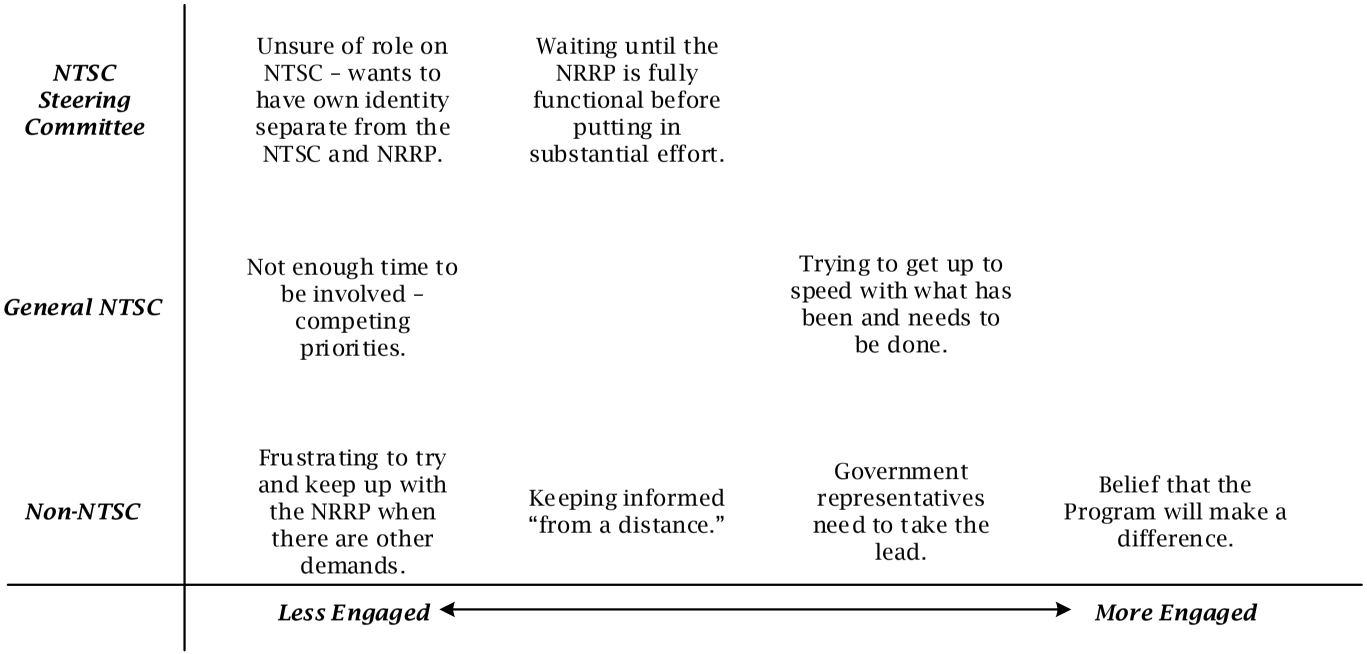

Figure 10: Example of a positional map showing stakeholders' roles on the National Tractor Safety Coalition compared to their engagement (determined by the research and hotline staff).

Once the initial interviews had been analyzed, the gaps presented were used to begin developing the interview guide for the follow-up interviews. Of major concern at this point was the disconnect between stakeholders supporting the NRRP and actually engaging in implementation. Thus, the follow-up interviews heavily focused on this area.

Once collected, follow-up interviews were again transcribed and imported into NVIVO for analysis. The follow-up interviews were then analyzed in the same way as the initial interviews. During this stage, no new codes or categories were developed; however, the follow-up interviews did serve to confirm and expand the original analysis. At the end of the analysis process, the themes developed were cross-referenced with the CFIR and Proctor constructs as a way of 1) validating these frameworks for use in the agricultural safety setting, and 2) evaluating the impacts of CFIR and Proctor constructs on the implementation process.

5.9 Understanding the Role of Media in the NRRP (Sub-study V)

Sub-study V was not originally planned as a portion of this dissertation, but was added in response to the research conducted for sub-studies III and IV. Through the surveys and subsequent interviews, it became clear that few stakeholders were aware of the political and media activity surrounding the NRRP implementation. In particular, around the time that the initial interviews for sub-study IV were being conducted and analyzed, a prominent US Senator launched a major campaign to preserve the NRRP, which fueled increased positive media coverage of the Program.

Realizing that political activity and media coverage could be an important component to the NRRP implementation process, and that this information was not being captured through either the surveys (sub-study III) or the interviews (sub-study IV), this manuscript was added. This sub-study served to examine the role that media and politics have played in the implementation and sustainability of the state and National Programs.

5.9.1 Data Collection

Over the course of the ROPS Rebate Programs, a database of media reports has been maintained by NRRP staff. The media reports in it were collected from newspaper clipping and alert systems including Burelles Luce and Google Alerts. These sources, along with any additional sources that could be identified by searching ProQuest Newspapers at the time of the research, were compiled and organized by the specific ROPS Rebate Program (either state-funded or National) that they related to. Thus, there were nine sub-sets of

media sources: New York, Vermont, New Hampshire, Pennsylvania, Massachusetts, Wisconsin, Minnesota, multi-state or National, and other.

5.9.2 Data Analysis

A discourse analysis for print media approach was taken to analyze the media sources included in this sub-study. Discourse analysis was selected as the analytical framework as it allowed us to understand how media coverage of events (in this case, of the ROPS Rebate Programs) can shape perceptions and thus the trajectory of such events. Each text was inductively coded using NVIVO, and memos were developed to track similarities and differences in the approaches to media used by each ROPS Rebate Program. In particular, three aspects were considered in this process: 1) the actual published text, 2) the process used to develop the text, and 3) the audience and the text's relationship to the audience.

In following through with this process, textual analysis (98) was used to assess the tone, content, and power structures portrayed in the print media reports. These components can be important, as they dictate how the media report is interpreted and what meanings are pulled from it. For example, the language, overall goal and structure of the media report, and the labels given to various actors presented in the piece can dictate how readers interpret the message. This in turn helps readers develop their own opinions about the event presented. As in this case, these perceptions can further help shape the trajectory of public health programs. While many of these outcomes can be dictated by the media itself, often, the values and culture of the target audience also play a role in how media reporters shape texts (99, 100).

After the coding process, which lent itself to the components described above, I, along with my supervisors, worked to compare the media portrayals of each ROPS Rebate Program to one another. This was beneficial in that while two of us are deeply connected to the daily activities related to the ROPS Rebate Programs, the other two supervisors could provide more of an outside perspective on the similarities and differences between the texts.

An external reviewer was also asked to review and summarize the media reports. Though no formal analysis was conducted by this individual, she was asked to comment on the aspects listed above. This secondary review helped to balance my own perspectives, which are somewhat biased based on my close relationship with the NRRP administration. Though there were no major differences between my analysis and the external reviewers', there were differences in the levels of importance assigned to different aspects of the media reports, which were considered in the final analysis. These differences

were embraced, and the results of the media analysis were presented and discussed based on the “middle ground.”

6 | Ethical Considerations

The work completed for this dissertation was approved by the Mary Imogene Bassett Hospital Institutional Review Board (project #2015). Each survey and interview invitation included ethical information, including 1) a notice that all responses would be kept confidential and no names or identifying information would be used, and 2) that participants were able to withdraw from the study at any time. For all surveys, consent was implied based on participants' responses. Verbal consent was given by all participants involved in the interviews conducted for sub-study IV.

Between September 2016 and January 2019, National Tractor Safety Coalition members were asked to participate in a total of eight surveys. In addition to the five surveys used in this dissertation, this also included three social networking analysis surveys for a separate, but closely related, study. In the US, participant incentives are commonly used to thank participants for their time and cover any expenses incurred as a result of study participation (e.g. travel costs). These incentives are often monetary (though this depends on the specific project), and are ethically appropriate as long as they are not considered large enough to significantly impact participation rates (101). In this study, National Tractor Safety Coalition members received one raffle entry for each completed survey. At the end of the eight surveys, a raffle was drawn for a 1,000 USD gift card. This method was chosen for two reasons. First, the research team felt that a chance to win one gift card of higher value was comparable to receiving a five USD gift card for each completed survey. Second, by giving only one gift card for a large amount, less money was spent on incentives, therefore preserving grant funds.

7 | Results

7.1 Understanding the Research to Practice Gap (Sub-study I)

7.1.1 Current Understanding of Research to Practice in Agriculture, Forestry, and Fishing Safety and Health

Fourteen studies were identified for inclusion in the literature review described in sub-study I. These articles focused primarily on agricultural safety and health initiatives (n=9), though three examined fishing research and two discussed agriculture, forestry, and fishing together. Per the inclusion criteria outlined in section 5.6.2, studies in this review included those that 1) focused on agriculture, forestry, or fishing safety or health initiatives, and 2) included one of the following terms in the title or abstract: research to practice, translational research, diffusion of innovations, evidence-based medicine, research design, implementation science, or research translation.

Within these studies, no clear distinction was made between the various phases of research translation. One possible reason for the lack of consistency is a lack of an appropriate process model applicable to agriculture, forestry, and fishing safety and health research. In practice, the NIH model (described in table 1 in section 3.1) is typically used; however, its utility in this setting has never been assessed. In conducting the literature review, it became clear that the T0-T4 model is not sufficient for capturing agriculture, forestry, and fishing safety and health processes. In particular, three issues were identified.

First, within the NIH T0-T4 model, there is an extremely limited focus on engaging target populations in formative research. As those in public health are aware, formative research is a key aspect of successful intervention development. It is in this stage that the researcher becomes acquainted with the target populations and begins to understand the cultural and contextual subtleties that have the potential to impact populations or their orientation to and perceptions of proposed solutions. Though this concept was recognized as a need in some of the reviewed literature (102, 103), other studies included in the literature review demonstrated that such work is often put off until after the innovation has already been developed (20, 88, 104).

A second major issue identified from the articles reviewed was the fact that in some cases, research was being moved forward in the T0-T4 process without ensuring efficacy, effectiveness, adoption, or sustainability. This goes hand-in-hand with the third barrier, which is that the NIH T0-T4 model has

no explicit mechanisms for obtaining and applying essential feedback on how solutions perform outside of the lab in the "real world." Thus, as researchers move through, there is little motivation for taking corrective action before moving on to the next phase. In the examples in which authors indicated that this had happened, the solutions that were widely implemented were not evidence-based, and resulted in static outcomes or unintended negative consequences (88, 105). Given that resources for implementation efforts are limited, it is vital that substandard solutions do not move into the T3 phase. Instead, those studies progressing through the translation stages must be thoroughly vetted before proceeding to each subsequent stage. The question then becomes, "how do we ensure that implementation resources are being appropriately allocated to effective solutions?"

These barriers further become issues when taking into account limited resources (financial, time, etc.) for addressing occupational safety and health issues. In addition, trust (of research and researchers) by target populations can become an issue if innovations are impractical, fail to meet the needs of the target population, and/or were developed without end-user input.

7.1.2 A Proposed Model for Research to Practice in Agriculture, Forestry, and Fishing Safety and Health

In an effort to begin a more meaningful conversation about research translation with other occupational safety and health researchers, the T0-T4 model was updated as part of sub-study I. The new model (**figure 11**) incorporated components to address the issues identified through the literature review.

The T0 phase of this updated model is the stage in which surveillance and descriptive studies are conducted in order to determine which public health outcomes are of greatest concern. This is followed by the T1 phase which includes formative research to develop innovations and small pilot tests to test those innovations. The T2 phase then focuses on larger scale pilot testing of the innovation. Once proven efficacious and effective in T1 and T2, diffusion, dissemination, and implementation strategies can be applied in T3 to encourage widespread adoption of the innovation. Finally, the T4 phase is used to evaluate the population impact of the innovation.

This model incorporates two main components to help ensure that implementation resources are appropriately allocated, rather than wasted on ineffective, non-sustainable solutions. First and foremost, researchers must understand that research translation is not a direct continuum; there may be setbacks, and changes to the innovation may be required.

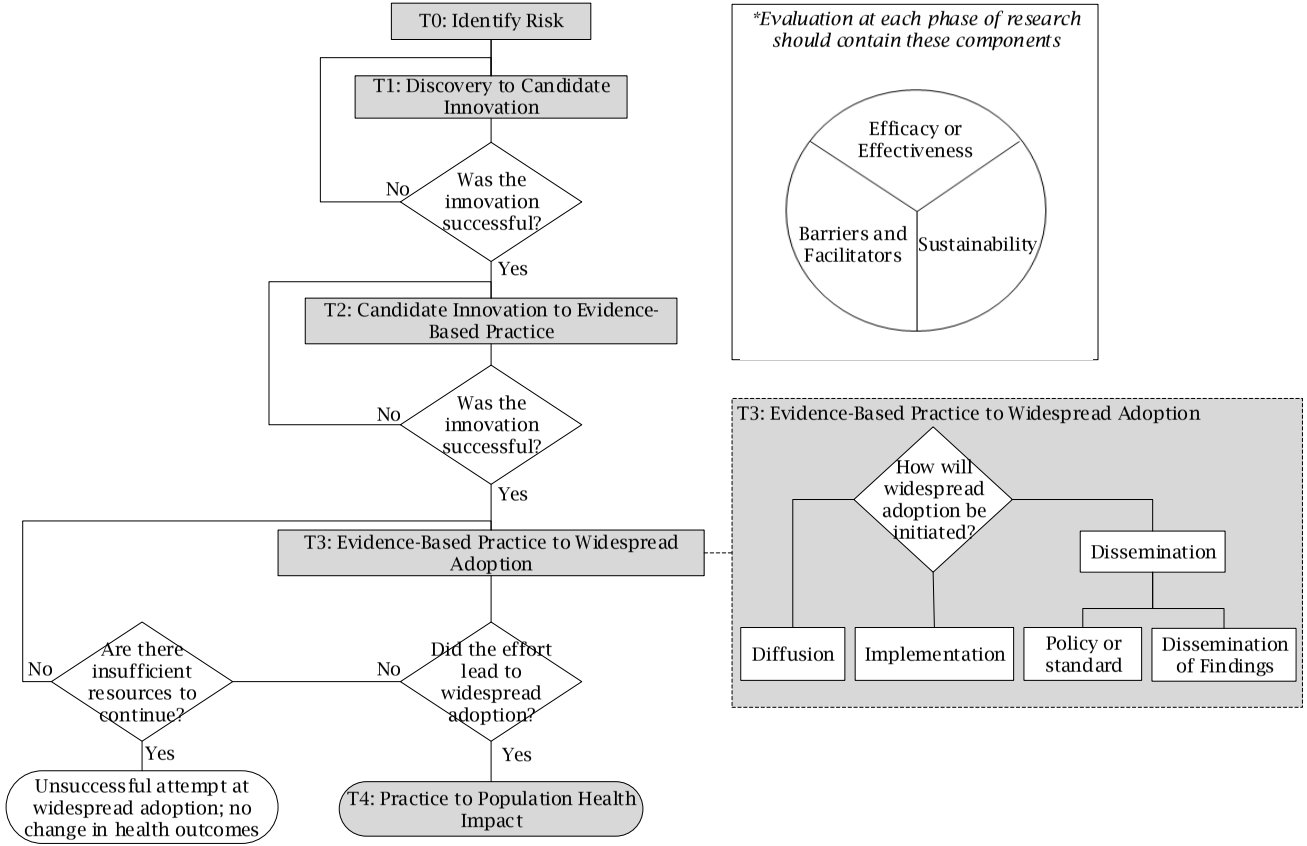

Figure 11: T0-T4 model proposed for agriculture, forestry, and fishing safety and health research. Originally published in Tinc et al., 2018 (sub-study I) (65).

To overcome this, feedback loops have been incorporated at each stage of the T0-T4 model. These feedback loops are initiated by the question, "was the innovation successful?" In order to answer this question, researchers must first evaluate the innovation; those areas which need to be considered (efficacy/effectiveness, adoption, sustainability) are all presented in the modified T0-T4 model. Efficacy relates to whether or not an innovation works in controlled settings, whereas effectiveness relates to whether or not an innovation works in real world situations (11). Adoption refers to whether or not the target population is receptive to the innovation and willing to use it. Finally, sustainability relates to the ability to maintain the innovation once the research has completed. Each of these components should be assessed at each stage of development. By doing so, issues can be addressed before expansion to new populations occurs. This will help preserve resources and increase the probability of success.

The model presented in this study also provides a framework to guide the trajectory of the ROPS Rebate Program research and expansion. As discussed earlier in this dissertation, the remainder of the sub-studies in this thesis focus on the T3 phase of research (depicted in the pop-out in **Figure 11**).

7.2 Adapting the CFIR and Proctor Taxonomy to Agricultural Safety Settings (Sub-study II)

Given the limited understanding of research translation in agriculture, forestry, and fishing, the remaining sub-studies aimed to learn more about these processes. The second sub-study in this dissertation was used to develop evaluation tools for use in sub-studies III and IV, which were used to evaluate an implementation study in this sector. Fifty-four National Tractor Safety Coalition members (75% of the total membership at that time) responded to the construct selection survey. CFIR and Proctor constructs were rated based on how relevant they were to the NRRP implementation.

On a scale of 1 (the construct is not at all important) to 5 (the construct is extremely important), the average score for each construct ranged between 3.11 and 4.78 (**table 6**). Nineteen constructs scored highly (defined by an average score of 4.25 or greater). The constructs with the highest scores were *farmer needs and resources* (4.78), *available resources* (4.67), and *cost* (4.64). Of these 19 constructs, 14 were included in the final evaluation. An additional seven low ranking (i.e. <4.25) constructs were also included. These decisions were made based on the selection process described in the methods (section 5.7.3). Thus, 21 constructs (bolded in the table) were selected for inclusion in the evaluation surveys (sub-study III) and interviews (sub-study IV) at this point. As described in sections 5.8.1, several additional constructs were added

Table 6: Average scores by CFIR and Proctor constructs. Constructs selected for the final evaluation are bolded. Originally published in Tinc et al., 2018 (sub-study II) (106).

	Domain	Construct	Overall (n=54)
Consolidated Framework for Implementation Research	**Intervention Characteristics**	**Cost**	**4.64**
		Evidence Strength & Quality	**4.63**[c]
		Design Quality & Packaging	**4.28**[c]
		Adaptability[b]	4.27
		Relative Advantage	4.22
		Trialability	3.77[d]
		Complexity	3.58
		Intervention Source	3.11
	Outer Setting	**Farmer Needs & Resources**	**4.78**[c]
		Cosmopolitanism	**4.35**
		External Policy & Incentives	3.98[e]
		Peer Pressure	3.45[d]
	Inner Setting	**Readiness for Implementation:**	**(4.44)**
		Available Resources	**4.67**[c]
		Leadership Engagement	**4.45**
		Access to Knowledge & Information[a]	**4.19**[c]
		Implementation Climate:	(4.05)
		Tension for Change	**4.43**[d]
		Goals & Feedback[b]	4.40[d]
		Relative Priority[b]	4.29
		Compatibility	4.11
		Learning Climate	4.02
		Organizational Incentives & Rewards	3.58
		Networks and Communications[a]	**3.98**[d]
		Culture[a]	**3.76**
		Structural Characteristics[a]	**3.59**[c]
	Characteristics of Individuals	**Knowledge & Beliefs About the Intervention**	**4.33**
		Individual Identification with the Organization	4.22[c]
		Self-Efficacy	4.09[c]
		Individual Stage of Change	3.85
		Other Personal Attributes	3.80[c]
	Process	Engaging:	(4.25)
		Champions	**4.62**[d]
		Formally Appointed Internal Implementation Leaders	**4.52**[d]
		External Change Agents	4.20
		Opinion Leaders	4.18
		Planning	4.24
		Reflecting & Evaluating[a]	**4.22**[c]
		Executing[a]	**4.15**
Proctor et al. Outcome Measures	**Implementation Outcomes**	Appropriateness[b]	4.60[d]
		Feasibility[b]	4.51
		Acceptability	**4.31**
		Penetration[a]	**4.18**
		Adoption	4.13
	Client Outcomes	**Sustainability**	**4.56**[c]
		Satisfaction	**4.53**[d]

[a]Low-ranking constructs included in the final evaluation after the review process. [b]High-ranking constructs removed from the final evaluation as a result of the review process. [c]One non-responder. [d]Two non-responders. [e]Three non-responders.

to the qualitative assessment (sub-study IV), resulting in the inclusion of 29 CFIR and Proctor constructs in the final evaluation tools (see **appendices 2, 3, 4**).

7.3 Evaluation of the NRRP Implementation using the CFIR and Proctor Taxonomy (Sub-studies III and IV)

Once the evaluation tools were developed in sub-study II, sub-studies III and IV applied these tools in order to evaluate the implementation of the NRRP. As described in section 5.8, sub-study IV built off sub-study III, in that the interview questions developed for sub-study IV were based on survey responses (sub-study III). Thus, the surveys conducted in March and September 2017 were used to develop the interview guide for October 2017. Similarly, all surveys and the October 2017 interviews were used to develop the interview guide for October 2018. To demonstrate how the results from each step built upon one another, the results of sub-studies III and IV are presented interchangeably here and based upon when each step was conducted in relation to the others.

A total of 74 National Tractor Safety Coalition members were invited to participate in at least one of the four surveys (participants were eligible for an average of 3.4 of the surveys each). The number of eligible National Tractor Safety Coalition members fluctuated over time due to individuals retiring, changing careers, or joining and leaving the National Tractor Safety Coalition for other reasons. Of those invited, 68 individuals (91.8%) completed at least one survey, with an average of 1.9 surveys completed per person. **Table 7** shows the response rates for each of the four evaluation surveys as well as the overall survey response rate.

Table 7: Response rates for the four repeat measure surveys.

	Respondents	Response Rate
All Surveys	141	57%
March 2017 Survey	34	50%
September 2017 Survey	32	49%
March 2018 Survey	37	60%
September 2018 Survey	38	69%

Sixteen stakeholders were invited to participate in interviews, as outlined in section 5.8.3. Of these, three did not respond to requests, and one additional participant was not able to be contacted for a follow-up interview. The primary stakeholder group, NRRP involvement, and state progress toward funding for each of these individuals (participants and non-responders) is shown in **table 8**.

Table 8: Interview participant characteristics.

Participant	Stakeholder Group	Involvement in NRRP	State Progress Toward Funding[a]
1	ROPS Manufacturer	Steering Committee	No Known Progress
2	University-based Engineer	Steering Committee	No Known Progress
3	ROPS Program Advisor	Steering Committee	State-Allocated Funding
4	Government	General Coalition	No Known Progress
5	Agricultural Outreach	General Coalition	Developing Plans/Fundraising
6	Agricultural Safety Researcher	General Coalition	Developing Plans/Fundraising
7	Agricultural Safety Researcher	General Coalition	State-Allocated Funding
8	Agricultural Safety Researcher	Non- Coalition	Developing Plans/Fundraising
9[b]	Agricultural Outreach/Farmer	Non- Coalition	Developing Plans/Fundraising
10	ROPS Distributer	Non- Coalition	State-Allocated Funding
11[c]	Agricultural Safety Researcher	Canadian	N/A
12[c]	Agricultural Safety Researcher	Canadian	N/A
13[c]	ROPS Manufacturer	Canadian	N/A
14[d]	Insurer	Steering Committee	Developing Plans/Fundraising
15[d]	Media	Non- Coalition	State-Allocated Funding
16[d]	ROPS Manufacturer	Non- Coalition	No Known Progress

[a]Progress toward funding is defined by the state in which the participant resides, not the participants' individual activities. This status was determined based on emails and contact records held by NRRP staff.
[b]Individual could not be reached for follow-up.
[c]Candian representatives were not included in the follow-up interviews.
[d]Individuals did not respond to interview requests.

7.3.1 Results of Surveys 1 and 2 (Sub-study III)

The survey item scores ranged between 3.41 and 4.73 (3= Neither Agree or Disagree and 5= Strongly Agree) in the first round of surveys (**table 9)**.

Table 9: Average survey item scores for surveys 1 and 2. (Continued on next page.)

Construct	Question	March (n=34)	Sept. (n=32)
Please indicate your level of agreement with the following statements (1 = Strongly Disagree; 2 = Somewhat Disagree; 3 = Neither Agree nor Disagree; 4 = Somewhat Agree; 5 = Strongly Agree)[a]			
Acceptability	• The NRRP is an acceptable response to tractor overturn fatalities.	4.59	4.81
Knowledge & Beliefs	• It is feasible to implement the NRRP.	4.73	4.32
	• The implementation of the NRRP is going well.	3.66	3.84
Tension for change	• It is important that the NRRP is implemented now.	4.50	4.52
Cost	• The cost of the NRRP has not prevented it from being implemented in my state.	3.41	4.29
Sustainability	• The NRRP is sustainable.	3.81	3.61
Farmer needs & resources	• Once implemented, the NRRP will meet the needs of my organization's target population.	4.00	4.00
Available resources	• I have the resources I need to promote the NRRP in my role.	3.43	3.68
Design quality & packaging	• NRRP materials (including the website, promotional materials, and information packets) are of high quality.	4.51	4.48
Access to knowledge & information	• NRRP information and materials are appropriate.	4.51	4.42
	• NRRP information and materials are engaging.	4.24	4.29
Reflecting & evaluating	• National Tractor Safety Coalition updates are helpful in allowing me to reflect upon progress toward implementation of the NRRP.	4.30	4.32
Leadership engagement	• The National Tractor Safety Coalition Steering Committee is supportive of the NRRP.	4.32	4.35
	• The National Tractor Safety Coalition Steering Committee encourages members to be involved in implementing the NRRP.	4.24	4.16
Evidence strength & quality	• Influential stakeholders (such as funders, manufacturers, or other influential individuals) are supportive of the NRRP.	3.84	3.66
Cosmopolitanism	• My employer encourages me to network with colleagues outside of my own setting.	4.25	4.09
What do you feel your role is in implementing the National ROPS Rebate Program? Check all that apply.[b]			
Engaging (perceived role)	• Monitoring progress so I can stay informed.	86.1%	84.4%
	• Providing feedback bout activities that others are planning and carrying out.	58.3%	50.0%
	• Sharing promotions and materials with partners outside of the Coalition.	75.0%	78.1%
	• Helping plan implementation activities such as events and fundraising.	27.8%	28.1%
	• Participation in implementation events.	27.8%	40.6%
	• Participation in fundraising.	25.0%	18.8%
	• Other.	25.0%	15.6%

In the past six months, how often have you done each of the following? (1 = Not at all; 2 = 1-2 times; 3= 1-2 times per month; 4 = 1-2 times per week; 5= More than 1-2 times per week)[a]			
Engaging (actual role)	Monitoring progress to stay informed:		
	• Read National Tractor Safety Coalition updates, information or materials.	2.84	2.90
	• Attended a National Tractor Safety Coalition webinar or conference call.	2.05	1.97
	• Attended a National Tractor Safety Coalition in-person meeting.	1.19	1.29
	Providing feedback about activities that others are planning and carrying out:		
	• Provided feedback or suggestions on National Tractor Safety Coalition activities or materials via a one-on-one email or call.	1.97	1.87
	• Provided feedback or suggestions on National Tractor Safety Coalition activities or materials during meetings or conference calls.	1.95	1.77
	Sharing promotions and materials with partners outside of the Coalition:		
	• Shared NRRP information or promotions with a group of individuals.	1.92	1.94
	• Incorporated NRRP information into a presentation or report that you were completing for another purpose.	1.72	1.68
	• Had a conversation about the NRRP with an individual(s) not involved with the National Tractor Safety Coalition.	2.14	2.23
	Helped arrange or plan National Tractor Safety Coalition activities or events.	1.33	1.26
	Participation in implementation events:		
	• Attended an event on behalf of the National Tractor Safety Coalition or NRRP.	1.22	1.26
	• Served as a spokesperson specifically for the National Tractor Safety Coalition or NRRP.	1.36	1.42
	• Recruited new members to the National Tractor Safety Coalition or connected National Tractor Safety Coalition members.	1.17	1.23
	Participation in fundraising:		
	• Helped submit a funding or resource request for the NRRP.	1.19	1.35
	• Met with potential funders to discuss funding the NRRP.	1.25	1.16

[a]Results are presented as an average of all responses.
[b]Results are reported as the percent of participants who selected each role.

The construct scores from the second round of surveys ranged from 3.61 to 4.81. No major changes in constructs were seen between the first two surveys (conducted six months apart).

Based on the results of the first two survey rounds, two areas of interest were identified. First, stakeholder engagement was much lower than the research team had hoped. This is shown by the constructs labeled *engaging (perceived role)* and *engaging (actual role)* in the table. The *engaging (perceived role)* measures indicate which activities National Tractor Safety Coalition members felt they were responsible for, with a low percent of National Tractor Safety Coalition members indicating responsibility for more complex implementation activities, such as fundraising. The *engaging (actual role)* measures indicate which activities National Tractor Safety Coalition members were actually engaged in and to what extent. Nearly all of these items scored between "1 (not at all in the last six months)" and "2 (1-2 times in the last six months)" on both surveys. Though this wasn't a new finding, the survey results confirmed patterns anecdotally-identified in the research and hotline staff members' interactions with stakeholders and highlighted the need to explore engagement issues further in sub-study IV.

Second, for the *cost* construct, many individuals agreed or strongly agreed with the statement, "the cost of the NRRP has not prevented it from being implemented in my state," (mean = 3.41 and 4.29 for the first and second surveys, respectively). This was contradictory to previous findings showing that the availability of rebate funding was a major barrier to fully implementing the NRRP. As a result of these two findings, questions relating to these areas were added to the interview guide for the first round of interviews.

7.3.2 Results of the Initial Interviews (Sub-study IV)

After the first round of interviews concluded, several types of situational maps were developed to explore not only how the CFIR constructs of *cost* and *engaging* impacted the research translation process but also how the other CFIR and Proctor constructs impacted implementation of the NRRP. In the first round of interviews this was explored by developing social worlds and arenas maps shown in **figure 12**, which focused on the primary discursive constructions (i.e. the discourses that are exchanged in discussion of the topic at hand, in this case the NRRP) presented in the data. These discursive constructions include the ideas that 1) the NRRP implementation is someone else's responsibility; 2) the problem (i.e. tractor overturn fatalities) will go away on its own, and 3) education is key [to reducing tractor overturn fatalities]. **Figure 12** shows how these discursive constructions, as well as key players (human actors) fit within the "tractor retrofitting world." These three discursive constructions tie closely to the *engaging* construct, as they each provide some explanation for why stakeholders are not engaged in the implementation process. In addition, though *cost* was a focus of these interviews, the discussions about cost revealed that participants were likely

thinking of the *cost* to participating farmers (rather than the *cost* to implement the NRRP) in answering the survey questions. Thus, much of the discussion about this construct fell into the realm of *farmer needs and resources* (which would fall within the farming arena in the situation and the map shown in **figure 12**).

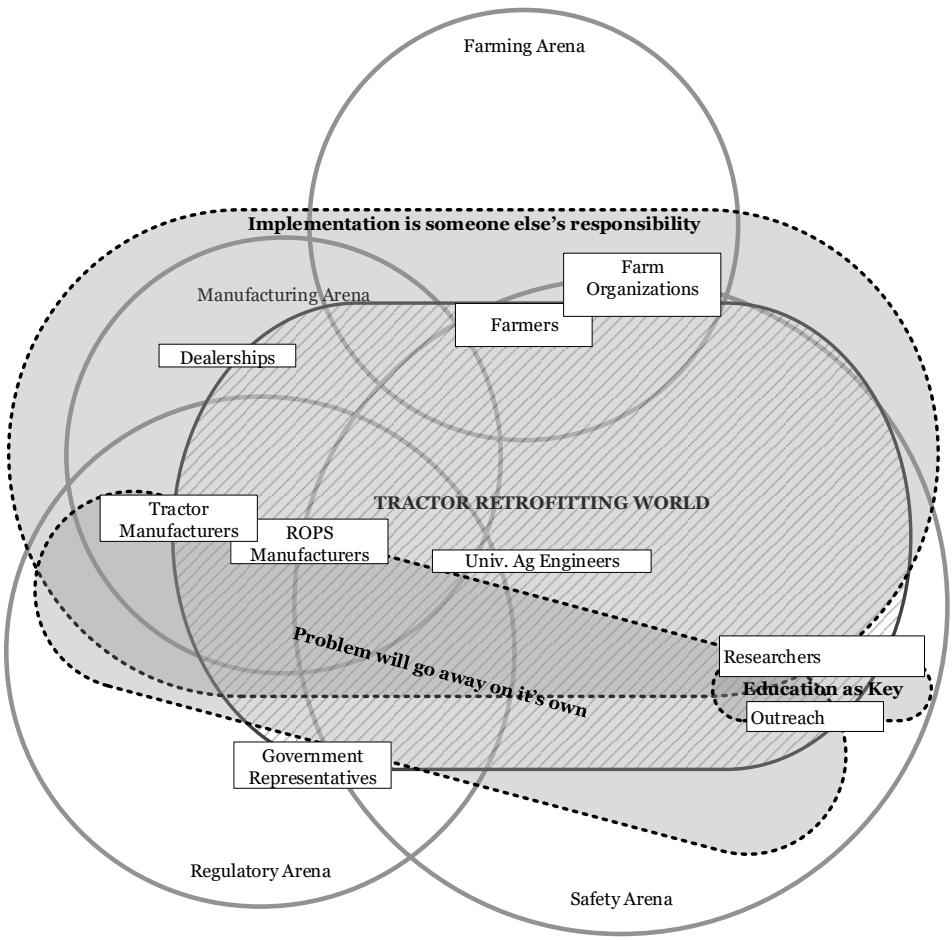

Figure 12: Social worlds and arenas map example. Embedded in the tractor retrofitting world are four related interest areas: farming, manufacturing, regulations, and safety. Within these arenas, several key players (white rectangles) and discursive constructions (solid grey ovals) are highlighted.

In considering the three discourses presented above, Cognitive Dissonance Theory (107) provides an understanding of why these discourses have been developed and sustained. Cognitive Discourse Theory is the idea that when individuals are forced to act in a way that is misaligned with their core beliefs, they naturally find ways to adjust their thinking to maintain mental and

emotional homeostasis (107). In this particular setting, this suggested that one of two scenarios was occurring. One possible scenario, which was discussed in the interviews, was that stakeholders were supportive of the NRRP implementation and wanted to be engaged; however, factors outside of their control prevented them from doing so.

"You know the department can't do something that... the governor has to be supportive of and the Commissioner, so you've got to have a group that's... You've got to have everything lined up just right to be able to do that."
-Government, General National Tractor Safety Coalition, No Known Fundraising Progress-

Alternatively, these results could have indicated that the stakeholders interviewed did not find the NRRP implementation to be a worthwhile investment of time or resources, but due to their professional affiliations, felt compelled to publically support the NRRP. Though this possible situation was not discussed in the interviews, it is possible that it occurs; however, stakeholders may be less willing to admit to such beliefs. In either case, returning to a state of cognitive homeostasis would require justification – potentially in the form of the three discourses presented in the figure ("implementation is someone else's responsibility," "the problem will go away on its own," and "education is key [to reducing tractor overturn fatalities"). To dig further into the issue of conflicting support for and engagement in the NRRP implementation, the follow-up interview guides were largely developed to provide a deeper understanding of stakeholder engagement.

7.3.3 Results of Surveys 3 and 4 and Overall Survey Results (Sub-study III)

The third and fourth surveys were largely unchanged when compared to the first and second, with similar responses across the board. In fact, upon completing the analysis, mixed ANOVAs demonstrated that there were no differences in survey item scores over the four time periods.

The complete results of the correlational analysis completed in sub-study III are shown in **table 10**. Only those survey items that were correlated at rho≥0.50 were discussed in sub-study III; these correlations are bolded and highlighted in grey in the table. This decision was made in order to be less dependent on p-values given the small sample size (ten regions) used in these analyses. Future research might also benefit from examining correlations between 0.33 and 0.50 (bolded in the table), which may provide further insight into the implementation of the NRRP.

After comparison of the overall change in CFIR and Proctor constructs, the survey items were compared to three ROPS outcomes: 1) *progress* in

fundraising, 2) *intakes* (i.e. enrollment in the NRRP), and 3) *retrofits*. In this analysis, two survey items related to the *leadership engagement* construct were both found to be highly negatively correlated with both *progress* and *retrofits*. As such, a question related to these correlations was also added to the follow-up interview guide.

Table 10: Results of the correlational analysis comparing survey item scores to ROPS outcomes (progress, intakes, and retrofits). (Continued on the next page.)

Construct	Question	Progress	Intakes	Retrofits
Knowledge and Beliefs about the Intervention	It is feasible to implement the NRRP.	-0.055	-0.080	-0.228
	The implementation of the NRRP is going well.	**0.352**	0.197	0.201
Access to Knowledge and Information	NRRP materials are engaging.	**0.687**[b]	**0.648**[a]	**0.567**
	NRRP materials are appropriate.	**0.335**	0.079	0.116
Leadership Engagement	The National Tractor Safety Coalition steering committee encourages members to be involved in implementing the NRRP.	**-0.729**[c]	**-0.442**	**-0.731**[c]
	The National Tractor Safety Coalition steering committee is supportive of the NRRP.	**-0.705**[b]	-0.273	**-0.574**
Tension for Change	It is important that the NRRP is implemented now.	**0.432**	0.297	0.246
Available Resources	I have the resources I need to promote the NRRP in my role.	0.274	0.219	0.199
Farmer Needs and Resources	Once implemented, the NRRP will meet the needs of my organization's target population.	0.030	**0.370**	0.150
Cosmopolitanism	My employer encourages me to network with colleagues outside of my own setting.	-0.230	0.140	0.062
Cost	The cost of the NRRP has not prevented it from being implemented in my state.	0.317	0.030	0.274
Evidence Strength and Quality	Influential stakeholders are supportive of the NRRP.	**0.407**	0.309	0.280
Design Quality and Packaging	NRRP materials are of high quality.	0.280	0.128	0.151
Engaging (Perceived Role)	Monitoring progress so that I can stay informed.	-0.006	-0.031	0.04839
	Sharing promotions and materials with partners outside of the Coalition.	**0.406**	**0.374**	**0.429**
	Providing feedback about activities that others are planning and carrying out.	**0.571**	***0.564***	**0.594**
	Helping plan implementation activities such as events and fundraising.	0.195	**0.359**	0.178
	Participation in implementation events.	0.235	**0.500**	**0.419**
	Participation in fundraising.	**0.691**[b]	**0.543**	**0.687**[b]
Engaging (Actual Activity)	Read National Tractor Safety Coalition updates, information, or materials.	**0.383**	**0.345**	**0.451**
	Attended a National Tractor Safety Coalition webinar or conference call.	0.128	0.043	0.322

	Attended a National Tractor Safety Coalition in-person meeting.	0.315	0.222	**0.447**
Engaging (Actual Activity) *Continued*	Attended an event on behalf of the National Tractor Safety Coalition or NRRP.	0.135	-0.006	0.228
	Provided feedback or suggestions on National Tractor Safety Coalition activities or materials via email or one-on-one phone call.	-0.159	0.128	0.137
	Provided feedback or suggestions on National Tractor Safety Coalition activities or materials during a National Tractor Safety Coalition webinar, conference call, or in-person meeting.	-0.182	0.188	0.171
	Shared NRRP information or promotions with a group of individuals via social media, email distribution lists, or newsletters.	0.036	0.139	0.273
	Incorporated NRRP information into a presentation or report you were putting together for another purpose.	**0.389**	0.164	0.232
	Had a conversation about the NRRP with another individual.	**0.492**	0.285	**0.410**
	Helped arrange or plan National Tractor Safety Coalition activities or events.	0.315	**0.335**	**0.415**
	Served as a spokesperson specifically for the National Tractor Safety Coalition or NRRP.	0.074	**0.460**	**0.380**
	Recruited new members to the National Tractor Safety Coalition or connected National Tractor Safety Coalition members with new partners.	0.151	0.119	0.300
	Helped arrange or plan National Tractor Safety Coalition activities or events.	0.315	**0.335**	**0.415**
	Submitted a funding or resource request for the NRRP.	***0.586***	**0.505**	**0.756**[c]
	Met with potential funders to discuss funding the NRRP.	**0.377**	-0.006	0.137
Reflecting and Evaluating	National Tractor Safety Coalition updates are helpful in allowing me to reflect upon progress toward implementation of the NRRP.	**0.388**	**0.583**	**0.387**
Acceptability	The NRRP is an acceptable response to tractor overturn fatalities.	-0.244	0.097	-0.226
Sustainability	The NRRP is sustainable.	0.244	0.164	0.171

[a]Significant at p≤0.05; [b]Significant at p≤0.03; [c]Significant at p≤0.02

7.3.4 Final Qualitative Results (Sub-study IV)

During the follow-up interviews with stakeholders, two potential theories emerged to explain why perceived steering committee engagement was negatively correlated with ROPS outcomes. One belief was that the existence of a steering committee suggested a top-down approach that dis-incentivized engagement by other stakeholders. This could cause a disjointed view of what

the steering committee does. Second, others suggested that although the steering committee may be engaged, they may not be engaged in specific state efforts. In this case, it may be that National Tractor Safety Coalition members are not regularly interacting with steering committee members, and thus do not understand their role.

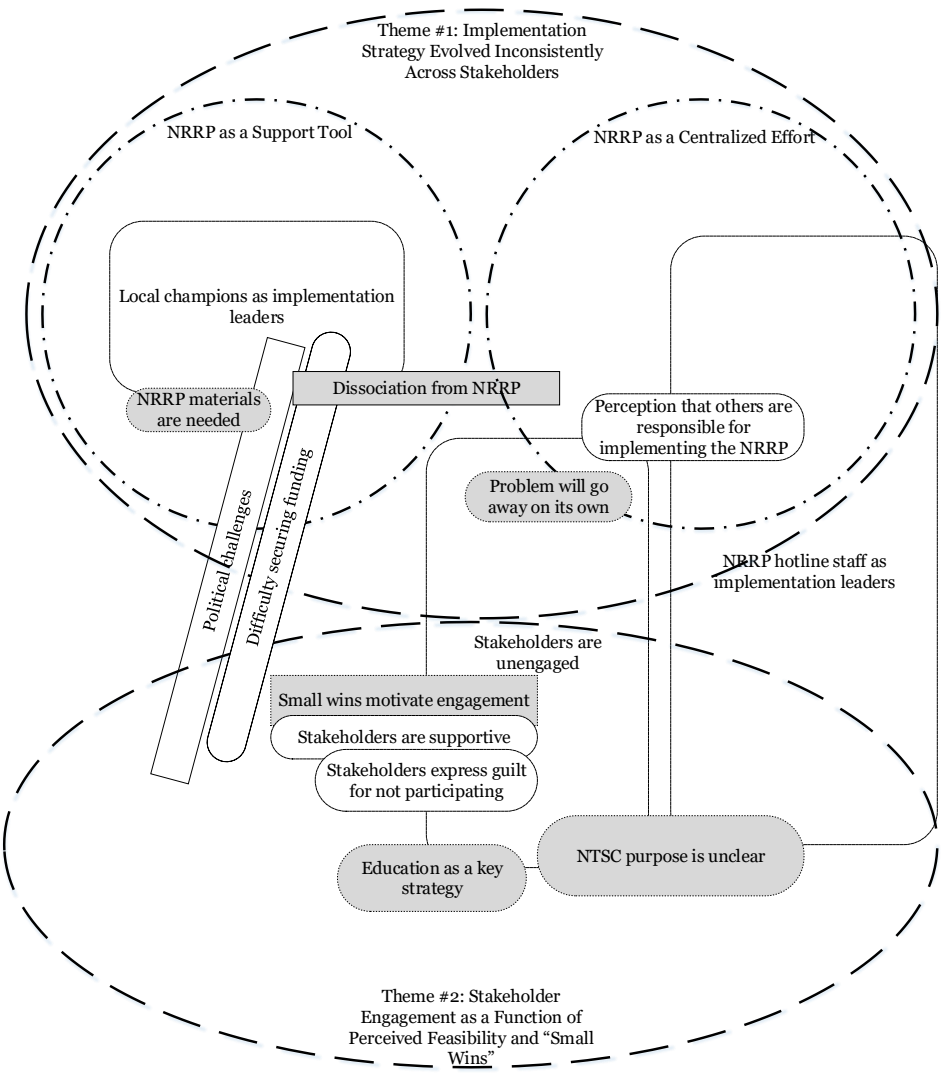

Figure 13: Final map indicating key themes and situational elements pertaining to the NRRP implementation. Different components of the situational elements described by Clarke et al. (97) are highlighted by different shaped and colored components of the figure.

In addition to feedback on this particular issue, the interviews also led to the identification of two core themes in the data, which are depicted by the situational map presented in **figure 13**. These themes are 1) the implementation strategy had developed inconsistently across stakeholders, and 2) stakeholder engagement is a function of perceived feasibility and "small wins."

As described previously, the CFIR and Proctor Taxonomy were conceptualized by the research team for this implementation study in such a way that the full National Tractor Safety Coalition was engaged in the *inner setting*. Based on the interviews conducted, it did not appear that this was the reality of the situation. Instead, the perception of participants was that stakeholders (including themselves) operated under one of two conceptualizations of the CFIR and Proctor Taxonomy. The changing conceptualizations of these models are shown in **table 12**. *Characteristics of individuals, process, implementation outcomes*, and *client outcomes* have been left out of the table, as these did not differ between conceptualizations.

Table 11: Comparison of the planned implementation strategy to the National Tractor Safety Coalition conceptualizations of the implementation strategy.

Domain	Implementation Strategy	First National Tractor Safety Coalition Conceptualization	Second National Tractor Safety Coalition Conceptualization
Inner Setting	Hotline staff, National Tractor Safety Coalition	Local champions	Hotline Staff
Outer Setting	Non-National Tractor Safety Coalition stakeholders	Hotline staff, other National Tractor Safety Coalition and non-Coalition stakeholders	National Tractor Safety Coalition and non-Coalition stakeholders
Intervention Characteristics (Pre)	State ROPS Rebate Programs	ROPS Rebate Program concept	State ROPS Rebate Programs
Intervention Characteristics (Post)	NRRP	State ROPS Rebate Programs	NRRP

The first conceptualization was that the NRRP is a "support tool" that could be used by stakeholders to implement their own versions of the ROPS Rebate Program in various states. In this conceptualization, the ROPS hotline staff was not described as involved in the implementation process, and thus positioned in the *outer setting*. Instead, localized state champions made up

the *inner setting*. Additionally, it seemed that the primary goal of these stakeholders was to develop a state ROPS Rebate Program, rather than to contribute to the NRRP. At times, this conceptualization was explained as states attempting to maintain their own identity, separate from the NRRP.

"I don't think there was a discussion among the states that were already working on programs about how… what this transition was… how we would fit, how we would be part of it and how we would still have our separate identities."
-ROPS Program Advisor, Steering Committee, Sufficient State-Allocated Funding-

In the second conceptualization, the NRRP implementation was conceptualized as a centralized effort in which the NEC is exclusively responsible. In this conceptualization, National Tractor Safety Coalition members were involved as members of the *outer setting* who did not have roles directly relevant to the implementation. In this capacity, stakeholders saw their role in the National Tractor Safety Coalition as participating in ways that supported their organizations priorities which at times overlapped with National Tractor Safety Coalition objectives.

"I think my opinion is they are doing it what is being asked of them and they are doing additional things when it's convenient or when the opportunity arises. I think my definition of convenience would be in my case if I'm going to a meeting then I'm going to talk to people about the National ROPS Rebate Program, but I wouldn't necessary schedule or go to the meeting specifically to address that."
-University Based Engineer, Steering Committee, No Known Fundraising Activity-

In terms of the CFIR and Proctor Taxonomy, this theme primarily relates to *engaging* different partners, including both leadership and champions. *Design quality and packaging, available resources,* and *access to knowledge and information* are relevant in the first conceptualization, as they describe champions abilities to access the materials and information necessary for furthering support for NRRP implementation in their home states or nationally.

In the second conceptualization, *cosmopolitanism* comes into play in terms of National Tractor Safety Coalition members' willingness and ability to cooperate and work with the administrators of the NRRP (i.e. the hotline staff). In addition, *self-efficacy* comes into play in this conceptualization. As described by interview participants, *self-efficacy* seems to be a primary barrier

in engaging National Tractor Safety Coalition members in the implementation process, thus leading to over-reliance on the hotline staff.

In addition to the differing conceptualizations of the NRRP implementation, a second theme was identified from the interviews and analysis process. This second theme related to the idea that stakeholder engagement is a function of 1) perceived feasibility, and 2) documented success. Depending on the stakeholder, these two things might be different. For example, one stakeholder might feel that feasibility is challenged by the fact that they personally are not able to fundraise (due to employment regulations, for example), while another individual may feel that feasibility is challenged based on the state government's receptivity to such programs.

"But we've had a larger issue in the Department of Ag considering the impact of invasive species on the economy. We have a lot of folks concerned about rural opioid abuse and rural health type stuff. So things… depending on who is the loudest and what will get the most voices heard… it's like you got to have more than just me in the ear of the politicians."
-Agricultural Outreach, General Committee, Fundraising-

Regardless of where the threshold is for stakeholders, perceived feasibility was shown to be relevant to getting stakeholders involved in the implementation process. Similarly, the level or type of documented success considered relevant for stakeholders to increase engagement was reportedly different depending on the stakeholder. In some instances, documented success from New York (which has had the longest running Program) was sufficient, while other stakeholders felt that they needed to show documented success in their own states.

"I think if I could capture one of those close calls or incidences where they retrofitted and there was an incident and it saved them. I think if I could capture that, if I could capture that and make that… I don't want to say… this is kind of selfish… but I want to put it as a poster child type thing. I want to be able to market that and, you know, say, 'Hey, looky here.' I think that's one of my goals is to capture that. I don't know if New York has done a great job doing that and showing that return on investment to funders, but I… that's one of my goals. To try and capture the impact on an individual basis, you know… put a name and a face with ROPS and tractor safety."
-Agricultural Safety Researcher, General Committee, Fundraising to Supplement Current State-Allocated Funding-

This theme really spans the various domains of the CFIR and Proctor Taxonomy. Again, *engaging* (*process*) various groups of stakeholders is

relevant in this theme, with various *intervention characteristics* playing a role in stakeholders' perceived feasibility. In addition, several *inner setting* and *outer setting* constructs further impact individuals' perceptions of the NRRP and their ability to be involved in implementation. Together, these factors also impact *characteristics of individuals* and how they interact with the NRRP implementation.

7.4 Understanding the Role of Media in the NRRP (Sub-study V)

Sub-study V served to fill a gap in the knowledge gained through sub-studies III and IV. In particular, this sub-study reviewed the impact of news media (and the political discussions presented in the media) on the NRRP implementation. A total of 212 unique media reports were printed 357 times between November 20, 2006 and October 31, 2018. These media reports represented each of the individual state-based ROPS Rebate Programs, as well as the NRRP. Reports were published before, during, or after implementation of the specific Program, and were used to different extents in each of the states.

In conducting the discourse analysis, three main commonalities were observed across the media reports. First, there was a consistent expression of gratitude for farmers and all that they do. In addition, the reports tended to highlight the fact that the ROPS Rebate Programs are beneficial to farmers as well as communities and that farmers are interested in participating in the NRRP.

Though many of the messages presented in these media reports were consistent across the Programs, the ways, times, and frequencies in which these messages were presented were reflective of the overall success of the Programs. In this case, I refer to success of the Programs in terms of the sustainability of state-allocated funding and thus the number of retrofits in the state over time. **Figure 14** compares success in terms of rebates per year (reflective of funding levels for each individual Program) to the number of media reports published annually.

Figures 14a, 14b, and 14c represent states that have used media primarily during the a) pre-implementation and implementation phases, b) implementation, and c) implementation and post implementation, respectively. The axis bounds are constant across the three figures to highlight the drastic differences in both retrofits and media coverage across the different Programs. This figure shows that the Programs with higher numbers of media reports also have higher numbers of retrofits (which are reflective primarily of the funding availability in the state). This is slightly

different for the NRRP, for which the media reports largely focused on the administration of the Program and preserving related funding. In addition, those states with continued use of media also have more consistent numbers of retrofits over time. Besides the number and consistency of media reports, the individuals featured in the media reports were also relevant, and appeared to play a role in the relative successes of the Programs.

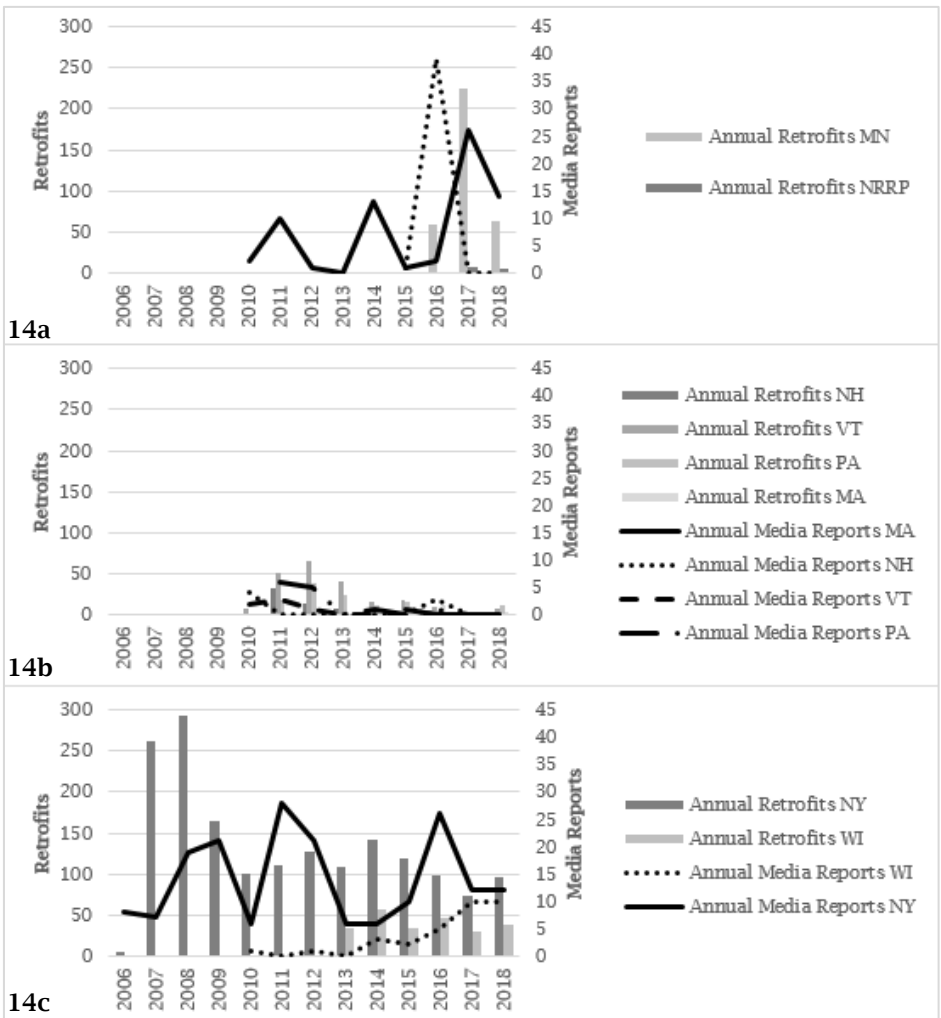

Figure 14: Comparison between annual retrofits and media reports by ROPS Rebate Programs in Minnesota (MN), nationally (NRRP), New Hampshire (NH), Vermont (VT), Pennsylvania (PA), Massachusetts (MA), New York (NY), and Wisconsin (WI).

Though sub-study V did not discuss the results of the analysis in terms of the CFIR and Proctor Taxonomy, it is relevant to do so here. Eleven CFIR and

Proctor constructs were identified in the media discourse analysis, including those from the following domains:

- *intervention characteristics* (*evidence strength and quality*, *design quality and packaging*);
- *outer setting* (*farmer needs and resources*, *external policy and incentives*);
- *characteristics of individuals* (*knowledge and beliefs about the intervention*);
- *process* (*executing, engaging champions, engaging external change agents*, *engaging opinion leaders*); and
- *implementation outcomes* (*acceptability* and *appropriateness*).

In particular, *executing* came up in terms of when media reports were published in relation to Program implementation, as the release of media reports can be considered part of *executing* the implementation strategy. *Design quality and packaging, acceptability,* and *appropriateness* were constructs that were similarly portrayed across the board through the commonalities in media reports. These commonalities largely related to the ways in which the Programs were portrayed in the media; in other words, the *design packaging*. In addition, these portrayals strived to demonstrate the *appropriateness* of the Programs for addressing tractor overturn fatalities, the *acceptability* of the Programs to the target populations (i.e. farmers), and the ability of the Programs to consider and address *farmer needs and resources*.

In considering the differences between more and less successful Programs, based on the media reports published about them, several factors were relevant. First, *engaging champions* and *engaging external change agents,* and *engaging opinion leaders* appeared to be important for diversifying and strengthening the messages distributed through the media. For example, in Minnesota, a reporter focused on the impact of tractor overturns was an instrumental *champion* in securing state-allocated funding for the Program. Similarly, a prominent politician (who can be considered an *opinion leader* or *external change agent*) led the media campaign that helped preserve administrative funding for the NRRP. These media reports highlighted the *evidence strength and quality* collected through years of evaluative research on the Programs. Together, the various components of the media reports help to shape the public's *knowledge and beliefs about the intervention.* Finally, media reports in the more successful states focused on highlighting *external policy and incentive;* in particular, the need to satisfy numerous Program champions and stakeholders by providing funding.

7.5 CFIR and Proctor Constructs as Predictors of Implementation Success (Sub-studies III-V)

This section aims to bring together the results of sub-studies III, IV, and V in order to better understand the big picture. Prior to the start of the implementation process and using data from the construct selection survey, 21 CFIR and Proctor constructs were identified as being potentially relevant to the implementation process.

As explained previously there were three main opportunities within this dissertation for these 21 CFIR and Proctor constructs to be evaluated. These evaluations were 1) the repeat measure survey that was administered at four time points (sub-study III), 2) two rounds of qualitative interviews (sub-study IV), and 3) a qualitative analysis of published media reports (sub-study V).

In addition to the 21 constructs identified from the construct selection survey, an additional eight were added to the qualitative interviews for various reasons (described in detail in section 5.8.1), yielding a total of 29 CFIR and Proctor constructs that were specifically asked about in the repeat measure surveys, qualitative interviews, or both. Of these 29 constructs, 12 were asked about in both the surveys and interviews, three were asked about only in the surveys, and the remaining 14 were only asked about in the interviews.

Table 12 lists all of the CFIR and Proctor constructs considered in this dissertation and defined by Damschroder et al. (56) and Proctor et al. (57). Among these are the 29 CFIR and Proctor constructs that were specifically asked about in the repeat measure surveys and qualitative interviews (sub-studies III and IV, respectively). These are shown in the "prompted for in evaluations" columns. The three columns in the right margin of the table indicate whether or not a construct was shown to be important to the implementation of the NRRP, independent of whether or not it was specifically asked about during the repeat measure surveys or qualitative interviews. Constructs that were not specifically asked about during these evaluations may have still been shown as important as a result of the qualitative interviews (sub-study IV) if participants voluntarily discussed the construct. In addition, the media analysis (sub-study V) was not developed based on the CFIR and Proctor Taxonomy. However; in analysis, the results were mapped to CFIR and Proctor constructs, providing another opportunity for any construct to be shown as important to implementation.

Ten constructs were shown to be relevant across at least two of the three evaluations. All ten of these were members of the original 29 that were

specifically asked about in the repeat measure surveys and/or qualitative interviews. Thirteen more of the original 29 constructs were shown to be relevant in only one of the three evaluations (one quantitatively, eight qualitatively, and four through the media analysis). Finally, six of the original 29 did not show up as important in any of the three evaluations.

Of the ten constructs relevant across multiple studies, six were shown to be important in both the repeat measure surveys and qualitative interviews (sub-studies III and IV, respectively): *engaging* (including *champions, formally appointed implementation leaders, external change agents,* and *opinion leaders*), *leadership engagement,* and *access to knowledge and information*. Further, *engaging* was shown to be important through the media analysis as well, making it the only construct found to be important in all three evaluation studies.

The remaining four constructs that were relevant across multiple sub-studies (*external policy and incentives, knowledge and beliefs about the intervention, evidence strength and quality,* and *design quality and packing*) were found to be important both qualitatively (sub-study IV) and in the media analysis (sub-study V).

Of the CFIR and Proctor constructs that were not specifically asked about in the repeat measure surveys or qualitative interviews, three were deemed relevant in the qualitative study and one was deemed relevant in the media evaluation. These included *relative advantage, individual stage of change, other personal attributes,* and *appropriateness*.

Table 12: Overview of CFIR and Proctor constructs relevant to the NRRP implementation based on repeat measure surveys (sub-study III) and qualitative interviews (IV) as well as an evaluation of media reports (sub-study V). Constructs specifically asked about in the repeat measure surveys and qualitative interviews are marked in the "prompted for in evaluations" column. Those not initially included in the evaluation but that were highlighted in either sub-study IV or V are italicized. Constructs deemed most relevant (i.e. those highlighted in at least two of the three evaluative studies) are highlighted in grey. (Continued on next page.)

Domain	Construct	Prompted for in Evaluations		Identified as Relevant to Implementation		
		Quantitative	Qualitative	Quantitative	Qualitative	Media Evaluation
Intervention characteristics	Cost	x	x		x	
	Evidence strength and quality	x	x		x	x
	Design quality and packaging	x	x		x	x
	Adaptability					
	Relative advantage				*x*	
	Trialability					
	Complexity		x			
	Intervention source		x			
Outer setting	Farmer needs and resources	x	x			x
	Cosmopolitanism	x			x	
	External policy and incentives		x		x	x
	Peer pressure					
Inner setting	Readiness for implementation:					
	• Available resources	X	x		x	
	• Leadership engagement	X	x	x	x	
	• Access to knowledge and information	x	x	x	x	
	Implementation climate:					
	• Tension for change	x	x		x	
	• Goals and feedback					
	• Relative priority		x			
	• Compatibility		x			
	• Learning climate					

	• Organizational incentives and rewards					
	Networks and communications		x		x	
	Culture					
	Structural characteristics		x		x	
Characteristics of individuals	Knowledge and beliefs about the intervention	x	x		x	x
	Individual identification with the organization		x		x	
	Self-efficacy		x		x	
	Individual stage of change				*x*	
	Other personal attributes				*x*	
Process	Engaging:					
	• Champions	x	x	x	x	x
	• Formally appointed implementation leaders	x	x	x	x	
	• External change agents		x		x	x
	• Opinion leaders		x	x		x
	Planning		x			
	Reflecting and evaluating	x	x	x		
	Executing		x			x
Implementation outcomes	Acceptability	x				x
	Adoption					
	Appropriateness					*x*
	Feasibility					
	Penetration					
Client outcomes	Sustainability		x			
	Satisfaction	x				x

8 | Discussion

8.1 Understanding the Research Translation Process

In conducting sub-study I, it became clear that the methods to successfully navigate the research continuum (identifying a negative health or safety outcome, developing evidence-based and accepted solutions, widely implementing those solutions, and demonstrating improvements in safety and health outcomes) are largely unclear to many in both agriculture, forestry, and fishing safety and health research, as well as more general public health research (67, 108-110). Of these steps, moving innovations into widespread practice is particularly challenging, especially in agriculture, forestry, and fishing safety and health research (20, 67, 88). Process models, such as the NIH T0-T4 model (64, 111, 112), the Stetler model (113), the Process Marker Model (114), and the cyclical model used by Blismas et al. for construction research (115), among others, can be helpful in understanding how to progress through the phases of research so that innovations are successfully adopted and have the opportunity to benefit populations (116).

The modified T0-T4 model presented as part of sub-study I aimed to increase agriculture, forestry, and fishing researchers' capacity to move scientific innovations into practice in order to demonstrate measurable improvements in safety and health outcomes. In addition, this model helps provide a framework to evaluate collective progress toward improved safety and health among agriculture, forestry, and fishing populations. The T0-T4 model was used as a starting point in an effort to "meet others where they are" by using a process model already known within the agriculture, forestry, and fishing safety and health research community. Upon review of the literature, several barriers to applying the NIH T0-T4 model to agriculture, forestry, and fishing safety and health efforts were identified (discussed in section 7.1). These challenges were used as a starting point for the modifications made to the T0-T4 model. For the purposes of this discussion, I focus on the similarities and differences between the model presented in sub-study I, the 2010 presentation of the NIH T0-T4 model by Khoury et al. (64), and a National Institute of Occupational Safety and Health-derived interpretation of the T0-T4 model that was published a month prior to ours and focused on occupational safety and health in general (20).

The NIH T0-T4 model is an important step for understanding the general process that research must take to reach target populations. Though research translation in clinical settings (which the NIH model is based on) is by no means easy, the challenges faced are quite different than those related to occupational safety and health, especially in the specific agriculture, forestry,

and fishing populations discussed in this dissertation. Two factors, in particular, are relevant here.

First, medical innovations (especially those that have been the focus of the NIH T0-T4 process models) often relate to improving a patient's immediate situation or preventing immediate health or safety complications. This is in contrast to the agriculture, forestry, and fishing setting, in which many innovations focus on preventing relatively rare injuries and fatalities. For example, though US agricultural workers face high fatality rates compared to other occupational settings (4), and those fatalities are primarily caused by tractor overturns (117), only about 125 overturn fatalities occur annually (117) among the 3.2 million farmers in the US (118).

Second, the context in which innovations are delivered is vastly different between clinical settings, public health settings, and agriculture, forestry, and fishing worksites. While patients in traditional health settings have a say in their treatment, they are largely guided by medical professionals who have scientific backgrounds sufficient for understanding and adopting the benefits of new innovations. In the agriculture, forestry, and fishing safety and health arena; however, buy-in must primarily come from the workforce (including business owners and workers). In these settings, researchers, product developers, and implementers are more likely to be seen as outsiders, and thus less trusted (119, 120).

Unfortunately, the NIH T0-T4 model (64) does not address many aspects of the culture and context of target populations; instead, downplaying the complexity of end-user adoption. Similarly, the model presented by Schulte et al. (20) also waits to address such complexities until after innovations have been fully developed. In public health, and especially in agriculture, forestry, and fishing safety and health efforts, these aspects are crucial to developing more widely-accepted and sustainable innovations, and have served as the foundation for methodologies including action research (121), community based participatory research (CBPR) (119, 120), and social marketing (39, 122, 123).

The T0-T4 model presented in sub-study I addresses this oversight by incorporating adoption into innovation evaluation at every stage of the process. In doing so, valuable (and limited) resources are not dedicated to developing innovations that are impractical or unpopular with end-users. In agriculture, forestry, and fishing, one of the most common innovation types is engineered solutions, which can be time-consuming and costly to design, test, and certify to safety and engineering standards. If such innovations are developed without a firm understanding of the intricacies of the worksite

(which only the workforce can provide) and the barriers that the workforce faces in adopting such technologies, the risk of developing inadequate innovations increases (119). Within the CFIR and Proctor Taxonomy, this idea is captured in the *intervention characteristics, implementation outcomes,* and *client outcomes* domains (57, 124). ROPS technologies are just one example of engineered solutions that fail to take into account farmer barriers to adoption (e.g. cost) in their designs. Within US agriculture, forestry, and fishing, other innovations that have failed to take workforce preferences and needs into account include respiratory protection for migrant farm workers (125) and personal floatation devices for commercial fishermen (126, 127), among others. In addition to the issues highlighted, such approaches can be seen as "top-down" and create further distrust of the research community when the proposed "solutions" cannot be implemented by workers due to economic, logistical, or cultural barriers. This can lead to a situation in which workers are well aware of the risks that they are taking; however, because the "solution" is unattainable to them and the work is still required, they are not able to improve safety. This can result in a false conclusion that the workforce is uninterested in the "solution" or otherwise to blame for continued safety problems (128).

This raises an additional challenge – what are sufficient adoption rates? This is partially dependent on the health or safety outcome in question; however, generally, sufficient adoption occurs when the innovation is prevalent enough to reduce (and ideally eliminate) the outcome. In this dissertation, the use of ROPS for preventing tractor overturn fatalities has been discussed. Based on international data, an 80% adoption rate is necessary to nearly eliminate such fatalities (16, 129). Relevant to this discussion; however, are evaluation measures. Often, long-term evaluations of safety programs are not available, likely due to a lack of long-term funding. Instead, occupational outcomes are identified primarily through surveillance efforts. As discussed, agriculture, forestry, and fishing fatalities are relatively rare. Thus, in order to identify improved health outcomes through surveillance data, a higher number of events need to be prevented. In order for this to happen, innovations need to be more widely adopted than in other settings to demonstrate measureable improvements over time. Further, widespread adoption can help preserve limited resources by allowing researchers and practitioners to build off of work already conducted, rather than starting from the beginning. Aside from these very practical considerations, it is also relevant to consider the ethical implications of not widely implementing proven innovations. As Sogolow et al. explain,

> *"This situation is equivalent to developing a life-saving medication but not telling physicians or patients that it is*

available, not packaging the product for public use, not having skilled pharmacists to dispense the medication, and not providing guidance about the management of its effects (130)."

Though both the Khoury (64) and Schulte (20) models can be applied to larger settings, both papers tend to focus on more localized settings. A focus on more localized implementation can mean that 1) fewer workers are benefitting from important research, and 2) already limited resources are being spent developing solutions to the same problems rather than investing time to implement proven solutions. In the T0-T4 model presented in sub-study I, this has been taken into account, and provided pathways for scaling up innovations during the T2 and T3 phases. In this model, T1 focuses on small-scale, local efficacy testing of innovations. The T2 phase is then used for effectiveness trials and to better understand how different local contexts will impact adoption. T3 then relates to efforts to promote widespread adoption across the spectrum. Related to the ROPS Rebate Program, T1 focused on pilot tests in NYS, T2 led to Program uptake in several additional states, and T3 focuses on the NRRP implementation.

Aside from these major differences, which are fundamental to understanding implementation processes in more traditional clinical and public health settings compared to agriculture, forestry, and fishing settings, several other modifications were made to the NIH T0-T4 model. Importantly, both our model and the model presented by Schulte et al. (20) incorporate feedback loops between the T-phases. The original NIH T0-T4 does not incorporate these feedback loops, thus giving the impression that the research process is straightforward and linear. This can be challenging in that it standardizes unrealistic expectations and fails to acknowledge tailoring and adaptation of innovations to fit, and be successful in, different or wider populations (131, 132). In addition to feedback loops between T-phases, the Schulte model also divides the T0-T4 model into two main components: basic and applied research (T0) and knowledge translation (T1-T4). In doing this, the authors also include feedback from the T1-T4 phases to the T0 phase. This is particularly important given contextual changes over time and the overarching picture of occupational safety and health research within a particular sector. Similar feedback loops have been incorporated into other recent process models as well (115).

Sub-study I and the Schulte et al. paper were published within one month of each other, highlighting the need for more work in later ends of the process (i.e. T3 and T4) in occupational safety and health. These two papers aim to orient researchers and practitioners to the process of research translation; though both also point out practical barriers to moving forward in this arena,

including both funding availability and challenges related to the infrastructure which such research operates within (20, 133). Together, these two papers provide a foundation to support further implementation efforts within the agriculture, forestry, and fishing safety and health sectors.

8.2 Factors Required for the NRRP Implementation

Though the CFIR and Proctor Taxonomy have been used in a wide variety of settings, this study is the first to apply the CFIR to an agricultural safety setting (76). Even those studies that focus on occupational settings more generally focus on disease prevention rather than safety (76). Sub-study II focused on making the necessary adaptations so that the CFIR and Proctor Taxonomy could be applied in this setting. Overall, few changes needed to be made to use the frameworks to evaluate the NRRP implementation. After collecting and analyzing evaluation data (explicitly in sub-studies III and IV, but also through sub-study V), the utility of the CFIR and Proctor Taxonomy in agricultural safety settings was confirmed. All factors identified as being important to the NRRP implementation, including those brought up spontaneously by participants in the qualitative interviews or discovered during the analysis of the media reports, fit within the CFIR and Proctor Taxonomy. The evaluation tools that were used were also successful in eliciting the necessary information. Because these tools were developed using recommended measures for the CFIR and Proctor Taxonomy, it is likely that they could be applied to other public health initiatives.

Sub-study III, IV, and V all played a role in understanding how the various constructs described in the CFIR and Proctor Taxonomy impact implementation; however, each paper did so differently. Sub-study III, a correlational analysis, shows which factors are correlated with implementation outcomes (*progress* toward fundraising, *intakes,* and *retrofits*). However; not all CFIR and Proctor constructs were measured through the quantitative evaluation. Similarly, sub-study IV sheds light on other factors that are also relevant to the success of the NRRP implementation, even if they were not sufficient for success according to the correlational analysis. Though not all CFIR and Proctor constructs were asked about in the qualitative studies, participants had the opportunity to discuss topics beyond those pre-defined by the interview guide. Thus, constructs and other factors not initially intended to be measured may have been shown to be relevant at the end of the study (as discussed in section 7.5 and shown in **table 12**). Finally, sub-study V, a media analysis, was used to highlight which CFIR and Proctor constructs were important in practice. Though the data collection and analysis for sub-study V was not designed based on the CFIR and Proctor constructs, the results were linked to these constructs in section

7.4 of this dissertation. By using these multiple methods, triangulation of the results could be achieved, resulting in a more truthful and objective interpretation of the study findings.

8.2.1 Key Implementation Factors

Table 12 (section 7.4) served to consolidate the results of this dissertation, and specifically the final three sub-studies, to highlight those CFIR and Proctor constructs that were identified as relevant to implementation in any of the sub-studies. This table also highlights the ten constructs that were shown to be relevant in at least two of the evaluative sub-studies, and therefore appear to be most important in the implementation process based on what is currently known. These include: *engaging* (*champions, formally appointed implementation leaders, external change agents,* and *opinion leaders*), *leadership engagement, access to knowledge and information, external policy and incentives, knowledge and beliefs about the intervention, evidence strength and quality, and design quality and packaging*. The specific studies in which these constructs were deemed relevant were previously discussed in section 7.5.

The following paragraphs consider each of these ten constructs both individually and as they relate to one another in order to support implementation efforts.

Knowledge and beliefs about the intervention ultimately describes the opinions formed by stakeholders based on the information that they provided (i.e. knowledge). Based on the results of this dissertation, implementation relies, at least partly, on the opinions of stakeholders. That is, positive opinions about the innovation are more likely to contribute to implementation success than negative opinions. To form these opinions, two types of knowledge, as defined by Everett Rogers (62), are highlighted in the findings: awareness-knowledge and "how-to" knowledge.

As can be expected, the media analysis highlighted awareness-knowledge (62) as an important component to promoting the NRRP through the media. This is expected, given that the primary purpose of media is to inform the public about various events and services, such as the NRRP (and former state ROPS Rebate Programs). In addition, how-to knowledge for potential participants is highlighted in these media reports in the form of contact and Program process information.

How-to knowledge (62) is also highlighted in the qualitative findings; however, in this case, the knowledge is focused on non-farming stakeholders' understanding of how the NRRP can be implemented. The qualitative results

highlighted the role that perceptions of the feasibility of implementing the NRRP play in engaging stakeholders. This item really relates to the knowledge that stakeholders have about how the NRRP can be expanded, and their beliefs about whether or not this is possible. The idea that stakeholders may find it difficult to engage in implementation when they are unsure of the process is highlighted further in the literature (63, 134). In the agricultural safety and health setting, where this type of implementation effort has not been done before, this type of how-to knowledge is extremely limited, and thus is likely to serve as a barrier to full implementation of the NRRP.

In order for individuals to form their own *knowledge and beliefs about the intervention,* they first need *access to knowledge and information*. This particular construct is helpful in understanding if National Tractor Safety Coalition members, or other more *outer setting* stakeholders feel they have what is needed to move forward with implementation efforts.

Though *access to knowledge and information* can relate to physically being able to access prior research and study results, it also ties closely to the constructs *evidence strength and quality* and *design quality and packaging.* One of the key points to be made in sub-study I of this dissertation, as well as by others working in the field of agricultural safety and health, is the need for ample evidence demonstrating the efficacy and effectiveness of programs (67, 135). This point is not only that evidence needs to be collected, but that it also needs to be compiled and presented in such a way that other researchers, practitioners, and other stakeholders can understand, use, and benefit from the evidence that has already been collected. This ties closely with the *design quality and packaging* construct, which refers to how the intervention, including supporting evidence, is presented as a whole. This construct was one of the focuses of the media analysis (sub-study V). The *design quality and packaging* of media reports was specifically important in maintaining consistent and truthful media messages based on the evidence collected about the ROPS Rebate Programs and framing issues in such a way that would appeal to the public, legislators, and potential funders. Here, packaging the message using lay language to encourage appropriate use by the media is important (136, 137).

A primary aim of developing and disseminating evidence is to increase the engagement of both *inner* and *outer setting* stakeholders, which leads this discussion to two additional constructs that were shown to be relevant. Within the *process* domain, the construct *engaging* received considerable focus across sub-studies III, IV, and V. Though this was partly due to the heavy focus on engagement in sub-studies III and IV, the results of sub-study V (the media evaluation) help confirm this finding. *Engaging* appears to be relevant

due to the nature of the implementation strategy, which relies on participation and engagement by all members of the National Tractor Safety Coalition, as well as engagement of external (*outer setting*) stakeholders that may influence the NRRP implementation in some way. Because of this, questions in both the surveys and interviews related to this topic area. The media analysis also highlighted the role of *engaging* a variety of individuals. In addition, some individuals in this setting may wear multiple hats. For example, individuals who are known *opinion leaders* in agricultural safety and health (identified through a prior ROPS Rebate Program study (50)) may also serve as local *champions* or *formally appointed internal implementation leaders*. Thus, it is difficult here to make clear distinctions between the sub-constructs under *engaging.*

In addition to the *engaging* construct under *process*, engagement is also covered in the *inner setting* domain, specifically related to *leadership engagement.* This construct was highly and negatively correlated with the outcome measures, and appeared as relevant in the qualitative findings (sub-study IV). This finding was particularly surprising as steering committee members should, in theory, be the most engaged members of the National Tractor Safety Coalition. In the surveys conducted for sub-study III, this construct was measured through two questions that focused on the National Tractor Safety Coalition steering committee's engagement in and support for the NRRP implementation. Similarly, because of the high negative correlations, questions about this topic were added to the interview guides for the qualitative sub-study. As described in section 7.3.4, two possible explanations were offered by interview participants. First, it is possible that individuals are not familiar with who is part of the steering committee, and thus cannot speak to their engagement in the implementation process. Second, the presence of a steering committee may represent a top-down approach, which may limit National Tractor Safety Coalition members' desire to be engaged, and therefore knowledge of who is engaged.

Stakeholder engagement in implementation efforts can result in several important outcomes. This dissertation found that one of the most important outcomes for implementation of the NRRP is e*xternal policy and incentives*, specifically in terms of incentivizing NRRP support. While shown to be quite important during evaluation (sub-studies IV and V), this construct was not initially selected to be assessed (sub-study II). It is possible that this point was missed during the construct selection process as policy tends to be closely associated with regulation – something that the National Tractor Safety Coalition agreed not to focus on during initial discussions. This decision was based on general opposition to regulatory measures among the farm community, as described in section 2.1.3. While an important consideration,

the political elements described in the qualitative and media analyses related to public health policies supporting the National ROPS Rebate Program rather than regulations mandating ROPS.

Specific examples of the impact of *external policy and incentives* include demands for ROPS Rebate Programs (as seen in the Minnesota media coverage) or opportunities for politicians to gain the public's support were seen. Though not captured through the sub-studies themselves, additional policies affecting the NRRP have also been noted, including, most importantly, passage of an American Farm Bureau Federation policy supporting state-based funding for the NRRP (138). This particular construct points to the impact of power structures on implementation activities. Here, I take the stance of Foucault's views that power circulates among members of a society and that no one individual or group of individuals holds all of the power (139). In this particular setting, three specific sources of power are at play in incentivizing particular views of the NRRP. First, policy makers (who would assume the power role in other power structures (139)) have the power to create policy and influence the ideas that society and the media focus on. Second, the media can be seen as power-holders in that they can dictate what information is presented to the public, and in what way. Third, society holds some power, in that society's priorities can help dictate what both politicians and the media talk about or support. This view of power interactions is highlighted by Andreasen as "the three agendas (39)." In his book, Andreasen highlights the interplay in power between the policy, media, and public agendas – a modern example of Foucault's understanding of power as it applies to health behaviors. Though each player holds some power, the compromise and balance between them shapes our society, and is ultimately what impacts outcomes and change. In the case of the NRRP implementation, the benefit of having all three power positions simultaneously supporting the NRRP is instrumental in achieving success. Similar instances can be found in assessing the role of politicians, media, and the public in developing agricultural policies around animal welfare and climate change, among others (140).

8.2.2 Missing Links

Collectively, the constructs described in section 8.2.1 suggest a fairly straightforward approach to implementation of the NRRP that relies on stakeholder engagement and impactful public health policies. Despite this, the NRRP has not yet been fully implemented. As described in the prior section, this could mean that more emphasis on the most concretely important CFIR and Proctor outcomes is needed. Alternatively, there are also several constructs that could be further explored in future studies. These include, primarily, constructs

that were only found to be important in one of the three evaluative sub-studies.

In particular, *reflecting and evaluating* (*process*) was shown to be correlated with improved ROPS outcomes, in that those living in states with successful ROPS Rebate Programs felt that "National Tractor Safety Coalition updates are helpful in allowing me to reflect upon progress toward implementation of the NRRP." While true, this construct was not found to be important to implementation in either the qualitative study or media assessment (sub-study IV or V). It is possible that this correlation occurs because individuals without state-allocated funding aren't as connected to the NRRP and thus don't feel that the updates apply to them. Thus, in their minds, there may be little value in reviewing these updates. This thought process is linked to the qualitative findings, which indicate that many stakeholders are taking a "backseat" approach to the implementation and waiting for the ROPS hotline staff to implement the NRRP before they make an effort to be involved.

In addition to this construct, a potential limitation to this study is that the analysis focused largely on implementation at the organizational level, rather than the individual level. Based on the results, it would appear that working to engage more appropriate individuals in *inner setting* activities would be beneficial to the NRRP implementation. In order to identify and engage these individuals, their qualities first need to be identified. While some individual-level constructs were assessed qualitatively in this study, most were not assessed quantitatively and may not have fit within the media analysis.

Self-efficacy was reflective of engagement in the implementation process of the NRRP and links closely to *knowledge and beliefs about the intervention*. In many cases, participants discussed difficulties participating in the implementation process, often because of a lack of knowledge about how they can help, and therefore belief in their own ability to do so. Despite this explicit discussion, it is also possible that social motivators (for example, pressure from employers) may contribute to stakeholders' reported *self-efficacy* (141, 142). For example, if a stakeholder is expected by his or her employer to focus exclusively on the initiatives led by that organization, the stakeholder may express low *self-efficacy* when asked to support the NRRP implementation. Unfortunately, the interviews (sub-study IV), did not provide enough detail about how participants feel that they can contribute, or what could help increase engagement. Thus, it is difficult to distinguish between these two explanations of *self-efficacy.* This finding highlights the need to 1) identify stakeholders with the greatest capacity to contribute to implementation and 2) provide additional learning opportunities for stakeholders that are tailored

to their current knowledge and also account for any societal influences of *self-efficacy* (143).

Individual identification with the organization was highlighted in discussing that National Tractor Safety Coalition members were interested in supporting the NRRP, but wanted their own, separate identities which highlighted and prioritized their organizations' contribution to the NRRP (sub-study IV). While it is imperative to secure state-allocated rebate funding for the NRRP, the lack of individual identification with the organization (in this case, the National Tractor Safety Coalition) may reduce an individual's propensity for contributing to tasks that move the NRRP forward overall (144). In terms of the NRRP, this may have negative consequences, such as inconsistent messaging, target audience confusion (i.e. not knowing whether the Program in their state is part of the larger initiative), and unwillingness to share strategies and experiences with other National Tractor Safety Coalition members and stakeholders.

Individual stage of change was not measured in any specific way in this study; however, much of the qualitative data collected suggests variances in this construct. Given this, *individual stage of change* is particularly important. It could be interesting to capture these data using measurement tools validated for the Theory of Planned Behavior (145), which this construct is based on. In particular, it could be interesting to use such data as the starting point of a doer-nondoer analysis (146), comparing those who are highly engaged in implementation to those who are less engaged. In addition, these comparisons could be further extended to understand how individual stage of change impacts state-wide change and success.

Similar to *individual stage of change, other personal attributes* were not specifically measured in this study. However, the qualitative results highlighted one *other personal attribute* in particular: guilt resulting from limited engagement in the NRRP implementation, despite beliefs about the NRRP's importance.

Despite the relatively good fit of the CFIR and Proctor Taxonomy to this study, the results point to a need to evaluate the NRRP implementation based on individual predictors of engagement and implementation readiness. While the National Tractor Safety Coalition functions as a collective effort in some ways, many of the barriers uncovered through this study related to individual-level engagement in the implementation process. Though the CFIR provides some focus on individual-level behavior, it would be particularly helpful for moving forward with the NRRP implementation to evaluate these behaviors and characteristics using the Theoretical Domains Framework (78), as previously

discussed. By doing so, individual-level detail that is not captured through the relatively limited *characteristics of individuals* domain could be captured, and may provide important insight and ideas for improving the implementation process. Thus, more information about the broadly defined *other personal attributes* construct could be collected. In addition, by determining who the key players in implementation are, or should be, a more cohesive and organized *inner setting* could be arranged to facilitate implementation activities. This would then have the potential to affect the influence of related constructs (e.g. many of the *inner setting* and *process* constructs) on implementation. This result suggests that evaluating this effort using the Theoretical Domains Framework (described briefly in section 3.5) (78) may be have been more appropriate, providing more usable feedback for improving the implementation.

Finally, it is also likely that the two closely-connected constructs *relative priority* and *tension for change* (both *inner setting* constructs) are more important to implementation than indicated through this dissertation. In terms of *inner setting* stakeholder engagement, it would seem that *relative priority* would be important for individuals deciding how much of the implementation that they can participate in, given their paid workload and *knowledge and beliefs about the intervention*; however, this was not explicitly stated in the qualitative studies, nor measured quantitatively. Despite not appearing as a factor in the *inner setting*, *relative priority* did come up in qualitative discussions of *outer setting* stakeholders, specifically in that the NRRP could be seen as "in competition" with a number of other programs or initiatives (both related and unrelated to public health or agriculture).

Tension for change was measured quantitatively; however, the results were fairly consistent across the regions, and it was therefore not correlated with the outcomes. This suggests that while *tension for change* may be important, it is perhaps not sufficient for implementation. This hypothesis was highlighted in the qualitative results, as stakeholders suggested that individuals who feel the strongest about needing change are likely to be involved in creating change (for example, fundraising for ROPS Rebates). As with *relative priority,* it is perhaps more relevant to measure *tension for change* among a wider audience of *inner* and *outer setting* stakeholders.

In this setting, the greater number of stakeholders that feel implementation of the innovation (in this case the NRRP), is important, the better the chance of the issue at hand being a higher priority than other initiatives (i.e. a higher *relative priority*). With high levels of both *tension for change* and *relative priority* among both *inner* and *outer setting* stakeholders (including the public), there is a greater chance of implementation success. This is

supported in the literature, as both *relative priority* and *tension for change* have also been touted as important implementation factors for public health and public health policy (147-149).

8.2.3 Practical Aspects of Implementation

This dissertation, its aims, and the sub-studies within it, were developed in response to the question, "what does it take to implement agricultural safety and health innovations?" Though the NRRP has not yet been fully implemented, this dissertation has provided some guidance for answering this question. Based on the results here, three overarching components of the ROPS Rebate Program and implementation strategies have contributed to its past and current successes, and that encompass numerous CFIR and Proctor outcome constructs, as described in sections 8.3.1 and 8.3.2.

First, the Program was developed in close collaboration with the farm population and is similarly implemented in various states with the help of local farmers and non-farming stakeholders. Innovation development sets the tone for all related and future work. Thus, the close inclusion of farmers and the bottom-up development of the ROPS Rebate Program helped to ensure that it incorporated an understanding of *farmer needs and resources*, is *acceptable, appropriate, and feasible* (to participate in), and that end-users are *satisfied* with it (150). By tackling these areas, which are all considered implementation factors under either the CFIR or Proctor outcomes, the ROPS Rebate Program had already overcome several challenges to implementation prior to attempts to scale up the Program.

Second, media about tractor overturns and the ROPS Rebate Programs has contributed to implementation and sustainability. In Minnesota, a state legislator was quoted stating that ROPS legislation would not exist in the state if it weren't for a particular media report (151). However, in other states, a direct line of causality could not be established through this study. Despite this, the results suggest that media is likely to be a promising implementation strategy that would be worthwhile to study further.

Finally, public health policies (and those who develop them) have provided a more stable foundation for the Program to develop. At the beginning of this thesis, I discussed the US farm community's strong opposition to regulations governing the activities that take place on or impact the farm environment (2). Often, words such as "regulation," "policy," "government," and "oversight" can cause emotional responses including fear and anger among this population (2). However, this study demonstrates how public health policies can be beneficial to farm communities and meet them where they are, so to speak. While the policies described in this dissertation (specifically,

those to fund the ROPS Rebate Programs) exist, they were developed with knowledge developed through years of research and work with the farm community (detailed in sections 2.2 and 3.2). This process describes the components of bottom-up approaches. In this context, such approaches have the potential to not only result in the implementation of life-saving programs (such as the ROPS Rebate Program), but also restore trust between opposing groups, including that between farmers and government.

8.3 Contributions to Implementation Science Research

8.3.1 Application of Implementation Science Models to New Public Health Settings

This dissertation took the opportunity to adapt and utilize three implementation science models (the CFIR and Proctor Taxonomy, as well as the T0-T4 model) to agricultural safety and health settings. Though implementation science is an important component of public health, the challenges of addressing safety and health outcomes in occupational settings are much different than addressing issues at individual or community levels. As a result, public health models that have been validated for other areas of research may not work in these settings.

Sub-studies I and II aimed, in part, to adapt two implementation science models using two diverse methods. First, the NIH's T0-T4 Process Model was adapted based on the results of a literature review. Initially, this was not an aim of the study. However, because of the overall lack of clarity in how to approach implementation efforts in agriculture, forestry, and fishing safety and health settings, this became a natural next step. Ideally, this review would also have provided some guidance in moving through the T3 phase of research, which could then be combined with National Tractor Safety Coalition member feedback in sub-study II. This sub-study aimed to develop evaluation tools based on the CFIR and Proctor Taxonomy that were appropriate for the agricultural setting. However, unlike the first sub-study, this one relied almost entirely on feedback from the National Tractor Safety Coalition, who had previously been tasked with jointly implementing the NRRP.

Though it would have been ideal to combine both the literature about implementation efforts and stakeholder feedback, this was, unfortunately not possible in this setting. However, in similar efforts to explore the utility of implementation science models in new settings, it could be valuable to combine such sources of knowledge about the perceived challenges of doing implementation, and how those might relate to the chosen model.

8.3.2 Utility of the CFIR and Proctor Taxonomy for Understanding Research Translation in Agricultural Safety Initiatives

Though the CFIR and Proctor Taxonomy have been used in a wide variety of settings, this study is the first to apply the frameworks to an agricultural safety setting (76). Even those studies that focus on occupational settings more generally focus on disease prevention rather than safety (76). Sub-study II focused on making the necessary adaptations so that the CFIR and Proctor Taxonomy could be applied in this setting. Overall, few changes needed to be made to use the frameworks to evaluate the NRRP implementation. After collecting and analyzing evaluation data (explicitly in sub-studies III and IV, but also through sub-study V), the utility of the CFIR and Proctor Taxonomy in agricultural safety settings was confirmed. All factors identified as being important to the NRRP implementation (sub-studies III-V) fit within the CFIR and Proctor Taxonomy. The evaluation tools that were used were also successful in eliciting the necessary information. Because these tools were developed using recommended measures for the CFIR and Proctor Taxonomy, it is likely that they could be easily applied to other public health initiatives.

In addition to adapting the CFIR and Proctor Taxonomy to an agricultural safety and health setting, this study also aimed to scale up an evidence-based program to a national level, which is less common than conducting several smaller scale implementation projects (i.e. innovation spread) (152, 153). This decision was made early on 1) because the Program model appeared to be suitable for use throughout the US, and 2) in order to ensure a quality and consistent Program across the country.

Scaling up presents some unique challenges in terms of the CFIR. In this study, these challenges related specifically to understanding how the *inner* and *outer settings* were organized and related (i.e. which factors, individuals, etc. belonged in each domain). As was shown through the qualitative results (sub-study IV), this challenge held true, with different stakeholders highlighting different implementation strategies and *inner* and *outer setting* members.

Despite the relatively good fit of the CFIR and Proctor Taxonomy to this study, the results point to a need to evaluate the NRRP implementation based on individual predictors of engagement and implementation readiness. While the National Tractor Safety Coalition functions as a collective effort in some ways, many of the barriers uncovered through this study related to individual-level engagement in the implementation process. Though sub-studies III and IV identified these issues, they did not provide clear direction on how to increase engagement and limit barriers to participation. Thus, evaluating this effort using the Theoretical Domains Framework (described briefly in section 3.5)

(78) may be have been more appropriate and provided more usable feedback for improving the implementation strategy.

8.3.3 Validation of the CFIR and Proctor Taxonomy

As described previously (section 8.1), occupational safety and health settings can be challenging in that there are different dynamics between program implementers and target populations (compared to the clinical setting, for example). In occupational safety and health, more buy-in is needed from target populations in order for implementation to succeed, and in many cases, this may be difficult to achieve due to long-standing trust issues between the farm population and groups including researchers and government officials. These differences in implementation settings may similarly result in differences in how implementation efforts can be studied (i.e. can the CFIR and Proctor Taxonomy be used in occupational safety and health settings). The sub-studies included in this dissertation helped to validate the use of the CFIR and Proctor Taxonomy for use in this setting.

Sub-study IV, in particular, served to identify any factor that impacted this implementation study. In this study, an inductive approach to Grounded Theory Situational Analysis was used to develop themes describing the implementation process and the situation within which this process exists. The discussion section of this paper then proceeds to return to the basis of this dissertation study and link the qualitative findings to the CFIR and Proctor constructs. In doing so, the findings of this study reflected these frameworks, and no other implementation factors emerged.

While no new constructs emerged, the CFIR construct other personal attributes (within the *characteristics of individuals* domain), which itself is quite broad and loosely defined, was used extensively in this analysis. This could suggest the need for future revisions of the CFIR to include more specifically defined constructs within the *characteristics of individuals* domain. Alternatively, it could be appropriate to incorporate some of the constructs described by the Theoretical Domains Framework (e.g. skills, optimism, intensions, goals, or social influences), or other individual-level implementation frameworks jointly with the CFIR. In this way, it may be possible to develop a more robust analysis that focuses not only on the organizational contributions to implementation, but also how individuals within an organization can contribute to implementation efforts.

8.3.4 An Inner-Outer Setting Spectrum

As defined by Damschroder et al., the *inner* and *outer settings* are two distinct groupings of people, policies, and events. Similarly, until now in this

dissertation, the *inner* and *outer settings* have been treated as such. However, based on the findings presented, I propose here the concept of the *inner* and *outer settings* as a fluid spectrum. In that, I suggest that individuals, policies, and events can be considered entirely *inner setting*, entirely *outer setting*, or somewhere in between. Further, this classification may change over time, particularly as it relates to human behavior and actions. This concept is discussed, to some extent, in the initial presentation of the CFIR (56); however, Damschroder et al. suggest these dynamics do differ depending on the specific study, while I propose here a model that allows for dynamic changes within a single study.

Take, for example, the case of Senator Charles Schumer; a proponent of the NRRP, and a key player in maintaining funding for Program administration during a period of drastic budget cuts in 2017 (demonstrated through the media reports collected in sub-study V). By traditional definitions, Senator Schumer remains part of the *outer setting*. He is not a member of the National Tractor Safety Coalition, nor is he employed by the NRRP. However, for several months, one of the Senator's primary goals was to preserve funding for the NRRP. During this time, the Senator worked closely with Program staff and executed a media advocacy campaign in support of the NRRP. In doing so, he became more actively engaged in implementation than the vast majority of Coalition members and took on a role that was more closely tied to the *inner setting* than the *outer*. Once successful in this effort, Senator Schumer slipped back into an *outer setting* role, supporting the Program more discreetly.

Though, by true definition of the *outer setting*, Senator Schumer could be considered an *external change agent*, this assumes that implementation efforts are black and white. In reality, real-life implementation is messy, and often falls within grey areas.

Though unproven based on this study alone, the concept of an inner-outer setting spectrum also helps to explain the primary challenge in adapting the CFIR and Proctor Taxonomy for this study setting. In this, the main challenge did not spur from applying these frameworks to an agricultural setting. Instead, it was about clearly defining the *inner* and *outer settings* when conceptualizing the CFIR for this study. In this process, I collected feedback from several others, including Laura Damschroder (the lead researcher behind the CFIR) about how to appropriately classify the inner and outer settings. The consensus was that there are no clear definitions, and that two different implementation studies may conceptualize the inner and *outer settings* differently in the same setting (56). This was a first hint in suggesting

that perhaps the *inner* and *outer settings* aren't as distinct as the CFIR suggests on paper.

Similarly, events and policies that impact implementation may also be classified on an inner-outer setting spectrum, though these would remain more steadily in place over time. For example, comparing three policies: 1) a Program policy that all ROPS must be installed by a certified mechanic could be considered exclusively as an *inner setting* policy; 2) current trade policies that have a trickle-down effect on farm income, and thus the ability to retrofit even through the NRRP could be considered an *outer setting* policy; and 3) a state-level policy that focuses greater efforts and funding on agricultural safety, in general, would fall somewhere between the *inner* and *outer settings*.

9 | Methodological Considerations

9.1 The Impact of Implementation Phase on Study Outcomes

The NRRP will be considered fully implemented at the point in which there is ample rebate funding to meet demand for ROPS rebates across the US. This goal has not yet been met. Thus, the work in this dissertation was conducted primarily during implementation, with some work done pre-implementation. Though monitoring this process in real-time provides important information and can provide information on how to modify the implementation strategy to increase the chance of success, there are also some downsides to conducting the evaluation at this phase. Conducting an evaluation in the post-implementation phase would mean that there is a greater ability to measure changes in outcomes measures (*progress*, *intakes*, and *retrofits*) and implementation factors. Thus, more concrete guidance about which factors are most important to implementation could be established than during the implementation phase.

9.2 Terminology and Consistency in the Literature

Though much research has been done in agriculture, forestry, and fishing safety and health, few published studies discussed research translation activities in such a way that they could be easily identified through a literature search. In sub-study I, for example, key terms related to research translation were required to be present in either the title or abstract of the text; only 14 such publications existed. This is not to say that only 14 studies within agriculture, forestry, and fishing safety and health research have discussed research translation; however, it does demonstrate the lack of consistency in how research translation is discussed, and therefore, how this information travels. This is further supported by the vast differences in how the authors of the 14 articles reviewed for sub-study I described research translation. In terms of the implications of this challenge, it is possible that some relevant papers were excluded from the scoping review (sub-study I) because different terminology was used. For example, knowledge translation was not included as a search term in sub-study I but may have produced additional articles for review. While this was largely an oversight in developing search terms, the term is rarely, if ever, used in agricultural safety and health settings (particularly in the US), and its exclusion is unlikely to have made a drastic impact on the results of the study.

9.3 Study Population

Overall, each of the five surveys (in sub-studies II and III) saw relatively good response rates (between 49% and 75%). These response rates were partially as a result of the mixed mode survey design that was used to distribute survey invitations and follow-up with non-responders. Though the response rates were quite high, the first three surveys (the construct selection survey (sub-study II) and the first two repeat measure surveys (sub-study III)) could not be linked to specific participants due to restrictions with the survey platform. After changing survey platforms, surveys were then linked using a unique ID number for each participant. Unfortunately, because the first three surveys were not associated with specific people, individual participants' survey responses could not be compared over time. Because of this, the only way to analyze changes in survey item scores (sub-study III) was to use ten regions as the unit of analysis.

Only National Tractor Safety Coalition members were asked to participate in the majority of the study. This was to ensure that the individuals responding to survey questions were familiar enough with the NRRP implementation to be able to appropriately respond. In the initial study plan, the intention was to have three US intervention regions, as well as using Canada as a control region. In this model, an equivalent selection of Canadian representatives would have also been surveyed for sub-study III. However, upon developing the survey instrument, it became clear that respondents needed to have a reasonable knowledge of the specific program and implementation effort in order to answer the questions. Thus, they were excluded.

Sub-study IV was the only study to include participants who were not active on the National Tractor Safety Coalition. This included both non-National Tractor Safety Coalition stakeholders based in the US and Canada. The US-based stakeholders served to provide a perspective of how the NRRP implementation was being received within the country by the *outer setting*. The Canadian participants served, primarily, as comparison and to collect ideas for improvement based on the systems in place in that country.

9.4 Construct Selection

The selection process taken in sub-study II was helpful in identifying both the viewpoints of the National Tractor Safety Coalition, as well as the CFIR and Proctor constructs relevant and important to the ROPS hotline staff, funders, and agriculture, forestry, and fishing research community more generally. Though the evaluation tools used in sub-studies III and IV could have been developed based on only the feedback provided by the National Tractor Safety Coalition, it was felt that several important components were missing.

Similarly, the research team felt that some of the constructs selected by the National Tractor Safety Coalition were duplicative of other measures that may have been more appropriate. In order to ensure the rigor of this process, three individuals selected constructs based on 1) the National Tractor Safety Coalition rankings, 2) her own knowledge of the NRRP implementation, and 3) her own knowledge of the larger occupational safety and health arena. Once these rankings were complete, the three reviewers worked together to achieve consensus. Further, the three reviewers came from different schools – medicine, anthropology, and public health, and had varying levels of experience working on implementation studies.

While it can be seen as a strength that such a diverse group of individuals reviewed the CFIR and Proctor Taxonomy to identify those constructs most likely to impact implementation of the NRRP, this process also limited the number of CFIR and Proctor constructs that were intentionally measured over the course of this study. This, in itself, can be seen as a limitation. A number of constructs were not specifically examined through this study, nor was attention drawn to them during the qualitative sub-study or media analysis. This includes two *intervention characteristics* (*adaptability and trialability*), one *outer setting* construct (*peer pressure*), four *inner setting* constructs (*goals and feedback, learning climate, organizational incentives and rewards, and culture*), and three *implementation outcome* constructs (*adoption, feasibility,* and *penetration*). Due to the nature of the study, particularly the qualitative sub-study and media analysis, it is likely that if any of these constructs were particularly important in this setting, they would have come up. However, it is also important to remember them in future evaluations of the NRRP implementation, as they have not yet been formally assessed.

9.5 Repeat Measure Surveys Construct Measurement

In sub-study III, a repeat measure survey design was used. This was intended to capture any changes that occurred over time as stakeholders began working on various components of the NRRP implementation. The thought was that, for example, if a person started to fundraise (i.e. progress in the *process* outcome), then it is likely that some of their survey item scores (e.g. *engagement* or *knowledge and beliefs about the intervention*) would also change. However, during this study time frame, no such changes were seen. This is likely due to the overall short timeframe of the study. Though it is possible to see change in an 18-month period, the limited scope of this project made it difficult to regularly conduct targeted outreach with stakeholders to encourage greater participation and therefore changes in CFIR and Proctor constructs and ROPS outcomes.

An additional challenge with this survey instrument is the specificity of the questions asked, particularly those questions related to stakeholder engagement. In reviewing the results of this study, it became evident that there could be a wide interpretation of the answer choices for how often National Tractor Safety Coalition members participate in various events. For example, "more than one to two times per week" could mean more than two days per week to one person, while another person may report two ROPS-related meetings on the same day as two "times." Because of this, some caution is needed in interpreting these results, especially for participants who reported higher engagement levels.

A final challenge relates to the number of survey questions associated with each measured construct. While some constructs, such as *tension for change,* are narrowly defined and have a limited number of questions that can be asked, other constructs are broader. For example, the *engaging* construct, in particular, is measured through two multi-part questions, and each part of the questions were assessed independently of the others. Thus, there were more opportunities for *engaging* to be deemed quantitatively relevant than *tension for change*, or other more limited constructs. Though potentially problematic for the assessment, added questions about particular constructs allowed for these factors to be explored more completely, improving our understanding of implementation more fully and allowing for better quality improvement in the specific implementation study.

9.6 Reliance on National Tractor Safety Coalition Stakeholders

This dissertation relied, largely, on input and feedback about the implementation process provided by National Tractor Safety Coalition stakeholders. Though some other stakeholders were included in sub-study IV, others, including prominent politicians who have had a demonstrated impact on the ROPS Rebate Programs, were not surveyed or interviewed for this dissertation. This was largely because upon development of the survey instruments and interview guides, it became clear that it would be difficult for individuals who weren't involved in the National Tractor Safety Coalition to appropriately answer many of the questions. Even still, unengaged Coalition members (who could be considered further toward the *outer setting* end of the inner-outer setting spectrum) struggled to answer more detailed interview questions, as they were not as familiar with the day-to-day implementation process. Though non-Coalition stakeholders were largely excluded from this study for justifiable reasons, this decision does have the potential to impact the results of this study. This is especially true when considering the role that these stakeholders have had in the NRRP implementation (or, in earlier phases, state Program implementation). By

including a greater number of non-Coalition stakeholders, it is possible that different CFIR and Proctor constructs could have been highlighted as more or less important to implementation.

9.7 Qualitative Rigor

This dissertation utilized three studies that were qualitative in nature (sub-studies I, IV, and V). Across all of these sub-studies, steps were taken to increase the trustworthiness of the research.

Credibility of the qualitative studies was improved in several ways. First, the participants and data sources included in the three studies came from diverse backgrounds, thus helping examine the issue from a number of different viewpoints. Next, across all three studies, analyst triangulation (154, 155) was used. Though I primarily carried out the analysis for each study, several other individuals, with varying knowledge of and connection to the research setting and NRRP as well as with different professional and academic background, assisted with this process. This particular point helps to improve credibility as well as confirmability. Third, the themes and ideas presented as a result of each study were carefully developed to ensure that the data are well represented. Finally, this dissertation, as a whole, employed triangulation methods to compare research findings based on both qualitative and quantitative studies.

Sub-study IV, which was the only study developed through use of participant interviews (compared to the analyses based on the literature and media reports) involved initial and follow-up interviews with the same participants. By doing so, participants were able to comment on changes in perspectives or situations over time, thus increasing dependability (154) of the findings.

Finally, across all sub-studies, transferability (154) was improved by giving clear overviews of the research context. Though true, as Graneheim and Lundman discuss, “it is the reader’s decision whether or not the findings are transferable to another context (154).”

In addition to these indicators of overall trustworthiness of this dissertation and the qualitative studies embedded in it, it is also relevant to consider the specific trustworthiness of sub-study IV using four additional criteria specific to Grounded Theory: fitness, workability, relevance, and modifiability (156).

Inductive coding was used to initially digest the data in sub-study IV, demonstrating a first step toward fitness of the themes to the data. Though the data for this study was initially categorized based on the situational

elements suggested by Clarke (97), the themes developed step away from this model, further enhancing fitness. These themes additionally help to provide a prediction of how the implementation process will move ahead in various scenarios. This predictive factor highlights workability. Given the basis of this dissertation and the implications of sub-study IV for improving implementation of the NRRP, relevance is demonstrated. Though true, relevance should be further assessed by others hoping to apply the findings to new areas of work. Finally, the theory and themes presented in sub-study IV are certainly modifiable. Additional follow-up with National Tractor Safety Coalition and non-National Tractor Safety Coalition members may serve to bolster the findings of this study and provide additional information about the themes developed and how they can be refined.

9.8 Generalizability

This study focused on the scaling up of a specific agricultural safety intervention. Thus, in many ways, it is difficult to say with confidence that the results of this study are generalizable to other settings. However, it is anticipated that both the methods applied throughout this dissertation, as well as the findings of the study could be helpful in guiding other researchers conducting similar studies, as described below.

While the process to adapt the T0-T4 model could be replicated for the same or other models, it is also likely that the adapted model itself could be used in other areas of public health. This hypothesis is based on the fact that the model broadly outlines the process of developing and spreading innovations. It was designed with the agricultural, forestry, and fishing safety and health research field in mind, which means that the framework takes into account different types of innovations (engineering solutions, programs, policies, etc.). As public health innovations often fall into these same categories, it is possible that the adapted T0-T4 model will also be applicable in these settings.

The results of adapting the CFIR and Proctor Taxonomy for use in this dissertation could also be of value to other researchers; however, in this case, the findings of this sub-study (II) may be less generalizable than the adaptation process itself, which could be used in a variety of public health settings. The specific constructs that were selected may be most generalizable to other agricultural safety settings; however, it is also likely that there would be some variance based on the implementation strategy and the dynamics of the implementation team (*inner setting*).

Similarly, the CFIR and Proctor constructs that were shown to be relevant to this study may provide some guidance to others, especially those working in agricultural safety or scale up settings, particularly when diverse coalitions are involved as the *inner setting*. However, it is also important to take into account the intricacies of each implementation setting. As this is the first identifiable agricultural safety implementation study using the CFIR and Proctor Taxonomy, it is not yet possible to determine what is needed across other implementation studies in the same field of research. As more implementation studies are conducted in agricultural safety and health settings, it may be possible to compare relevant implementation factors and develop more rigorous guidelines of "how to do implementation" in this setting.

10 | Conclusions and Future Directions

Though much work has been done over the past decade to ensure the success of the ROPS Rebate Programs (and now NRRP), implementation has proven to be quite challenging at various levels.

First, the foundation for completing implementation science research in agriculture, forestry, and fishing is lacking. While progress has been made in other areas of public health, the contextual factors, including the environment and culture that innovations are implemented in, tend to be different, making it difficult to create a direct link between public health and occupational safety and health. Implementation efforts in occupational safety and health are further hindered by unique logistical challenges, namely funding for work on the later end of the T0-T4 spectrum. Though the National Institute of Occupational Safety and Health provides funding and support for research to extramural partners, translation efforts are traditionally the responsibility of other organizations such as the Occupational Safety and Health Administration, Cooperative Extension, and equipment manufacturers, which are often separated from the research perspective. Though the NRRP has not yet been fully implemented, there have been marginal successes and movement toward this end goal. This progress would not have been possible without collaboration between a wide variety of individuals, including those who make up the National Tractor Safety Coalition (the *inner setting*) as well as those whose responsibilities fall within the *outer setting* as it relates to this effort. Despite this progress, much work is still needed to increase engagement among these stakeholders in order to more quickly move the NRRP along. Future evaluations using the Theoretical Domains Framework may be helpful in better understanding challenges and opportunities related to individual-level engagement.

Second, in addition to challenges funding research translation work (and aligning those whose traditional responsibilities lie on both the research and practice ends of the spectrum), understanding the "checkpoints" along the research to practice continuum and the end goal of research (i.e. to improve safety and health outcomes), is a challenge. Reviews and publications such as sub-study I in this dissertation and the similar study prepared by Schulte et al. (20) are helpful in starting the conversation and moving the entire agriculture, forestry, and fishing research community toward an improved understanding. Over the past year, I have collaborated with Dr. Schulte's team to further clarify discrepancies, assess challenges in research translation, and suggest future directions through several presentations (157-159) and a manuscript (Cunningham et al., Forthcoming). Such collaboration and open

discussion is important in moving the ball forward in implementation science among agriculture, forestry, and fishing researchers and should be continued.

Third, though there has been increasing discussion on the research to practice process in agriculture, forestry, and fishing safety and health research, very little has been done to understand how to successfully navigate the later ends of this process. Sub-studies II-V provide resources for others who hope to attempt implementation studies, especially on a large scale. These studies have helped to highlight various implementation factors that have both helped and hindered the implementation and sustainability of the NRRP, as described throughout the results and discussion sections of this dissertation. Importantly, these results are now being used to reassess the implementation strategy to improve the chance of success. Some of the most immediate changes include finding ways to tailor study results and epidemiological data to specific regions of interest, reassessing National Tractor Safety Coalition leadership roles, and identifying specific tasks to boost engagement in the implementation process. Moving forward, it will be important to continue evaluating the implementation process and making additional corrections as needed.

In terms of the NRRP implementation, specifically, much of what has been learned through this dissertation could be useful in continuing efforts. In particular, media advocacy was demonstrated as a promising implementation strategy; however, a more formal assessment of this strategy would be helpful and necessary. Future evaluations of media advocacy efforts may be helpful in both implementing the NRRP and further assessing the impact of media on implementation efforts. In addition, the inclusion of modern media and communication channels, such as social media platforms, could provide additional information about how stakeholders obtain information about and discuss public health programs.

This dissertation has provided much information about a single implementation effort. Though true, the processes and results can likely be applied to many other contexts, both within OHS research and public health. Engaging and sharing findings with researchers and practitioners focused on other implementation studies will be valuable for moving implementation science along and reducing the extraordinary length of time needed to fully implement innovations.

In an academic sense, this dissertation has provided an extensive look at the challenges and opportunities for widely implementing research in the agriculture, forestry, and fishing safety and health setting. Despite the knowledge gained in both this study and its predecessors, which served to

build the body of evidence supporting the ROPS Rebate Programs, progress toward a fully-implemented NRRP has been remarkably slow. During a 1991 address to the Surgeon General's Conference on Agricultural Safety and Health, Dr. James Merchant said,

> *"If we cannot develop a US model for a proven intervention on the single most important cause of agricultural mortality – tractor overturns – how can we succeed in addressing the less dramatic yet still important causes of agricultural diseases and injuries?"*

Though an appropriate solution has been developed and thoroughly vetted, this sentiment still holds true today as we struggle to make this solution widely available to US farmers. As Dr. Linda Forst highlighted in the American Journal of Public Health (quoted specifically on page 31 of this dissertation), the ROPS Rebate Program serves "as a model for implementation research in public health" in that it has demonstrated success from numerous standpoints including lives saved, cost-effectiveness, and satisfaction among the target population, among others throughout the pre-implementation phase, thus providing the tools necessary for scaling up. This then begs the question, if we can't successfully and widely implement the NRRP, then how can we succeed in other areas of public health in the US? The rather slow uptake of this Program at the national level, despite the potential public health impact, highlights a dire need for the US, as a whole, to refocus priorities and opportunities to enhancing human wellbeing – the mission of public health. This applies not only to instances of agriculture, forestry, and fishing safety and health, but to the broader field of population health, in which research translation takes an average of 17 years to accomplish. Moving forward, it is imperative that public health researchers and practitioners, along with policy makers and society as a whole, dedicate the time necessary to establish ample evidence supporting best practices and find efficient ways of spreading proven innovations so that populations may benefit. By doing so, the research conducted in the fields of clinical and public health will allow us to more effectively and ethically improve public health while simultaneously preserving resources.

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Appendices

Appendix 1: Construct selection survey instrument for sub-study II.

Appendix 2: Repeat measure survey instrument for sub-study III.

Appendix 3: Interview guide for initial interviews, sub-study IV.

Appendix 4: Interview guide for follow-up interviews, sub-study IV.

Appendix 1: Construct Selection Survey Instrument

Translating Research into Practice: Survey to Identify Factors Important to Implementing the National ROPS Rebate Program

The purpose of this survey is to identify factors that are important for implementing the National ROPS Rebate Program (NRRP). Below you will find factors that could impact the implementation process. Please review these, and rate each based on how important you feel it is to implementing the NRRP using a scale of 1 (not at all important) to 5 (extremely important). Base your answers on you own opinions (not what you believe other NTSC members or your organization think).

Important Acronyms and Definitions:
1) NRRP: National ROPS Rebate Program
2) NTSC: National Tractor Safety Coalition (NTSC members include researchers, engineers, insurance companies, government organizations, agricultural organizations, health and safety organizations, and farmers/farm advocates. The Steering Committee, which oversees the Coalition, includes representatives from many of these sectors.)
3) NEC: Northeast Center for Occ. Health and Safety (NRRP administrators)

Thank you for participating in this survey! If you have any questions, please feel free to contact:
Pam Tinc at pam.tinc@bassett.org or 800-343-7527, ext. 2230.

Note: In order to earn a raffle entry, you must complete the entire survey (questions 47-48 are optional). As a reminder, this is the first in a series of 7 surveys. For each one that you complete, you will receive one raffle entry for a $1,000 Amazon gift card.

In implementing the NRRP, how important is/are…

	Not at all important	Somewhat unimportant	Neutral	Somewhat important	Extremely important
1. NTSC members' perceptions about whether or not the NRRP was developed by the Coalition.					
2. Evidence of whether or not the NRRP can help prevent tractor overturn fatalities.					
3. NTSC members' beliefs that the NRRP is the best option for reducing tractor overturn fatalities.					
4. The degree to which the NRRP can be tailored to meet local conditions.					
5. The ability to test the NRRP in an area and end the program in that area, if warranted.					
6. The perceived difficulty of starting the NRRP.					
7. The perceived excellence in how the NRRP is promoted.					
8. The costs associated with starting, administering, and promoting the NRRP.					
9. The NTSC's understanding of farmers' needs, as well as the ability to meet those needs.					
10. The degree to which the NTSC is networked with other sectors or organizations.					
11. Pressure (on the NTSC) to launch the NRRP from organizations not involved in the NTSC.					
12. External activities, such as development of regulations or standards that support NRRP implementation.					
13. The structure of the NTSC.					
14. The number and quality of peer-to-peer relationships and communications within the NTSC.					
15. The norms, values, and basic assumptions of NTSC members.					
16. The degree to which NTSC members perceive the current situation (high rates of tractor overturn fatalities) as intolerable or needing change.					
17. The fit between NTSC members, the NTSC mission, and the NRRP. The NTSC mission is, "to prevent tractor-related injuries and deaths in U.S. agriculture by developing and implementing collaborative, stakeholder-driven, evidence-based solutions.					
18. NTSC members' shared perception of the importance of implementing the NRRP.					
19. Incentives (for NTSC members to participate) such as networking opportunities, benefits to customers, or increased stature or respect.					
20. The degree to which NRRP goals are clearly communicated, acted upon, and fed back to NTSC members.					

	Not at all important	Somewhat unimportant	Neutral	Somewhat important	Extremely important
21. A climate in which: NTSC steering committee members express their own fallibility; NTSC members feel valued and safe to make suggestions; and there is time and space for reflection.					
22. Commitment, involvement, and accountability of the NEC in implementing the NRRP.					
23. Commitment, involvement, and accountability of the NTSC Steering Committee.					
24. The level of resources dedicated to NRRP implementation and on-going operations.					
25. Access to information about the NRRP and NTSC members' ability to use this information.					
26. NTSC members' attitudes toward the NRRP as well as familiarity with facts and principles related to the NRRP implementation.					
27. NTSC members' belief in their own capabilities to take action to achieve NRRP implementation goals.					
28. NTSC members' change in attitude and behaviors as they become more engaged in the NRRP implementation.					
29. NTSC members' relationship and degree of commitment to the Coalition.					
30. Personal traits (of NTSC members) such as motivation, values, competence, and capacity.					
31. The degree to which tasks for implementing the NRRP are developed in advance and the quality of those methods.					
32. Individuals on the NTSC who influence others' attitudes and beliefs about the NRRP.					
33. NEC staff who have responsibility for supporting the implementation of the NRRP. Specifically, this includes the NRRP hotline staff and research team.					
34. NTSC Steering Committee members who have responsibility for leading the implementation of the NRRP.					
35. Individuals who dedicate themselves to supporting, marketing, and 'driving through' the NRRP implementation.					
36. Individuals who are affiliated with an outside entity (such as rebate funders or manufacturers not on the NTSC) who formally influence or facilitate NRRP decisions.					
37. Carrying out or accomplishing the implementation according to plan.					
38. Regular debriefing about the progress and quality of the NRRP implementation.					

	Not at all important	Somewhat unimportant	Neutral	Somewhat important	Extremely important
39. The perception among NTSC members that the NRRP is acceptable.					
40. The intention, initial decision, or action to launch the NRRP.					
41. The appropriateness of the NRRP to address tractor overturn fatalities.					
42. The feasibility of successfully carrying out the NRRP in the US.					
43. The expansion of the NRRP to all states.					
44. The extent to which the NRRP is maintained.					
45. The degree to which the NRRP meets or exceeds farmers' expectations.					

1. Do you have any comments about the factors listed above? (Optional)

2. Are there any factors that you feel may impact the implementation of the NRRP which we have not included in this survey? (Optional)

Thank you for your response!

Appendix 2: Repeat Measure Survey Instrument

Implementing the National ROPS Rebate Program
[Date]

The purpose of this survey is to help evaluate how the implementation of the National ROPS Rebate Program (NRRP) is going. Please base your answers on your own opinions (not what you believe other NTSC members or your organization think).

Important Acronyms and Definitions:

1) NRRP: National ROPS Rebate Program

2) NTSC: National Tractor Safety Coalition (NTSC members include researchers, engineers, insurance companies, government organizations, agricultural organizations, health and safety organizations, and farmers/farm advocates. The Steering Committee, which oversees the Coalition, includes representatives from many of these sectors.)

Thank you for participating in this survey! If you have any questions, please feel free to contact
Pam Tinc at pam.tinc@bassett.org or 800-343-7527, ext. 2230.

NOTE: In order to earn a raffle entry, you must complete the entire survey by midnight on *[Date]*. As a reminder, this is the *[number]* in a series of eight surveys. For each one that you complete, you will receive one raffle entry for a $1,000 Amazon gift card.

1. Please indicate your level of agreement with the following statements:

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
The NRRP is an acceptable response to tractor overturn fatalities.					
It is feasible to implement the NRRP.					
It is important that the NRRP is implemented now.					
The implementation of the NRRP is going well.					
The cost of the NRRP has not prevented it from being implemented in my state.					
The NRRP is sustainable.					
Once implemented, the NRRP will meet the needs of my organization's target population.					
I have the resources I need to promote the NRRP in my role.					
NRRP materials (including the website, promotional materials, and information packets) are of high quality.					
NRRP information and materials are appropriate.					
NRRP information and materials are engaging.					
NTSC updates are helpful in allowing me to reflect upon progress toward implementation of the NRRP.					
The NTSC Steering Committee is supportive of the NRRP.					
The NTSC Steering Committee encourages members to be involved in implementing the NRRP.					
Influential stakeholders (such as funders, manufacturers, or other influential individuals) are supportive of the NRRP.					
My employer encourages me to network with colleagues outside of my own setting					

In the space below, please include any further explanation of your responses that you feel we should know, especially for points that you disagreed with.

2. **What do you feel your role is in implementing the National ROPS Rebate Program? (Please check all that apply)**
   - ☐ Monitoring progress so that I can stay informed
   - ☐ Providing feedback about activities that others are planning and carrying out
   - ☐ Sharing promotions and materials with partners outside of the Coalition
   - ☐ Helping plan implementation activities such as events and fundraising
   - ☐ Participation in implementation events
   - ☐ Participation in fundraising
   - ☐ Other (please specify):

3. **In the past six months, how often have you done each of the following?**

	Not at all	1-2 times	1-2 times per month	1-2 times per week	More than 1-2 times per week
Read NTSC updates, information, or materials.					
Attended a NTSC webinar or conference call.					
Attended a NTSC in-person meeting.					
Attended an event on behalf of the NTSC or NRRP.					
Provided feedback or suggestions on NTSC activities or materials via email or one-on-one phone call.					
Provided feedback or suggestions on NTSC activities or materials during a NTSC webinar, conference call, or in-person meeting.					
Shared NRRP information or promotions with a group of individuals via social media, email distribution lists, or newsletters.					
Incorporated NRRP information into a presentation or report that you were putting together for another purpose.					
Had a conversation about the NRRP with another individual(s).					
Served as a spokesperson specifically for the NTSC or NRRP (through interviews, presentations, etc.).					
Recruited new members to the NTSC or connected NTSC members with new partners.					
Helped arrange or plan NTSC activities or events					
Submitted a funding or resource request for the NRRP.					
Met with potential funders to discuss funding the NRRP.					
Other (Please specify):					

The next two questions will be used to determine whether or not the appropriate stakeholders are involved in the NTSC and NRRP implementation.

4. Name the first three collaborators (individuals or organizations) you would go to if you needed assistance moving forward with an agricultural initiative.

5. Name the three individuals or organizations whose support is crucial to successfully implementing the National ROPS Rebate Program.

Thank you for your response!

Appendix 3: Interview Guide for Initial Interviews

Implementing the National ROPS Rebate Program
Interview Guide – October 2017

Note: *Alternate question choices have been noted for different groups, as necessary. These divisions are between National Tractor Safety Coalition members (including steering committee and general members) and non-National Tractor Safety Coalition members, as well as between all US-based participants, participants located in the program states (old and new), and Canadian participants.*

Question 1:

National Tractor Safety Coalition members: Could you tell me about your involvement with the National Tractor Safety Coalition (National Tractor Safety Coalition) and National ROPS Rebate Program (NRRP)?

Non-members: What do you know about the National Tractor Safety Coalition (National Tractor Safety Coalition) and National ROPS Rebate Program (NRRP)?

Question 2:

All: What is the fit between the NRRP and what stakeholders (farmers or others) in your state/country need?

Question 3:

All: How do you think and feel about the NRRP implementation? What about others in your organization/state/nationally? **IR1-3:** Does it matter that the NRRP was developed in NY?

Question 4:

US: Discuss your experience with the NRRP implementation. (Ease/difficulty; clarity of process; information that was helpful or missing, etc.)

Canada: Discuss your experience with attempts to implement solutions to tractor overturn fatalities in Canada. (ease/difficulty, missing components, etc.)

Question 5:

US: Who would you consider "people with influence or leaders" who aided the NRRP implementation? **Program States:** What about in your state?

Canada: If Canada were to implement the NRRP, who would you consider "people with influence or leaders" who would aid in the implementation?

Question 6:

US: What may have negatively influenced the NRRP implementation nationally? In your state? If a person or organization, what would you say have been their views of and attitudes toward the project?

Canada: If Canada were to implement the NRRP, what might be some barriers or negative influences on the implementation?

Question 7:

US: In the surveys that we conducted, many stakeholders expressed that cost was not a barrier to implementing the NRRP. Could you share your opinions and experiences related to this?

Question 8:

US: Do you think that information about the NRRP got through to the farmers who needed to hear them? What about stakeholders? How do you know?

Question 9:

All: What do you see as the prospects of the NRRP, specifically the ability of sustaining it in your state/nationally? What improvements or actions would you suggest to maintain/improve sustainability?

Question 10 (Added During the Interview Process):

All: Can you describe a time when you were engaged in getting another program started (at any scale)? What was your role? Why were you engaged?

Question 11:

All: Is there anything else you would like to add?

Appendix 4: Interview Guide for Follow-up Interviews

Implementing the National ROPS Rebate Program
Interview Guide - October 2018

Our last interview took place in the fall/winter of 2017. This round of interviews serves two purposes: 1) to understand if and how things have changed over the last year, and 2) to clarify questions that arose after reviewing last year's interviews and the surveys that have been conducted since then. As such, some of the questions that I will be asking you are new, and some may be the same as or similar to questions that I asked you last year. Do you have any questions for me before we get started?

1. How do you think the National ROPS Rebate Program implementation is going overall?
    a. Has this changed since last year? If so, why/how?
    b. Does anything in particular stick out to you as going well or not so well? Could you provide some examples?

2. In implementation, there are two major groups of stakeholders who are involved. One group is called the inner setting, which is generally defined as the organization or group directly responsible for moving forward with the implementation process, while the outer setting consists of those organizations or factors that are not directly responsible for implementation, but may influence it. In the case of the NRRP implementation, where do you feel you fall, and why?
    a. If you play multiple roles, does working in the inner or outer setting depend on what role you are in? How?
    b. Who (else) do you believe falls within the inner setting? Why?

3. What tasks do you feel the National Tractor Safety Coalition is responsible for in implementing the NRRP?
    a. Why are/aren't certain tasks (e.g. fundraising, promotions, etc.) the responsibility of the National Tractor Safety Coalition? What makes it difficult for them to complete certain tasks?

4. What do you feel your specific role is in getting the National ROPS Rebate Program going?
    a. Do you feel like this is in line with what the NEC has asked of you? How do these opinions influence the priority you place on being involved with the NRRP implementation?

b. What makes, or would make, the NRRP implementation a high priority for you personally?
c. For others involved in the National Tractor Safety Coalition?

5. Do you feel that by participating in the NRRP implementation you are making a difference? Why? If yes, who are you making a difference to?
    a. How and in what way does this influence your participation?

6. Tell me about your understanding of how the NRRP runs (i.e. leadership, facilitation, funding, etc.) How does this understanding impact your ability or desire to be involved with the Program?

7. What level of trust do you have in the NEC as it relates to this Program? How does this impact your engagement in getting the NRRP going?

8. What have you heard about political support/opposition for the NRRP? How does this impact your involvement with getting the Program going?
    a. Do you feel other National Tractor Safety Coalition members are more or less likely to be engaged with implementation if there is strong political support? Why?
    b. Is the type of political support particularly important (i.e. regional support? Federal/state support? Republican/Democrat?)Why?

9. From the surveys, we see that *stakeholder perception of steering committee support* and *stakeholder perception of the level to which steering committee members encourage National Tractor Safety Coalition members to be involved in implementation* are both negatively correlated with ROPS outcomes (NRRP intakes and completed retrofits). Please share your thoughts on why this might be.

10. Are there specific types of information that you think would be helpful to National Tractor Safety Coalition members to gather support for ROPS rebates in their regions?