

Closeout Report

Title of Project

Putting ROPS Research into Practice: Paving the Way for a National Program

Program Director/Principal Investigator

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List of Terms and Abbreviations

AgFF: Agriculture, fishing, and forestry
AM: Aftermarket Manufacturer
EBI: Evidence-based intervention
CFIR: Consolidated Framework for Implementation Research
NAICS: North American Industry Classification System
NIOSH: National Institute for Occupational Safety and Health
NIH: National Institutes of Health
NRRP: *National ROPS Rebate Program*
NTSC: National Tractor Safety Coalition
OEM: Original Equipment Manufacturer
OHS: Occupational Health and Safety
ROPS: rollover protective structures
R2P: Research to Practice

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Abstract

Farmers have considerably elevated rates of occupational fatality, as compared to other U.S. industries. Although this fact alone warrants consideration, it is even more remarkable to note that the most frequent cause of death on farms, tractor overturns, has a readily amenable solution, which is the installation of rollover protective structures (ROPS). ROPS are commercially available and 99% effective in protecting a tractor operator from death and injury. However, 40% of U.S. tractors lack this crucial safety technology. The over-arching objective of this proposal was to translate the wealth of knowledge about ROPS and interventional strategies into a national program that would decisively address the issue of tractor overturn fatalities.

To do this, the research team worked to establish evidence-based ROPS installation programs in high-risk states, while at the same time mobilizing the stakeholder investment necessary for launching a National ROPS Rebate Program. Evaluation of the implementation process in high-risk states included a structured, staged approach, which provided valuable information on how program fidelity is maintained in these environments.

Evaluation of efforts to mobilize a collaborative, multi-industry approach to national program implementation involved an exploration of the research translation process and the barriers and facilitators that come with the translation of evidence-based research to worker environments. Research activities included a scoping literature review on occupational safety and health (OSH) interventions that have made it to the later stages of the T0-T4 model. Manuscripts were identified through six databases. A survey was also conducted utilizing the Consolidated Framework for Implementation Research (CFIR) to examine the process for the National ROPS Rebate Program (NRRP) implementation. Using the results from this survey, quantitative and qualitative evaluation tools were developed. Following this survey, a repeat measures survey was used to collect CFIR and Proctor construct data at four time points. Qualitative research interviews were also conducted in order to facilitate a Grounded Theory Situational Analysis. A cost benefit analysis of one state program was also conducted to look at the cost-effectiveness of the ROPS Rebate Program model.

Through this research, the research team: 1) modified T0-T4 research translation model, 2) identified 21 CFIR and Proctor constructs that National Tractor Safety Coalition members believed would be important to the NRRP implementation, 3) identified eight CFIR and Proctor constructs highly correlated ($\rho \geq 0.5$) with at least one outcome measure (*progress, intakes, or retrofits*), 4) discovered in qualitative interviews that the NRRP implementation evolved inconsistently across stakeholders and stakeholder engagement was tied to perceived feasibility and "small wins" and 5) the cost-benefit analysis of the NY program demonstrated an almost \$5 million savings as a direct result of the ROPS rebate program.

Section 1 of the Final Progress Report (2-page limit)

Significant Key Findings

The long-term goals of this proposal were to identify promising R2P processes and to address the most frequent cause of farm deaths, tractor overturns. Over the course of the research project, the research team launched a National ROPS Program that built upon years of interventional research. This program focused initial resources and efforts in high-risk regions of the U.S.. Implementation efforts were also evaluated using the constructs outlined in the Consolidated Framework for Implementation Research (CFIR), which permits the assessment of “what works where and why across multiple [implementation] contexts”.

Specific Aim #1: Address the most frequent cause of farm-related death by setting the stage for a National ROPS Rebate Program (NRRP). In June of 2017, the research team officially launched the National ROPS Program (see <https://www.ropsr4u.org/>). The program offers logistical support to tractor owners seeking rollbars for their tractors. It also provides helpful resources and materials for individuals seeking to garner financial support for ROPS rebates in their own state or region. Thanks to the support of the research team and the National Tractor Safety Coalition (NTSC), several states were able to raise funds for tractor owners in their state. The project continues to provide needed ROPS resources and support to farmers across the country and addresses the most frequent cause of death on U.S. farms. It is also the only national, organized effort to prevent tractor overturn morbidity and mortality. Most importantly, the research team conducted a cost benefit analysis in 2018 of the NY ROPS Rebate Program and found that it has led to \$4,242,134 in cost savings over ten years, based on injuries prevented as a direct result of the program. Researchers also found that “the one-time retrofit costs will continue to prevent injuries as long as the tractors are used, generating additional (projected) future savings of \$12,136,512, \$15,781,027, and \$18,924,818 if retrofitted tractors remain in operation 15, 20, or 25 years after their retrofit.”

Specific Aim #2: Utilize the implementation process as an opportunity to examine what works and does not work in research translation efforts. In addition to launching a national program for ROPS installation, the research team invested considerable effort in examining the NRRP implementation process. By assessing intermediate and summative endpoints through the CFIR lens, researchers have contributed markedly to the discussion of implementation science in the scientific literature. In particular, a modified T0-T4 research translation model was developed, which takes into account the real-life challenges in moving proven innovations into widespread practice. Project research has also characterized 21 CFIR and Proctor constructs that stakeholders identified as being important to the implementation process. Eight of these CFIR and Proctor constructs were found to be highly correlated ($\rho \geq 0.5$) with at least one primary outcome measure, such as ROPS program inquiries or retrofits. Researchers also learned that the implementation of the NRRP evolved inconsistently across stakeholder groups, pointing to areas of improvement for future implementation projects. Lastly, our implementation research identified the need to underscore the feasibility of the implementation process among stakeholders and to highlight “small wins” to keep stakeholders engaged. This research will continue to provide needed guidance to occupational health and safety researchers on how to effectively implement evidence-based interventions.

Translation of Findings.

A primary goal of the “Putting ROPS Research into Practice: Paving the Way for a National Program” was to address the gap in knowledge regarding how to effectively translate research into worker practice and workplace improvements. Our research findings have contributed greatly to current knowledge of what works or does not work in research implementation. It is worth noting that an editorial in the American Journal of Public Health highlighted the research from this project, stating the “intervention 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 timeline, 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”.

Thus, our research will serve future occupational health and safety endeavors, by providing much needed guidance on how to effectively implement evidence-based, injury prevention efforts. It also offers a wide array of innovative research methods and practices for monitoring the implementation process and evaluating outcomes. These can be applied to the amelioration of any occupational injury issue or public health issue, for that matter.

Dissemination of our research has been notable. As demonstrated in the list of references, an impressive number of research articles have been published on study methods and results. It is also worth noting that the project’s research Coordinator has been integrally involved in NIOSH discussions of translational and implementation research, having co-presented with Dr. Schulte and other NIOSH implementation researchers at national conferences and in peer-reviewed publications.

Research Outcomes/Impact.

In addition to developing a proven ROPS Rebate Program intervention model, which has been demonstrated to save lives and state resources (end outcome), project researchers have conducted early-stage, OSH implementation research, which has served as a foundation for implementation studies in the field of occupational safety and health (intermediate outcome). A summary of advances in implementation science research include a review of the implementation literature in agriculture, forestry and fishing occupational health and safety research, development and testing of implementation evaluation and the identification of key factors and processes for guiding implementation efforts. The following list provides further documentation of the project’s productivity and impact in the field of occupational safety and health:

- Development of a Program model with target population appeal (99% highly recommend the Program)
- Substantial leveraging of funds - over \$3 million in ROPS Rebate Funding from private and state sources
- Installation of nearly 3,000 ROPS on tractors in 12 years
- Assessment of impact (16 fatalities prevented in NY, 188 self-reported close calls from NY participants)
- Assessment of cost-savings (More than \$4.2 million saved in NY between 2006 and 2017)
- Development of over 60 farmer-tested ads, factsheets, and brochures for promoting ROPS
- Construction of a ROPS website (www.ROPSR4U.com) that gives US farmers access to ROPS information
- Organization of the NTSC, which includes more than 50 high-profile, multi-sector organizations
- Increased media coverage of overturns/ROPS, i.e. the Wall Street Journal, USA Today and RFD-TV
- Development of three videos targeted to increasing stakeholder engagement and support
- Recognition as a NIOSH R2P ‘success story’ <http://www.cdc.gov/niosh/r2p/moreAction.html#tractor>

Section 2 of the Final Progress Report

Background

Despite efforts to increase the installation of ROPS on US tractors there are still many tractors in the US that lack this crucial safety device. Given the high number of fatalities from tractor overturns, this research was conducted to expand evidence-based, ROPS Rebate Programs to additional states. The following sections provide a detailed overview of the research highlighted in peer-reviewed publications generated from the project.

Paper #1: A Scoping Review of T0-T4 Research in Agriculture, Forestry and Fishing OSH Research

Introduction. Agriculture, forestry, and fishing (AgFF) workers face the highest risk of fatal injury: 25.3 fatalities per 100,000 full time workers, compared to the all-worker fatality rate of 3.4 fatalities per 100,000 full time workers.¹ Though much research has been conducted to identify viable solutions for preventing these events, examples of successful and complete adoption of these solutions among target populations are rare.

The primary funder of AgFF health and safety research in the US, the National Institute for Occupational Safety and Health (NIOSH), encourages researchers to “develop new knowledge in the field of occupational safety and health and to transfer that knowledge into practice,” in order to improve health and safety outcomes for workers^{2,3}. To advance the mission of putting research knowledge into worker practice, NIOSH launched the Research to Practice (R2P) initiative in 2004 to encourage intramural and extramural researchers to increase the reach of evidence-based research. The R2P initiative focuses on “the use, adoption, and adaptation of NIOSH knowledge, interventions, and technologies,” as well as the evaluation of these activities⁴. Based on the descriptions of this effort, we understand R2P as efforts involving: 1) sharing knowledge through diffusion, dissemination, or implementation, with target populations so that they may benefit from it, and 2) actively seeking to ensure that evidence-based research is widely adopted in the workplace.

AgFF populations are often well aware of the risks associated with their chosen occupations; however, the wide array of life-saving technologies and interventions designed by research teams to address these risks have yet to be fully accepted or made widely accessible to these workers⁵⁻⁹.

Unfortunately, various researchers have demonstrated that health and safety initiatives are a low priority for these workers as a result of myriad obstacles, including those related to finances, environmental conditions, and increasing regulations¹⁰⁻¹⁴. In order to meet the goals of both NIOSH and the R2P initiative and make a significant impact on health and safety outcomes within these populations, researchers must find ways to increase the widespread adoption of evidence-based research and evaluate progress toward this goal^{3,15,16}.

In the past, AgFF researchers have referred to the National Institute of Health’s (NIH) clinically-based T0-T4 model of translational research¹⁷ to evaluate where they are along the R2P continuum¹⁸. Within the NIH T0-T4 model, the T0 and T1 phases start with the development and application of disease-focused interventions. This is followed by the T2 phase, which involves experimental applications with patients and the T3 phase, which involves patient trials in less restrictive, real world settings. In the T4 phase, research innovations are finally rolled out to the population level, at which point health and safety outcomes can be measured¹⁷.

In particular, the research team was interested, specifically, in the T3, or implementation, phase, which appears to be the most significant gap in AgFF and public health research^{3,16,19,20}. The T3 phase of the NIH T0-T4 model is the key to ensuring worker adoption and application of evidence-based research in practice, as this phase focuses on the diffusion, dissemination, and implementation of research findings¹⁷. Further explanation of these terms, as well as examples of each.

Although the T3 phase includes diffusion, dissemination, and implementation, previous work has shown that more “hands-off” approaches such as diffusion and dissemination can make it difficult to ensure that: 1) public health and AgFF research is adopted by target populations, and 2) that health and safety impacts can be evaluated^{16,21,22}. This can be seen, for example, within the agricultural population where rollover protective structures (ROPS) were made standard on new tractors in 1985²³. At the same time, retrofit ROPS kits became available and were initially promoted by manufacturers (dissemination); however, after a short time, little was done to actively encourage farmers to retrofit (diffusion)²⁴. Despite predictions that 75% of US tractors would be retrofitted with ROPS kits by 2015,²⁵ this has not been the case; nearly 50% of US tractors remain unprotected today^{26,27} demonstrating the strong need for more intensive approaches to increasing worker adoption.

In addition to limited exploration of the T3 phase in AgFF research, the use and applicability of the NIH T0-T4 model in AgFF efforts had prior to this project, not been fully examined. The scoping review conducted as part of this U01 research funding mechanism sought to fill these gaps by: 1) providing an overview of R2P efforts in the AgFF sector, 2) comparing the way R2P, and specifically T3 research, is defined and discussed in AgFF health and safety literature, 3) determining progress along the R2P continuum in AgFF published research, and 4) examining the utility of the NIH T0-T4 model for use in AgFF efforts.

Paper #2: Using CFIR to Monitor the Intervention Implementation Process

Introduction. When it comes to appropriate integration of research results in the areas of occupational safety and health, there is often a disconnect between research and widespread implementation of evidence based interventions (EBIs)^{3,8,9,15,16,19,20}. In this case, we consider EBIs that have proven to specifically minimize injuries and mortalities in the agriculture, forestry, and fishing (AgFF) arena. In order to bridge this gap, methods for guiding, informing, and evaluating widespread implementation efforts are needed. Though some of the earliest implementation studies began in agricultural settings²⁸, researchers and practitioners in this field have not yet documented active pursuit of widespread implementation of health and safety related EBIs according to a literature review conducted by the research team.

Though there are few documented attempts to achieve widespread implementation of EBIs in the AgFF arena, there is evidence that researchers have applied implementation models in more localized settings. Recently, the RE-AIM framework²⁹ was used to implement a farm safety program, which originated in the mid-western United States, to South Carolina³⁰. The authors of the study suggested that while RE-AIM was useful in its original form, the study would have benefitted from tailoring the framework to their specific implementation setting³⁰.

Given the lack of widespread AgFF implementation examples, the research team looked to the realm of clinical research for guidance in examining the process of widespread implementation. Within the clinical field, much work has been done in implementation science, which is defined as “the scientific

study of methods to promote the systematic uptake of research findings and other EBIs into routine practice, and, hence, to improve the quality and effectiveness of health services ³¹.” As a result, several frameworks and theories for advancing the field have been developed ³²⁻⁴¹.

One such framework is the Consolidated Framework for Implementation Research (CFIR). Like RE-AIM, the CFIR provides a framework for researchers attempting to link implementation process to outcomes and a means of evaluating implementation of EBIs. The CFIR combines twenty smaller implementation theories, into one comprehensive framework ³². The CFIR was designed so that it could be adapted and applied in a variety of settings to encourage consistency in evaluation and reporting of translational efforts ³². In addition to helping users understand what works, or doesn’t work, in implementation research, the qualitative-based CFIR is unique in that it also helps researchers understand why and how implementation processes work ^{32,42}.

In total, the CFIR contains 26 constructs (three of which include a total of 14 sub-constructs) divided into 5 domains: characteristics of individuals, inner setting, intervention characteristics, outer setting, and process ³². In addition, seven supplemental outcome constructs were developed to help users more fully plan and evaluate implementation efforts ⁴³. These supplemental outcome constructs are divided into two domains: implementation outcomes and client outcomes ⁴³. Throughout this discussion, both constructs and sub-constructs will simply be referred to as constructs, and discussion of the CFIR will include not just CFIR constructs but also the supplemental outcome constructs.

We thus applied the CFIR to monitoring the expansion of an evidence-based Rollover Protective Structure (ROPS) Rebate Program ⁴⁴⁻⁵⁰, which provides financial assistance to farmers who wish to install life-saving ROPS kits on their tractors. Among US farmers, tractor overturn fatalities are the number one cause of death each year ²⁷; when used with a seatbelt, ROPS are 99% effective in preventing these tragic fatalities ²⁵. Though ROPS are standard on newer equipment, tractors manufactured prior to 1985 did not include ROPS and must be retrofitted ^{23,49}. Retrofit ROPS kits are available to farmers; however, barriers to retrofitting, such as cost and sourcing difficulties, stand in the way.

The ROPS Rebate Program was launched in New York (NY) in 2006 ⁵⁰. This program is voluntary and provides farmers with assistance identifying the proper ROPS kit for their specific tractor. The Program also provides a rebate of approximately 70% of the cost of the ROPS kit, shipping, and professional installation with a cap on out-of-pocket expenses ^{47,50}. In surveys conducted with every fourth participant approximately six months after completion of the ROPS installation, 99% say that they would recommend it to another farmer ⁵¹. Since launching in 2006, the ROPS Rebate Program has expanded to six additional states: Vermont, New Hampshire, Massachusetts, Pennsylvania, Wisconsin, and Minnesota. To date, more than 6,200 farmers have signed up for the Program and more than 2,300 farmers completed ROPS retrofits in these seven states ⁵¹. An additional 148 farmers have inquired about the Program from other states.

In 2014, ROPS Rebate Program facilitators, who administer the ROPS Rebate Program, invited a multi-sector group of agricultural stakeholders to a two-day Future Search workshop ⁴⁸. During this workshop, the group developed a joint plan for expanding the Program into the National ROPS Rebate Program (NRRP). This group, which is now known as the National Tractor Safety Coalition (NTSC), continues to work together to pursue this goal. The Coalition is populated with representatives from a wide range of sectors, including equipment manufacturers and dealerships, insurance agencies, health and safety organizations, agricultural organizations, government organizations, and media outlets, as well as farmers and farm safety advocates, university-based engineers, and ROPS Rebate Program experts.

Given this expansive representation, the NTSC was well-positioned to encourage the launch of the NRRP^{45,49}. The NTSC was led by a 15-member steering committee, which is representative of the Coalition at large and includes the ROPS Rebate Program facilitators.

These efforts were designed to examine the efficacy of CFIR as a framework for monitoring the implementation of an AgFF EBI, i.e. the NRRP. The first step in applying the CFIR to AgFF and public health implementation studies, included: 1) determining which CFIR constructs are applicable in non-clinical settings, specifically implementation of the NRRP; and 2) developing evaluation tools (including a survey and passive data collection tools) to capture useful measures of the CFIR domains over time. Useful CFIR measures would be ones that are predictive of, related to or associated with positive outcomes of NRRP implementation, such as an increase in the number of ROPS orders.

Paper #3: Cost Analysis of the NY ROPS Rebate Program

Introduction. A 2002 study found that nationwide, tractors were the cause of 37% of all agricultural fatalities.⁵² Rollover protection structures (ROPS) on older tractors can substantially reduce the risk of injury in the event of a tractor overturn. In 1985 ROPS became standard equipment on tractors, however, many pre-1985 tractors are still in use.⁵³ Addressing this gap in ROPS protection for older tractors is critical for two reasons. First, tractors are the leading cause of farm-related deaths, and overturns are the principle cause of these deaths. Second, ROPS could virtually eliminate a primary source of agricultural fatalities.⁵⁴

Research shows a clear relationship between the percentage of non-ROPS tractors and the rate of annual tractor-related fatalities. The northeastern US had the highest tractor-related fatality rate in the nation at 15.4 deaths per 100,000 workers for the years 1992-1995.⁵⁵ From 2001-2004, NY ranked second nationwide in prevalence of non-ROPS tractors (61%), while Pennsylvania ranked first at 62%.⁵⁶ Nationwide, the prevalence of non-ROPS tractors decreased from 62% in 1993 to 49% in 2004, while between 1992 and 2007 tractor overturn fatality rates declined 28.5%.⁵³ Swedish studies indicate fatality rates from tractor overturns fell to nearly zero when non-ROPS tractor prevalence dropped to between 20% and 25%.⁵⁷

The barriers to ROPS retrofitting are significant. A 1996 study found that 40% of NY farmers would never install ROPS, even if it were free, due to storage concerns.⁵⁸ In a similar study, ROPS barriers included finding the right ROPS, availability of the ROPS, transport to a dealer for installation, and cost.⁴⁷ In a study of ROPS incentives, researchers offered farmers a range of subsidies for ROPS installation based on a percentage of the total cost to retrofit. As the subsidy increased to 100%, buy-in by farmers increased up to a maximum of 80%.⁵⁹

Over the past few decades, numerous strategies have been employed to address the issue of tractor overturns. These include: (1) sales and promotion of ROPS; (2) human factors research to alert the operator of an imminent rollover; (3) re-engineering of automatically deployable and cost-effective ROPS; and (4) education.⁵⁴ These efforts have led to various levels of limited success. In NY, prior educational efforts had increased awareness of tractor overturns, however, few farmers had considered installing them prior to 2007.⁶⁰⁻⁶³ Knowledge of risks had failed to create behavior change to any substantive degree.⁴⁷

In 2008, the National Research Council reported that roughly 52% of tractors on farms lacked a ROPS.⁶⁴ Two years earlier, investigators at the New York Center for Agricultural Medicine and Health

launched a social marketing program in NY to overcome financial, logistical, and perceptual barriers to retrofitting. Social marketing identifies a population's needs, values, and barriers to change and designs interventions that match these.⁶⁵ The NY campaign used the following approach:^{47,66,67}

- *Audience segmentation.* Researchers identified at-risk segments of the farm community. They selected small-scale crop and livestock farms and aimed to assure that at least 1-2 tractors had ROPS protection on each farm.
- *Identify barriers.* Researchers conducted in-depth interviews with farmers. Three themes emerged—(1) “Constant exposures with positive outcomes normalize risk”, (2) “Risk is often modeled by significant others”, and (3) “There is tremendous pressure to reduce costs, save time, and accept risk.”
- *Design incentives.* Two incentives were provided: (1) a rebate to reduce cost (the State of NY provided rebates up to \$600 per tractor) and (2) a hotline to assist callers in locating ROPS.
- *Design messages.* Based on focus group feedback, the most powerful messages featured the danger to families and the economic burden of a personal disability. Visuals were determined to be highly relevant.

Piloting elements of the social marketing campaign. Researchers selected four regions to evaluate campaign impact based on different combinations of intervention components. Piloting of the incentives led to a marked increase in ROPS retrofitting in NY, especially in regions that combined messages and incentives.

A barrier in the expansion of this intervention model has been the lack of widespread state or industry rebate contributions. Given the relatively low cost to fund state-based initiatives (at most \$250,000 annually), the research team sought to examine savings over time in a state like NY, which receives adequate rebate funding. In 2010, the research team conducted a cost-effectiveness analysis of the intervention and predicted a net benefit of \$1,910,000, over ten years.⁶⁸ In this component of the research process, the research team sought to assess the accuracy of original projections and to provide evidence of program benefits to state governments and industry groups to make informed decisions about investments in tractor overturn prevention.

Paper #4: Important CFIR Constructs in Implementation Research

Introduction. Though much work has been done to identify viable solutions to common health and safety issues in agriculture, little research has focused on how to successfully translate these solutions into widespread practice^{3,69,70}. At the time of this study, no other published efforts to scale-up agricultural safety interventions could be found. While in some cases, this is likely the result of a limited and inconsistent understanding of what it truly means to translate research into practice⁶⁹, another major barrier to such work is a lack of understanding of what works (or doesn't work) in translating occupational health and safety innovations to practice and why translational successes or failures occur^{3,69,70}.

Despite slow progress in agricultural safety and health implementation research, implementation science efforts have rapidly expanded in the areas of clinical medicine and public health. In particular, implementation researchers have sought to develop frameworks or models that can answer key questions about the implementation process. The Consolidated Framework for Implementation Research (CFIR) is one such model that was developed in order to answer questions of what works, in what settings, and why. This study uses the CFIR to quantitatively evaluate the scaling up of an

agricultural safety initiative to the national level in order to provide valuable information about implementing evidence-based agricultural safety interventions.

The Consolidated Framework for Implementation Research. The CFIR was developed as a tool for use in health services, including primarily clinical medicine, but also public health^{32,42}. Development of the CFIR began with a review of the literature on theories, frameworks, and models for implementation efforts, and resulted in the combination of 19 of these into one cohesive framework³². The CFIR was selected as an evaluation tool for this study due to its comprehensive nature and its ability to be adapted for and applied to diverse settings.

The CFIR consists of five domains related to implementation efforts: individual characteristics, inner setting, outer setting, intervention characteristics, and process^{32,42}. In addition, supplemental domains, including implementation outcomes and client outcomes, were developed to further describe implementation efforts⁴³. Each of the CFIR domains have been developed in relation to various constructs, which help describe each aspect of the implementation.

The individual characteristics domain consists of five constructs that help describe different qualities of the individuals involved in the implementation process. The inner setting is intended to describe the interactions between these individuals, as well as the immediate implementation environment. This domain uses five constructs and nine sub-constructs. The outer setting, which includes four constructs, describes the influences from stakeholders and networks outside of the inner setting implementation team.

As the name suggests, the intervention characteristics domain includes eight constructs that describe the qualities of the intervention throughout the implementation process. The process domain, which includes four constructs and four sub-constructs, logically helps to describe how the implementation occurs. Finally, implementation outcomes (five constructs) and client outcomes (two constructs) help explain whether the implementation was successful.

Because the CFIR has been developed out of other implementation frameworks, the construct definitions and suggested questions have been validated individually over time^{42,71}. In addition, the CFIR as a framework has been assessed for validity through a systematic review of its use⁷². Despite these assessments, no applications of the CFIR to the agricultural safety setting could be found, with the exception of this study's predecessor, which served to develop the survey instrument applied in this study⁷³. Thus, the utility of the CFIR in agricultural safety settings has yet to be determined.

Study Setting. Within agriculture, tractor overturns have long been the leading cause of death²⁷. These fatalities can be prevented by using rollover protection structures (ROPS), which are designed to keep tractor operators in a protected zone in the event of a tractor overturn. Though ROPS became standard on newly manufactured tractors in 1985²³, approximately 40-50% of tractors on US farms currently lack the devices^{27,57}. This is in large part due to the extended lifespan of most tractors, combined with the high cost (approximately \$1,200 per kit) and time required to retrofit these older tractors with ROPS^{5,6}. In addition, because many farmers do not feel personally vulnerable to tractor overturns, it can be difficult to justify the cost associated with retrofitting⁶.

The ROPS Rebate Program was first launched in New York in 2006 after several years of formative research to better understand farmers' barriers and motivators to installing the safety devices^{5,6}. An initial pilot study confirmed that targeted messaging combined with technical assistance and a monetary incentive was the key to increasing the number of ROPS-equipped tractors on farms⁴⁷. Since then, more

than a decade of research has been conducted and has established the ROPS Rebate Program as efficacious, effective, and economical^{5,6,46,47,74-79}.

Paper #5: Grounded Theory Situational Analysis of Stakeholder Perspectives

Introduction. ROPS come in several forms and, when used with seat belts, are 99% effective in keeping tractor operators in a protected zone in the event of an overturn, therefore preventing fatalities and serious injuries²⁵. In 1985, industry standards in the US were updated to ensure that all new tractors were sold with ROPS²³. Despite this attempt, only 51-59% of tractors on US farms are equipped with ROPS today^{27,57}. Rather, many older tractors, which were originally sold without ROPS, are still in use, and have yet to be retrofitted.

Internationally, tractor overturn fatalities have been significantly reduced using combinations of regulations, marketing, and monetary rebates⁸⁰⁻⁸². Within the US; however, such regulatory actions are not feasible, therefore making progress in this area more difficult⁸³⁻⁸⁵.

Rather than attempting regulatory measures, agricultural safety researchers and stakeholders in the US have attempted to encourage ROPS retrofits in other ways^{24,25,48,49}. One initiative, the ROPS Rebate Program⁵⁰, has been particularly successful in increasing the number of ROPS-equipped tractors on farms.

The ROPS Rebate Program uses social marketing principles to reduce farmers' barriers to retrofitting while simultaneously increasing and improving facilitators. Research conducted prior to the development of the Program indicated that financial and time constraints, coupled with low perceived risk were the main barriers farmers faced^{5,6,86}. To combat these issues, Program developers included a toll-free hotline (for identifying and ordering the correct ROPS kit) as well as 70% rebates toward the cost of purchasing and installing ROPS⁵⁰. In addition, targeted messages were developed, many of which took into account those factors that acted as motivators for farmers (e.g. tractors being driven by family members)^{47,79}.

In the decade since the ROPS Rebate Program was first launched in New York, the Program has been expanded to six additional states (Vermont, Pennsylvania, New Hampshire, Wisconsin, Massachusetts, and Minnesota). Evaluations of efficacy and effectiveness have demonstrated that the Program has provided life-saving benefits (at least 17 overturn events in which a tractor operator was likely saved due to the ROPS have been documented), as well as cost-savings (more than four million US dollars were saved in New York over the first 11 years of the Program)⁸⁷.

In 2014, the National Tractor Safety Coalition (NTSC), a multi-sector group comprised of researchers, farmers, manufacturers, ROPS experts, and government, insurance, media, agricultural, and health and safety organizations, came together with a primary goal of reducing tractor overturn fatalities through the expansion of the ROPS Rebate Programs^{45,48,49}. Facilitated by a representative steering committee, the coalition provides the opportunity for the multi-sector agricultural stakeholders to share resources and knowledge to better achieve joint goals. The commitments made by the Coalition reflected these goals and included collecting and disseminating improved injury and fatality measures, educating stakeholders about the dangers of tractor overturns, addressing manufacturing and technology issues related to retrofitting, and raising funds to support a National ROPS Rebate Program (NRRP).

In June 2017, the NTSC formally announced and began implementing the NRRP, a nationwide offering of the ROPS Rebate Programs, as described above⁸⁸. The NRRP implementation includes 1) information, guidance, promotions, and fundraising through the NTSC, and 2) a media advocacy campaign to increase stakeholder support of the NRRP. Once fully implemented, the NRRP will provide all intervention components included in the original ROPS Rebate Programs, including ample funding across all 50 states.

Currently, at the national level, a small pool of funds exist for rebates; however, states that have recognized the importance of the NRRP can dedicate funding to their own farmers. While no additional states (beyond the seven already mentioned) have secured allocated funds for rebate Programs over the course of this study, eight have begun to develop plans for fundraising.

Paper #1: A Scoping Review of T0-T4 Research in Agriculture, Forestry and Fishing OSH Research

Methods. A scoping review of the literature, using the PIECES method⁸⁹, which involves defining the research question, identifying key search terms, and meticulously tracking the search and analysis process, was followed.

Definitions. The 2012 North American Industry Classification System (NAICS) was used to specifically define and set boundaries for each of the industry groups included in this study: agriculture, forestry, and fishing^{90,91}. Occupational health and safety (OHS) is defined as “the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and well-being of workers⁹².”

Search Terms. Prior to beginning the literature search, the lead author and an information specialist with a focus in OHS research worked to determine the most appropriate search terms using pilot searches through PubMed, Scopus, and Medline. Based on these searches, the research team and information specialist found that in order to effectively conduct the literature review, searches needed to utilize a combination of three term categories: 1) research translation and related terms; 2) occupational health or occupational safety; and 3) industry-related terms. Using this combination of terms, references unrelated to the study (e.g. those dealing with OHS in different occupations) were more likely to be excluded from the search results, while those related to OHS R2P in AgFF remained. Using the identified key words, medical subject headings (MeSH terms) were identified through PubMed, and those deemed appropriate by the research team were added to the search terms to be used.

Inclusion and Exclusion Criteria. To be comprehensive, a variety of literature types, including grey literature, were included in this review. Furthermore, work published any time prior to the date of the search (July 20, 2016) was eligible for inclusion. References were excluded from the study if they did not meet the NAICS definitions for at least one of the included industry sectors, as well as the definitions of OHS. Additionally, non-English language references were excluded.

Any text that referenced translational research or another of the related search terms in its title or abstract was retained for analysis. For texts without abstracts, the search terms needed to be present in the title and/or introductory sections (e.g. in books and longer texts) or full texts (e.g. in news releases and short texts).

Literature Search Process. Six databases (PubMed, Scopus, Web of Science, Medline, PsychInfo, ProQuest Dissertations) were searched by the lead author and information specialist using all possible combinations of search terms (i.e. one term from each category per search). When possible, truncated forms of industry-related terms were used to consolidate searches. During this process, filters for 'English language' and 'title and abstract search, only' were used whenever available. The lists generated by each search were imported into EndNote⁹³ for tracking purposes. Once all of the searches were complete and duplicates were removed, titles and abstracts were reviewed by the lead author and articles were removed if they did not meet the inclusion criteria. One reference, which used the term 'diffusion of innovations,' in its abstract, was excluded because the authors described and applied the term as a method in planning an intervention, rather than a method for R2P. Bibliographies of the remaining texts were then scanned to identify additional references.

Analysis. Full texts were analyzed using NVIVO qualitative data analysis software⁹⁴. Each reference was first coded to determine how authors defined and applied key R2P terms. The 'definitions' were largely extracted from introductory sections of the texts and the 'applications' were based on the methods, results, and discussion sections of the texts.

Within the definition and application categories, sub-categories reflective of each phase of research, including: prioritizing needs, innovation development, manufacturer collaboration, pilot-testing and evaluation, diffusion, dissemination, implementation, and impact evaluation, were developed. These sub-categories were largely based on the authors' own descriptions of the research process and the types of work in which they were they were engaged.

Secondly, the texts were analyzed to describe the current progress along the R2P continuum by using the categories and sub-categories developed in the first stage of analysis as well as by returning to the full texts. References describing the action of putting research into practice (i.e. those coded under the sub-categories of diffusion, dissemination, and implementation) in either definitions or applications were further examined to determine if the discussion was related to widespread or localized efforts. Texts describing or applying dissemination efforts were evaluated to determine if policies, standards, or guidelines were discussed. Additionally, the two first stages of analyses were used to assess the utility of the NIH T0-T4 model and develop a revised version specific to, and based on, AgFF research processes.

Paper #2: Using CFIR to Monitor the Intervention Implementation Process

Methods. Given that a literature review did not yield any studies documenting widespread implementation efforts in AgFF or in relation to adapting the CFIR, the research team used their own understanding of implementation science and the AgFF setting to make initial revisions to the CFIR model and its definitions³² so that they could be applied to a non-clinical setting. Modifications at this stage largely involved removing clinical terminology. The CFIR was organized into a construct selection survey which asked respondents to rate each construct on an ordinal scale (from 1: the construct would not impact implementation of the National ROPS Rebate Program to 5: the construct would have a strong impact on implementation). At this stage, the survey included 43 questions directly related to CFIR constructs, which were organized into seven sections labeled with each domain name. In addition, the survey included two open-ended summary questions. In collecting information through such a survey, a wide range of backgrounds and experiences can be taken into account while narrowing the focus of the CFIR for the implementation of the NRRP.

Validating Survey Questions. Ten NTSC members were invited to participate in short interviews via telephone, which served as a pilot-test for the construct selection survey. These ten individuals were selected as they represented diverse stakeholder groups as well as varying levels of involvement in the NTSC. Due to a low response rate (two respondents out of ten), an invitation to participate was extended to all NTSC members; participants were selected on a first come-first served basis, though an effort was made to ensure that participants represented several different sectors. A total of six individuals including one state department of health employee, one university-based engineer, one insurance agent, and three agricultural safety and health professionals (with foci in both research and outreach) participated in this pilot.

Each participant was emailed a copy of the survey prior to a conference call. The survey questions were divided into six question groups, each of which contained one or two constructs from each CFIR domain. All question groups also included summary questions and the survey. Each participant was assigned a question group.

At the time of the call, the lead author used 'Think Aloud' interview techniques⁹⁵ to solicit information about participants' perceptions of the questions, as well as to identify any issues with understanding or responding to the questions. To achieve this, the interviewer first began with the survey introduction and instructions. Participants were asked to provide their understanding of what was being asked in the survey, as well as any comments about these sections. Next, individual questions were reviewed. The interviewer asked each participant to: 1) describe what (s)he felt each question was asking, and 2) verbally walk through the thought process used to answer each question. If a participant indicated that a question was particularly difficult to answer, they were prompted to elaborate on the "why." Interviews were not recorded; however, detailed notes were taken by the first author.

Development of the Final Construct Selection Survey. Once all interviews were completed, the research team used the information to develop a final version of the construct selection survey. Changes pertained to the phrasing of the instructions and questions. In addition, the domain titles were removed from the survey to reduce confusion. The final construct selection survey took approximately 15 to 20 minutes to complete and consisted of 47 questions. This included 45 questions with ordinal-scale responses and two open ended questions in which participants could further reflect on the constructs presented or provide suggestions for other factors to consider.

Each scaled question was reflective of one of the 43 CFIR constructs; two constructs, *leadership engagement* and *formally appointed implementation leaders* were allocated two questions each to distinguish between the NTSC Steering Committee and the NRRP facilitators. Participants were asked to rate (from 1: not at all important, to 5: extremely important) each construct based on their opinion of how important it was to implementing the NRRP. The order of these questions was randomized for each participant to reduce the impact of both response fatigue and priming bias.

Data Collection. The construct selection surveys were distributed to all 77 NTSC members (representing all different agricultural safety stakeholders) via several channels, as suggested by Dillman, et al.⁹⁶. Initially (day 1), surveys were distributed to all NTSC members via individualized emails which contained several key components: 1) the link to the web-based survey form, 2) an explanation of the overall study and survey purposes, 3) instructions for completing the survey, and 4) information about participants rights and contact information for the research team and the Institutional Review Board (IRB).

After one week (day 8), all NTSC members were again emailed. This message largely contained duplicate content and served as a thank you to those who already responded and a reminder for those who had not. One week later (day 15), mailings were sent to non-responders. This letter contained the same information as the previous emails, as well as a hard-copy of the survey and a postage-paid, addressed return envelope. Mailing addresses were not available for five individuals; a third email request was sent to these individuals instead. Two weeks after the mailed reminders were sent (day 23), an information specialist conducted telephone follow-ups with those who had still not responded. Each individual was contacted one to two times within a one-week period, depending on whether or not the caller had been able to speak directly to the participant during the first attempt, as well as whether or not the participant had completed the survey by the second round of calls. The survey was closed five weeks after the original request was sent (day 36).

As thanks for their time, construct selection survey participants were given a raffle entry toward a \$1,000 Amazon gift card. Participants were also advised that the drawing for this raffle would take place approximately two-years later, and that additional raffle entries could be obtained through the completion of seven additional surveys (for a total of eight tickets per person), which would be distributed periodically in that time frame.

Data Analysis & Evaluation Development. Three members of the research team developed a process to identify the final CFIR constructs that would be measured over the period of time that the NRRP was being implemented; the other researchers were also asked to provide feedback when necessary. To ensure that the final set of CFIR constructs were manageable for the research team and participants, the goal was to select between 20 and 25 constructs.

To achieve this goal the following selection process was conducted:

1. Identification of the highest rated constructs within each domain, and inclusion of constructs with a rating of 4.25 or higher.
2. Individual selection of constructs: The three researchers individually selected the constructs that they deemed to be important to evaluate throughout the implementation process, regardless of their rating. These lists were reflective of each individual's diverse background (public health, anthropology, and medicine) and varying experience in implementation science research and allowed for other, lower-ranking constructs to be brought in if deemed important.
3. Open discussion, achieving consensus, and final selection: The three lists were then combined and discussed in terms of the "bird's eye view" of the NRRP and its implementation process, and consensus was reached in order to determine the most appropriate constructs to include in the final evaluation instrument. This includes consideration of: NIOSH and R2P Program goals; the dynamics, goals, and processes of the NTSC; and the administrative processes related to facilitation of the NRRP. As a result of this discussion, some of the higher ranking constructs were excluded from the evaluation, and the research team agreed to include some of the lower ranking constructs (introduced through the individual lists). Examples are provided in the results section.

Once the final constructs were selected, the evaluation design and data collection were developed based on prior CFIR research and recommended measures⁴².

Paper #3: Cost Analysis of the NY ROPS Rebate Program

Methods. Cohort Survey and Exposure Time. An annual survey was sent to individuals who had obtained a ROPS retrofit through the NY ROPS Rebate Program. Participants who had reported an overturn or nearly fatal event in the survey were asked to describe the event. Over time, events have also been reported by participants who contact the hotline. A review of these event reports identified 17 tractor overturns.

Based on this information, exposure time (in years) was calculated as the time between the date of the retrofit, and either the date of the most recent survey or the date of contact in cases where events were reported via a call to the hotline. For subjects who never reported an event, follow-up time was calculated as the date of the retrofit until the date of the last survey attempt. A second measure of total ROPS exposure time was calculated as the time from the retrofit date to December 12, 2017. These estimates of exposure time were used in conjunction with the 17 reported overturn events to produce estimates of the number of ROPS tractor years per rollover.

Injury Outcome Analysis. Researchers estimated the number of fatal injuries, disabling injuries, and non-disabling injuries prevented using survey data from a tractor overturn study conducted in Kentucky⁹⁷, combined with estimates published by the CDC.⁹⁸ In the Kentucky study, researchers estimated the probability of death or serious injury with a correction for the “healthy worker effect.” Briefly, this phenomenon refers to the bias that can occur when workers healthy enough to remain in the work force are included in estimates, while those gravely injured leave the work force and tend to be overlooked. The corresponding corrected estimates for death, disabling injury (resulting in hospitalization or permanent disability), and non-disabling injury are 7.98%, 20.0%, and 21.9% respectively for a non-ROPS tractor and 1.7%, 3.0%, and 9.0% for a ROPS-equipped tractor. The CDC estimates for the probability of death were 40.0% and 1.7% for a non-ROPS and ROPS equipped tractor respectively. The CDC probabilities of non-fatal injury lacked the degree of granularity necessary to be combined with the data from the Kentucky study, and as a result injury probabilities were exclusively derived from the Kentucky study. From this, the probabilities used in the calculation of death and serious injury were:

- P death | non-ROPS tractor = $[\.0798^{97} + \.40^{98}]/2 = .240$
- P death | ROPS-equipped tractor = $[\.017^{97} + \.017^{98}]/2 = .017$
- P disabling injury | non-ROPS tractor = $.200^{97}$
- P non-disabling injury | non-ROPS tractor = $.219^{97}$
- P disabling injury | ROPS-equipped tractor = $.034^{97}$
- P non-disabling injury | ROPS-equipped tractor = $.090^{97}$

Cost Analysis. Given these probabilities, researchers examined intervention investments vs. injury cost savings based on the choices to retrofit versus not retrofit a tractor with ROPS Program costs per event were calculated by dividing total program costs by the number of events, with all dollars being converted to 2017 dollars using the Consumer Price Index. Program expense calculations for the NY ROPS Rebate Program included total program administrative and rebate costs from 2007 to 2017. Funds to finance rebates were provided by the State of NY, and private donors.

The best estimate of the cost of fatal and nonfatal agricultural injuries is provided by Leigh et al,⁹⁹ which provides direct and indirect costs. Direct costs include the cost of hospital services, doctors,

pharmaceuticals, and insurance overhead. Indirect costs are composed of lost wages, but also include lost fringe benefits and home production. These researchers found that the average fatal occupational injury in agriculture has a direct cost of \$69,297 and an indirect cost of \$572,180, for a total cost of \$641,477. The average occupational nonfatal disabling injury has \$16,891 in direct costs and \$20,085 in indirect costs, for a total cost of \$36,975, while the average nonfatal non-disabling injury has \$1,162 in direct costs and no indirect costs (all dollars adjusted to 2017 dollars). The fatal, disabling, and non-disabling injury costs prevented by the retrofit program were estimated by weighting these numbers by the estimated proportion of events that would have resulted in each type of injury, using the probability of such events as identified in the Kentucky study.⁹⁷ These cost estimates do not include pain and suffering, emotional effects, or other non-monetary impacts.

Thus, to estimate the total fatality, disabling, and non-disabling injury related costs prevented by the program, we used the number of tractors retrofitted each year to estimate the number of fatalities and serious injuries which were prevented each year by the program, multiplying these by Leigh et al.'s cost estimates which were adjusted using the CPI for fatalities and injuries prevented in 2017 and prior years, and a 3% discount rate for fatalities and injuries prevented in 2018 and future years. The 3% discount rate is very close to the current ten year Treasury Bill interest rate, which was 2.88% at the time of our calculations.

Paper #4: Important CFIR Constructs in Implementation Research

Methods. The soft launch of the NRRP, which occurred in March 2017, involved rebranding of the ROPS Rebate Programs into the NRRP and updating the website and Program database. This occurred prior to the official launch (June 2017) so that technical issues related to the updates could be corrected before the public announcement. This study took place during a 24-month timeframe surrounding the NRRP implementation, beginning six months prior to the soft launch and ending 18 months after the soft launch.

NRRP Implementation Regions. The 50 states were divided into ten implementation regions. These ten regions were defined based on three factors: 1) geographic location, 2) the requirement that at least one NTSC member resided in the region at each data collection point, and 3) the availability of different NRRP intervention components.

All 50 states have access to the toll-free hotline and website. Additionally, states in regions one, two, and three had secured at least some state-allocated funding prior to March 2017 and subsequently implemented the social marketing campaign. Region one (New York) was separated from regions two and three because the Program had originated in New York and had been active for the longest period of time. Regions two and three were divided based on geographic location (region two = Vermont, New Hampshire, Pennsylvania, and Massachusetts located in the Northeast, region three = Wisconsin and Minnesota located in the Midwest). As described, the remaining regions (four through ten) all have access to the toll-free hotline and website and limited national-level funding. However, state-allocated funding and social marketing campaigns are not available in these states.

Measurement of CFIR Constructs. In a prior study, NTSC members (n=65) were asked to score CFIR constructs from “not at all important” to “extremely important” to the NRRP implementation⁷³. Using these responses, Program evaluators with backgrounds in clinical medicine, public health, anthropology, and implementation science developed a corresponding survey instrument containing 36 questions (termed “CFIR survey items”) that covered 14 constructs⁷³.

Surveys were conducted at four time points: March 2017, September 2017, March 2018, and September 2018, with each survey asking participants to reflect on the six months prior. Thus, the surveys relate to four six-month periods: September 2016 through February 2017 (period one), March through August 2017 (period two), September 2017 through February 2018 (period three), and March through August 2018 (period four). The first time point, March 2017, served as a baseline measurement as it was collected at the time of the soft-launch of the NRRP. The additional three time points served to capture change over time in CFIR constructs.

Each survey was distributed to all members of the NTSC that were active in the Coalition at the time of the surveys (between 56 and 68 at each data collection point). This number fluctuated due to factors such as NTSC members' retiring and new NTSC members joining; however, overall the number of responses from each region remained relatively stable over time. At each data collection point, a mixed-mode survey method⁹⁶ was used to improve response rates.

Participants who responded to surveys were provided with one entry per survey for a \$1,000 Amazon gift card raffle. This study was approved by the Mary Imogene Bassett Hospital Institutional Review Board (project #2015).

Short-Term Outcome Measure. For each six-month survey period, the project team (consisting of two researchers, the hotline coordinator, and the marketing coordinator) assigned each state a progress score between zero and six, where 0= no program and no known fundraising activity and 6= current program with sufficient funding. Program records (such as email correspondence and meeting notes) were used to determine these scores. This seven-level outcome was termed "progress."

Long-Term Outcome Measures: Intakes and Retrofits. Using the NRRP hotline, the number of individuals who sign up for the Program ("intakes"), as well as the number of tractors that are retrofitted ("retrofits") are regularly tracked. These data were obtained for each of the ten intervention regions between September 1, 2016 and August 31, 2018. For individuals completing both an intake and a retrofit during the study period, only the retrofit was counted; however, the date used was reflective of the intake date. For example, if a participant completed an intake in January 2017, and then completed the retrofit in March 2017, they were counted as a retrofit in January 2017 (period 1).

Data Analysis. The change in each of the 36 CFIR survey items was compared between the ten regions over the four time periods using a four by ten mixed analysis of variance (ANOVA). The F-test for the interaction of region by time was used to evaluate whether the change in each item over time was significantly different between the regions. This same four by 10 model was used to analyze the changes in the three outcomes: retrofits, intakes, and progress scores.

The ANOVA models described above did not find significant time or region by time interaction effects. Because of this, the data were aggregated across the four time periods for each region by taking the mean value. This was done both for the CFIR survey items and the three outcomes.

The correlations between these time-averaged CFIR survey items and the three outcomes were analyzed using Spearman's rho. Due to the small sample size (n=10 regions), these correlational analyses had limited statistical power, which presented the possibility that CFIR survey items with correlations of practical relevance were not necessarily statistically significant. Therefore, any Spearman's correlation

between a CFIR survey item and an outcome of .50 or greater was deemed to be predictive of the outcome regardless of the significance level.

Paper #5: Grounded Theory Situational Analysis of Stakeholder Perspectives

Methods. This study utilized purposive sampling, and in that, maximum variation sampling. To ensure that the results of this study would reflect a diversity of perspectives related to the NRRP implementation, the following selection criteria were used:

- 1) State progress towards funding: participants residing in states representing the following levels of progress toward securing state-allocated funding were included: no known fundraising activity, some progress in fundraising, or previously obtained state-allocated funding.
- 2) Involvement in NRRP: participants were selected based on their level of involvement with the NRRP implementation on the following levels; steering committee members, general NTSC members, and non-NTSC members.
- 3) Stakeholder group: the profession of participants was also taken into account; individuals from agricultural safety organizations, insurance companies, manufacturing companies, the media, government organizations, and pre-existing ROPS Rebate Programs were invited to participate.

Finally, representatives from agricultural safety organizations and ROPS manufacturers in Canada were invited to participate. As in the US, Canada faces high rates of tractor overturn fatalities; approximately 17% of agricultural fatalities in Canada are due to tractor overturns¹⁰⁰. Unfortunately, there has not yet been a successful, unified attempt to rectify this issue in Canada. As such, these participants were included in order to provide an outsider perspective.

Potential interviewees were contacted via email and invited to participate in the study, which involved two interviews approximately one year apart, beginning in October 2017. If the subject was agreeable, an interview time was scheduled. Out of the 16 individuals contacted, 13 chose to participate. Participants, except for the Canadian interviewees, were contacted one year after the initial interview to schedule the follow-up interview. Canadian participants were excluded from the follow-up interviews, as the content of the interviews focused specifically on US activities and engagement. Out of the ten remaining individuals, nine participated in the follow-up interviews. Prior to all interviews, a copy of the interview guide was emailed to participants to allow them time to prepare for the interview.

Data Collection. The first round of interviews was collected between October and December 2017 by the first and second author. Follow-up interviews were conducted in October 2018 by the first author. Due to the varied locations of the participants, interviews were conducted over the phone and were recorded. Initial and follow-up interviews lasted for an average of 30 minutes each.

Interview Guides and Emergent Study Design. The interview guides used in this study were developed based on previous work by the research team. In an initial study, CFIR constructs applicable to the NRRP implementation were identified by NTSC members⁷³. Subsequently, those CFIR constructs were measured using a survey that was distributed at four points beginning at the launch of the NRRP and continuing over an 18-month period (Tinc et al., forthcoming). Results of the surveys provided the basis for these interviews. For example, based on the CFIR survey results, questions related to the

intervention cost were added to the interview guide. In addition, the semi-structured design of the interviews allowed participants to further discuss their perspective and experiences related to the implementation of the NRRP.

After each interview, the research team would debrief and develop a summary of the content discussed in the interview. In using an emergent design, the interview guide was further developed during data collection. Thereby, data collected during the first round of interviews was used, along with the survey results, to develop the guide for the follow-up interviews. In particular, the surveys and first interviews resulted in questions relating to motivation for stakeholder engagement and stakeholders' perceptions of the NTSC steering committee (leadership engagement).

Data Analysis. This study was conducted using a Grounded Theory Situational Analysis approach ¹⁰¹. Situational analysis is an inductive method that builds on Grounded Theory by providing structural guidance for categorizing and organizing coded data based on the environments in which a situation occurs ^{101,102}. By using a Grounded Theory Situational Analysis approach, participant feedback could be framed in terms of the various environments that the NRRP implementation exists within.

All interviews were transcribed verbatim and loaded into NVIVO 12 for analysis ¹⁰³. Though diverse stakeholders were invited to participate in the study, it became clear during the interviews that these differences were not clearly aligned with particular positions related to implementation. Thus, all analyses considered the data as a whole, rather than comparing differences between stakeholders and their roles or positions relevant to the NRRP implementation.

Each transcript was coded line-by-line by the one member of the research team using an inductive approach. Codes were then organized into categories, or groups of related codes, for further analysis. Categories of codes were then organized based on the elements of situational analysis recommended by Clarke ¹⁰¹: individual human, collective human, and nonhuman actors, discursive constructs of human and nonhuman actors (i.e. ideas about how human and nonhuman actors exist in the situation), major issues and debates, and political, economic, temporal, sociocultural, and spatial elements.

Once the situational elements were defined, "messy maps" ¹⁰¹ were developed in order to visualize and understand the connection between categories in the different elements. Using the messy maps, as well as the coding structure and elements defined above, additional visualizations depicting various standpoints represented in the data, as well as the arenas and world impacting the National ROPS Rebate Program implementation were developed as recommended by Clarke ¹⁰¹.

Though different questions were asked in the follow-up interviews, the codes used to describe both sets of interview data were largely the same. Similarly, no new maps based on the second interviews, as the data from the follow-up interviews confirmed the findings from the first round of interviews.

Through the mapping and data analysis exercises described, two core themes emerged from the data. These themes tie together several situational elements, and provide an understanding of stakeholder experiences related to the National ROPS Rebate Program implementation. The final results were agreed upon by all members of the research team.

Paper #1: A Scoping Review of T0-T4 Research in Agriculture, Forestry and Fishing OSH Research

Results. Fourteen references were eligible for inclusion in the literature review. One reference was related to health and safety research within all three industries (AgFF) ¹⁰⁴; two were related to fishing ^{18,105}; and the remaining 11 examined agricultural safety and health ^{8,106-115}. No references related to forestry work met the inclusion criteria.

Although each of the references included in the review discussed R2P in some form, there was little agreement among their authors about what the end goal of R2P was and how related terms are defined. In part, this is likely due to the fact that R2P is conceptualized as a continuum ^{8,18,105,107-111,113,114}. Take, for example, O’Fallon and Dearry’s definition of R2P that involves intervention development, pilot testing/evaluation, and dissemination of findings, which implies that if you develop and share an innovation, others will adopt it ¹¹³. This is in comparison to Huy’s definition, which includes these same research components, but also emphasizes the need to ensure worker adoption to initiate a change in health and safety outcomes ¹⁰⁹.

Toward Widespread Adoption: T3 in AgFF Research. In order to make a significant impact on worker health and safety outcomes, research must be successfully adopted by workers on a widespread basis during the T3 phase. Many authors identified in this review described their beliefs about and efforts to move research into worker practice; however, lessons learned about successful translational processes were not discussed.

In regard to methods used to achieve T3 research aims, six of the authors did not specify which method (diffusion, dissemination, or implementation) should be used to encourage adoption of research innovations by workers ^{104-107,109,114}. The remaining authors described diffusion, dissemination, and implementation efforts as follows:

Diffusion (Passive Effort): Two references discussed using diffusion to increase adoption of research findings ^{8,104}. Fiske and Earle-Richardson, for example suggest that once manufacturing challenges have been overcome, little should be needed to encourage worker adoption of safety products ⁸. This is echoed on the NIOSH R2P website, which discusses several engineering solutions (including personal air-sampling devices, emergency-stops for fishing winches, and mobile assessment systems for musculoskeletal injury prevention, among others) that have been developed, but not actively promoted ¹⁰⁴.

Dissemination (Active Encouragement): In demonstrating how R2P terminology was applied in their work, the authors of the texts included in this category relied heavily on policy and non-policy based dissemination efforts. Three references cited using policy to spread innovations ^{18,108,114}. Although two of these texts demonstrated widespread success in policy implementation efforts, neither incorporated evidence-based research in these policy recommendations. As a result, one of the authors reported no change in health and safety outcomes ¹⁰⁸ while the other reported an increase in fatalities over the course of the program ¹⁸.

In addition to those who described policy-based attempts at dissemination, five texts described non-policy attempts at dissemination ^{18,105,109,112,113}. Levin et al., for example, describe the development and testing of a training course to help fishermen understand how to execute a Mayday call ¹⁰⁵. Once the course proved to be effective, the team swapped hands-on instruction for an instructional DVD that

could be quickly disseminated and promoted to regional fishermen by local opinion leaders; however, long-term measures of adoption or impact were not measured ¹⁰⁵.

Implementation (Active and Planned Effort): Within this category, just two references discussed implementation efforts ^{104,115}. Though Storm et al. discussed the need for widespread adoption of innovations and described their study as, “the first large-scale implementation of Certified Safe Farm outside the mid-western United States,” the authors also indicate that only 3.1% of North Carolina farms participated in the intervention ¹¹⁵. Unfortunately, despite an attempt to increase the reach of this program, there is no evidence of widespread adoption on US farms. Examples and case studies provided on the NIOSH R2P effort website also described implementation efforts; however, they did not specify the need for or demonstrate widespread adoption ¹⁰⁴.

Evaluating Progress toward Widespread Adoption of Innovations. This extensive literature review identified a relatively small number of publications in which researchers have overtly thought about the challenges of widespread adoption. Even in these examples, we find that few AgFF studies have progressed through the T3 phase of research. Based on the results of this review, only two studies have successfully achieved widespread adoption of an intervention; however, neither study used evidence-based research, and therefore failed to improve health and safety outcomes ^{18,108}. While others have attempted various methods of increasing worker adoption in an effort to improve health and safety outcomes, no studies reported having successfully accomplished this mission on a large scale. This indicates that either these efforts were not published or that successful navigation of the T3 phase is a primary challenge for OHS researchers. This suggests that researchers need to focus increased efforts on how to successfully translate evidence-based research to worker adoption, and ensure that such research is adequately documented and reported.

Utility of the NIH T0-T4 Model. Though AgFF interventions could, in theory, follow a similar developmental trajectory as is demonstrated by the NIH T0-T4 model, there are several barriers which impede the application of the NIH T0-T4 model in AgFF settings. As a result, AgFF interventions have had limited success in implementation efforts. In AgFF and public health settings, cultural and environmental factors related to the target population must be taken into account in early stages of research ^{30,116}. Thus far, these components have not been reflected in the NIH T0-T4 model. Unlike clinical settings where the end-users of an intervention are medical professionals and the benefits are clearly salient to patients, their families, and clinicians, interventions targeting AgFF injury prevention are often designed to prevent relatively few fatalities. For example, although logging workers face the highest risk of occupational fatal injury (132.7 per 100,000 full-time workers, compared to the all worker fatality rate of 3.4 per 100,000), only 67 total fatalities occurred in this industry in 2015 ¹¹⁷. In a world where small business owners face myriad competing demands, safety and health initiatives often take a backseat to those that have a direct impact on work productivity and financial viability ¹⁰⁻¹⁴.

Further, regulations and legislation are often unproductive in AgFF settings for two reasons: 1) business owners and workers tend to oppose such actions and have been shown to stop such action from being taken ⁸³⁻⁸⁵, and 2) such regulations, when implemented, are only applicable to those under OSHA jurisdiction which excludes more than 60% of the AgFF workforce ¹¹⁸.

The need to address rare events in a population that is resistant to change, especially when mandated, creates a challenge for AgFF researchers working through the translational research process. Within the NIH T0-T4 model, there is little room to explore the target population’s culture and environment beyond small, localized pilot tests, a task that is vital to successfully implementing AgFF and other public health

research³⁰. As is evidenced by the references included in this review, AgFF has not yet progressed beyond these small pilot tests^{104,115}, except in cases where dissemination or diffusion is relied upon, adoption is limited, and improved outcomes are not guaranteed^{8,18,104,105,108,109,112-114}.

Adapting the NIH T0-T4 Model for AgFF Efforts. To address the NIH T0-T4 utility issues identified through this review, the research team propose a modified AgFF T0-T4 model, which is tailored to the AgFF sectors and could potentially be applied to other areas of public health. In moving through the AgFF T0-T4 model, there are several key differences from the original, NIH T0-T4 model.

First, while clinical studies often undergo a lengthy period of basic research in laboratory settings, this phase is not represented in the NIH T0-T4 model. While basic research is important to both clinical and AgFF research, its absence from the NIH T0-T4 model can be particularly challenging for AgFF researchers. Without fully exploring cultural contexts at various phases in the T0-T4 process, it can be difficult to ensure successful implementation and sustainability. For this reason, initial formative research was added to the T1 phase of the AgFF T0-T4 model, and additional research on the barriers and facilitators to expansion was added in later phases.

While both the NIH and the AgFF T0-T4 models provide space for larger pilot tests in T2, the AgFF T0-T4 model places more of an emphasis on the steps required to scale up, which can pose different challenges than those experienced in clinical research settings where guidelines and policy development are heavily relied upon. The AgFF T2 level includes specific efforts, such as collaboration with manufacturers (when necessary), to ensure that research products are appealing, user-friendly, and cost-effective for the larger target population. Unfortunately, most manufacturing companies are far removed from the target populations that they serve, and therefore have a limited knowledge of the contextual factors related to product adoption. In these instances, researchers must be prepared to work with manufacturers, as suggested by two authors included in this review^{8,110}. Social marketing efforts have shown to be useful in this respect, as they allow researchers to solicit necessary feedback from target populations and relay it to manufacturers so that innovations can be tailored to address the target populations' needs and barriers^{77,119}. In addition to providing opportunities to partner with manufacturers, the AgFF T2 phase includes research to identify barriers and facilitators to promoting, scaling-up, and sustaining the particular innovation.

Within both the T1 and T2 phases of the AgFF T0-T4 model, every effort should be made to ensure that innovations entering the T3 phase are thoroughly evaluated and found to be suitable for widespread adoption. The Society for Prevention Research suggests rigorous criteria for defining interventions as efficacious, effective, and ready for scaling up¹²⁰. These guidelines are intended for preventive interventions that target health problems in clinical and community contexts and the criteria are extensive and well specified. Though considerable effort would be required to adapt these criteria to AgFF interventions, the three stages of efficacy, effectiveness, and scaling-up may be more intuitive for AgFF researchers and end-users and thereby provides complementary guidance for moving through the AgFF T0-T4 model.

Once the T2 phase is completed, the AgFF T3 phase moves into efforts to diffuse, disseminate, and implement innovations widely, with a special emphasis on ensuring that target populations are actively participating in and using safety and health innovations. Using this model, diffusion, dissemination, and implementation are combined in the T3 phase to provide complementary pathways for reaching target populations. While disseminating information to other research organizations is included in this model, this should not be considered an endpoint or as fulfillment of R2P goals, as it often is in AgFF research

¹²¹. In the T4 phase of the AgFF T0-T4 model, work is done to measure the change in health outcomes, as well as monitor sustainability, cost, and unanticipated outcomes.

Paper #2: Using CFIR to Monitor the Intervention Implementation Process

Results. Upon conducting ‘Think Aloud’ interviews to pilot test the construct selection survey, all six participants voiced the same concern with the survey: the language was too complex, which made it difficult for those unfamiliar with the concepts to answer the questions. In addition, during all interviews, participants regularly answered questions differently than how the research team had intended. Most commonly, this occurred when participants felt as if the goal of a construct had already been met. For example, participants would indicate that because *x construct* has already been achieved, it could not have an impact on implementation, even if the construct outcome had the potential to change over time. To better understand this issue, the applicable questions were rephrased and discussed. These discussions again alluded to the complexity of the language used, as well as some minor issues with the survey instructions that had not previously been detected. In developing the final construct selection survey, these issues were addressed. Because saturation was reached with these six participants no further interviews were conducted.

The final construct selection survey was distributed to 77 NTSC members, 54 (70%) of whom responded. Respondents were representative of the nine stakeholder groups represented on the NTSC. Though all domains were viewed as important (values ranging between 4.05 and 4.54), the client outcomes, implementation outcomes, and process domains were thought to be most important by the respondents (average domain scores: 4.54, 4.35, and 4.25, respectively). The average score for each construct (across stakeholder groups) ranged from 3.11 to 4.78. Both the domain and construct ratings are based on a scale of 1 (not at all important) to 5 (extremely important).

Construct Selection. Using the process defined above, 23 constructs were selected for inclusion in the final evaluation instrument. Though most often the highest rated constructs (4.25 and above) within each domain were selected for inclusion, there were some exceptions.

Intervention Characteristics. Within the intervention characteristics domain, no constructs ranking below 4.25 were included in the final evaluation instrument. Only adaptability (4.27) was excluded from the final evaluation instrument. This was due to the nature of the intervention; as the NRRP is a scaled-up version of the EBI, i.e. the ROPS Rebate Program, rather than individually adapted programs, the research team did not feel that adaptability was relevant.

Inner Setting. As the implementation of the NRRP is a collaborative effort driven by the NTSC, seven inner setting constructs were selected for inclusion in the final evaluation instrument. Available resources (4.67), leadership engagement (4.45), and tension for change (4.43) rated above 4.25 and were therefore all included. In addition, several lower-ranking inner setting constructs were included during the construct selection process. These constructs included access to knowledge and information (4.19), networks and communication (3.98), culture (3.76), and structural characteristics (3.59).

As the NRRP progresses, changes in the CFIR constructs will be tested for association with the change in number of ROPS shipments over time. Among other factors, change in ROPS shipments will reflect the target population’s knowledge of the NRRP. As a result, the research team decided it was important to include access to knowledge and information in the final evaluation instrument, as partners within the NTSC will not be able to share information with target audiences if they do not have access to it.

Similarly, the research team also decided that because the implementation is Coalition-driven and the NIOSH R2P initiative¹⁰⁴ focuses on collaborative efforts, the networks and communications construct should be included.

The research team believed that because implementation science is a new area for AgFF researchers, monitoring and evaluating structural characteristics (including the NTSC, as well as components such as telephone systems, databases, etc.) was necessary. By doing so, the research team will later be able to provide guidance to other researchers about the resources required for scaling up interventions.

Finally, culture was included as it is often a vital component of public health initiatives^{30,116}. Though this construct was designed to evaluate stakeholder culture, the research team will be exploring how stakeholder culture reflects that of the target population (and farmers' willingness to take advantage of the NRRP) in subsequent interviews and passive data collection efforts.

Two constructs within the inner setting domain were excluded: goals and feedback (4.40) and relative priority (4.29). Though both constructs are important to the implementation of the NRRP, the research team decided that goals and feedback could be captured within the reflecting and evaluating construct (process), which is more comprehensive. Relative priority was excluded as no viable alternatives exist for the NRRP to be compared against.

Process. Two constructs in the process domain scored above a 4.25 and were selected for inclusion in the final evaluation instrument: engaging champions (4.62), engaging formally appointed opinion leaders (4.52). In addition to these constructs, engaging external change agents (4.20), engaging opinion leaders (4.18), reflecting and evaluating (4.22), and executing (4.15) were also included.

The number of ROPS shipments relies heavily on the number of individuals who can be provided rebates for installation of their ROPS kits. Because rebate funding is provided by state and private donors, it is vital that external change agents and opinion leaders are engaged in implementation efforts, thus leading to the inclusion of these relevant constructs.

As described, another main component of the NRRP implementation is stakeholder engagement. To help ensure that NTSC members remain active in the implementation process, the research team decided that it was necessary to allow ample opportunity for reflecting and evaluating. In addition, the research team believed that this construct also includes aspects of the goals and feedback construct (inner setting), which was excluded from the evaluation.

Executing was included in the final evaluation instrument given the possibility that a poor execution of the NRRP implementation could result in lost partnerships, diminished credibility, and fewer ROPS shipments as a result. Therefore, researchers believed it was important to evaluate this construct over time.

Implementation Outcomes. Though appropriateness (4.60), feasibility (4.51), and acceptability (4.31) all met the inclusion cutoff, acceptability and penetration (4.18) were the only implementation outcomes constructs selected for the final evaluation instrument.

Acceptability was included (rather than appropriateness, which scored higher) because the team felt that it better captured the ROPS intervention aspects of the target population culture, and their resulting support, (a) better than appropriateness.

Penetration was selected (over adoption) because the intent of the NRRP is to scale up. Because the NRRP will be administered by a sole organization, rather than adopted by several organizations, adoption is less applicable than the reach of the program (penetration).

Feasibility was excluded as the research team felt that it could be better described using other constructs (such as cost, sustainability, and knowledge and beliefs about the intervention) and because the feasibility, efficacy and effectiveness of ROPS had been well established in prior research (citation).

Evaluation Development. The final evaluation instrument involves a survey to be administered biannually. This was distributed to NTSC members four times, each six months apart. In addition, passive data collection systems were set up to track project budgets (e.g. for hotline facilitation, marketing, and travel, among other items), discussions and decisions within the NTSC, and media content about the Program. At a minimum, when collecting this information; dates, partners, content, and relevant documents (such as news releases or meeting minutes) were recorded and retained.

Paper #3: Cost Analysis of the NY ROPS Rebate Program

Results. Overturn Probability. Between 2007 and 2017, 1,567 tractors were retrofitted with a ROPS through the NY ROPS Rebate Program. Of these, follow-up data exist for 1,054 (67.2%). These 1,054 subjects reported 17 overturns. In addition, seven participants reported that the ROPS also shielded them from falling objects, thus preventing “struck-by” injuries, however, these events were not included in cost calculations as injury and fatality probabilities were unavailable. Under the assumption that the experience of the 513 subjects without follow-up is similar, dividing the total follow-up time of 3,941 ROPS years of exposure by the 17 rollovers reported by these 1,054 subjects yields an estimate of one rollover for every 231.8 ROPS years. Considering the 10,963 ROPS years of exposure accumulated by the cohort as of December 31, 2017 it is estimated that $10,963/231.8 = 47.3$ rollovers have occurred in the cohort. The net outcome is the difference between the “No ROPS” and “ROPS” injury outcomes, and is used to calculate the cost of injuries averted by the intervention.

Intervention Costs and Expected Number of Injuries Averted. Program expense calculations included: 1) costs of program promotion such as paid media, website development/maintenance, and materials development, 2) administrative costs such as salaries, rent, and phone fees, and 3) the total costs of ROPS rebates distributed. Rebate costs were the largest programmatic expense, accounting for \$975,951 of the \$1,629,692 in total funding.

Cost-Effectiveness. Based on these calculations the data suggest that the NY ROPS Rebate Program prevented approximately 10 fatal, 8 disabling, and 6 non-disabling injuries, and a total of \$6,018,742 in fatality and injury-related costs, through the end of 2017.

The retrofitted tractors will continue to prevent injuries as long as they remain in operation, at no additional program expense. If the average retrofitted tractor remains in operation for 15 years, then the retrofits installed through 2017 are expected to prevent 22 deaths, 17 disabling, and 13 non-disabling injuries, at a program cost of \$33,761 per incident.

If instead, a retrofitted tractor continues in operation for 20 years, program retrofits are expected to prevent 30 deaths, 23 disabling injuries, and 17 non-disabling injuries at a cost of \$25,321 per event. A 25 year horizon, predicts the prevention of 37 deaths, 29 disabling, and 22 non-disabling at a cost of

only \$20,257 per event (future dollars are discounted at 3% annually).

Our calculations indicate that the \$1.78 million in program investments made through 2017 would result in savings of \$13,913,120 in fatality and injury-related costs if retrofitted tractors remain in operation for 15 years, \$17,557,635 if the retrofitted tractors remain in operation for 20 years, and \$20,701,426 if the tractors remain in operation for 25 years (all numbers are 2017 dollars).

Limitations. Response Bias. These findings are significantly influenced by participant survey responses, which indicated a potentially fatal or disabling injury occurs every 446 years of tractor operation. To check the sensitivity of potential response bias on results, we revised the analysis with the assumption that none of the non-responders had had a rollover, which would mean that one rollover occurs for every 373 years of tractor operation, and a fatal or serious nonfatal rollover-related injury occurs every 719 years of tractor operation. At this rate, the program would have prevented 6 fatal, 5 disabling, and 8 non-disabling serious injuries up to 2017 (compared to 10, 8, and 6 in the original analysis, respectively), and \$3.74 million in fatality and injury-related costs. This is still higher than the overall program costs of \$1.78 million.

Potentially High Rate of Overturns in the Cohort. As our analysis indicates 10 deaths, 8 disabling injuries, and 6 non-disabling injuries were prevented through 2017 in a cohort of 1,567 NY Rebate Program participants with varying ROPS exposure times over an 11-year period. Given the fatalities documented in NY from year to year (10-15 on average), our number may seem inordinately high. A potential explanation is that farmers who are at increased risk are more likely to self select to participate in the program than other farmers in the state.

Potentially Higher Rates of Serious Non-fatal Injuries in Non-ROPS Tractor Overturns. Lastly, our analysis likely undercounts the cost of overturn-related, non-fatal injuries. A 2002 study with a randomized sample of farm operators in Kentucky found that in 113 overturn reports, 25 and 88 incidents occurred on ROPS-equipped and non-ROPS tractors, respectively.⁹⁷ Of the 25 overturns of ROPS-equipped tractors, one (4.0%) resulted in a death on a roadway when the teenage operator was not wearing his seatbelt, four (16.0%) were injured requiring emergency care (averaging 3.5 days in the hospital), no permanent disabilities occurred, and the four who were injured experienced an average of 20 lost workdays. In contrast, the 88 non-ROPS tractor overturns resulted in 24 fatalities, another 48 were injured requiring emergency care (averaging 20 days in the hospital), 10 had permanent disabilities and most could not work again. The injured lost an average of 104.6 workdays (not including lost workdays beyond 365 days for 10 patients). The costs of these factors are unknown, however, so we used the same cost factors in our comparison between the two tractor types, even though the costs of nonfatal injuries are considerably higher for victims of non-ROPS tractor overturns. Moreover, since our analysis assumes a 59% reduction in wages for agriculture as compared to all occupations (an assumption made in the Leigh study⁹⁹), the outcome costs in our analysis may under value farmer income. Many small farm households earn most income off the farm.¹²²

Paper #4: Important CFIR Constructs in Implementation Research

Results. The response rates for the surveys were 50.0%, 49.2%, 60.7%, and 67.9% for the first, second, third, and fourth surveys, respectively. Over the study period, there was a total of 1,445 intakes and 404 retrofits across all regions. Most of the intakes, nearly all of the retrofits, and the highest progress scores were in the regions 1, 2, and 3, which all had obtained funding for rebates prior to this study.

A total of eight CFIR survey items were correlated with one or more of the three outcome measures. CFIR survey items two and three were correlated with both progress and retrofits, and CFIR survey items one, four, six, and seven were correlated with all three outcome variables. These eight CFIR survey items covered four constructs in two domains: access to knowledge and information (inner setting), leadership engagement (inner setting), engaging (process), and reflecting and evaluating (process). Those that correlated with all three outcome variables included CFIR survey items related to access to knowledge and information (inner setting) and engaging (process).

Paper #5: Grounded Theory Situational Analysis of Stakeholder Perspectives

Results. The two core themes developed in the analysis were that 1) the NRRP implementation strategy had evolved inconsistently across stakeholders, and 2) stakeholder engagement is a function of perceived feasibility and “small wins.” These themes will be presented individually, examining the various situational elements relevant to each theme.

Theme #1: Implementation Strategy Evolved Inconsistently Across Stakeholders

As described, the 2014 strategy plan for implementing the NRRP focused on a cohesive, multi-sector, nationwide effort in which all stakeholders were expected to participate. In this strategy, the funding for the program was anticipated to fall under a hybrid model in which both national and state-allocated funds were used. However, participants in this study revealed a different reality and two distinct viewpoints about how the NRRP should be implemented: the NRRP as a support tool, and the NRRP as a centralized effort.

The NRRP as a Support Tool. In this view of the NRRP implementation, non-human discursive constructions focused on the NRRP as a support tool that state-based champions could use as part of their efforts to secure state-allocated funding for the NRRP. In this description, the NRRP provided resources such as printed materials, fundraising support, technical guidance, and eventually, Program administrative services.

“I mean it comes down to the individual. I mean if we can get a champion within these associations, and that, that it, you know... bottom line what it boils down to it’s all about individual relationships and partnerships. And we have got to make, we have to continue to make those, you know, relationships, and foster those relationships and those partnerships. Because those are the ones who have the biggest impact in you know, making things happen.” (Participant #8)

Along these lines, human discursive constructions presented in the data related to state-based champions as the sole NRRP implementers. While NRRP hotline staff were considered vital to the implementation, their role was considered to be supportive rather than centralized. NRRP hotline staff members were described as the leaders, but only in the sense that the NRRP model would otherwise not exist. The actions of state-based champions, on the other hand, were central to the implementation process and focused largely on educating non-farming stakeholders and potential donors about tractor overturns and the NRRP with the intention of securing state-allocated funds.

“Yeah, okay. I believe that there’s folks from the [blinded] who are just specifically focused on the ROPS Program and doing the administration and trying to get the waiting list, get people moved through that as much as

possible. And then on the state-level, each state finds their funders whether it's an organization or a business, an industry or insurance companies, or state funding, or some other source, and then they create that pool, and then have the administrators that can use the [blinded] and the National ROPS materials and resources that make that relevant for the statewide programs." (Participant #5)

In addition to human and non-human discursive elements and human actions, spatial, political, and economic elements come into play in this view of the implementation strategy. In terms of spatial elements, the stakeholders providing this understanding tended to dissociate themselves from the broader NRRP, both implicitly and explicitly. Most appeared to have unintentionally dissociated themselves from the broader Program, primarily due to a lack of understanding of what the NRRP was intended to be, as well as the purpose of the NTSC. Those explicitly dissociating themselves from the larger picture indicated that the national-level Program was potentially damaging to local efforts, and thus could not be directly considered as part of the local implementation strategy. In both cases, NRRP materials and resources were used in support of the efforts.

"The prevalence of a National Program... or trying to say that we are part of a National Program or there is a National Program tends to bring up questions about funding that can be detrimental to us. So it's like if there is a National Program, why are people donating money to [state] to run a program? Why isn't [state] part of the National Program?" (Participant #3)

Similarly, political and economic elements came into play as stakeholders aligned with this view of the NRRP implementation focused on funding discussions, such as with their state legislators. The political and economic differences across states were thought to be influential on the implementation process.

"Yeah, where I have thought obviously my enthusiasm would be if we could figure out how to replicate the kind of funding commitment that you guys have had in New York. Which to me, not exactly, but to me means that there is perhaps some state based commitment while at the same time my sense is that you're developing philanthropic and other streams of funding to help support the initiative. I honestly don't know how to do the government side in the state of [state]." (Participant #6)

The NRRP as a Centralized Effort. Unlike the view that the NRRP is a support tool, non-human discursive constructions for this view focused on the NRRP as a centralized and cohesive Program that features a single pool of national-level funding. In this viewpoint, the human discursive constructions demonstrated that stakeholders tended to associate themselves and others with specific roles in the NRRP; few of which related to the implementation process. The NRRP hotline staff were described as central players solely responsible for implementation in this model. Stakeholders describing these scenarios viewed their own roles as integrated with the fully-functioning NRRP, rather than the implementation process.

"The problem is getting the coalition to start formulating their approaches and going after fundraising support in terms of uh, you know on their own." (Participant #2)

“Well, for me, it’s just hypothetical, I really don’t know the situation, but it seems like if people have this perception that you guys are doing a lot, then they’re just gonna step back and rely on you. And then they really don’t have boots on the ground in the state doing the promotion and talking to people directly about it.” (Participant #5)

While this implementation viewpoint focused largely on human and non-human discursive constructions, temporal elements are also relevant. As mentioned, this view assumes that stakeholders are not a part of the NRRP implementation, and thus action comes at a later stage and only when directed by specific needs that are directly related to the individuals’ primary expertise.

“My understanding is that uh, at [organization], we’re here to support the Program as in when there becomes a large demand for a specific ROPS that might not be readily available for the public, but we may be able to um, help with that situation.” (Participant #1)

Theme #2: Stakeholder Engagement as a Function of Perceived Feasibility and “Small Wins”
Despite the overwhelming and unanimous verbal support for the Program, not all stakeholders expressed engagement in the implementation of the NRRP. Over the course of the interviews, several situational elements came into play that together explain this disconnect.

Sociocultural standards dictate how people behave and think. In this study, this translates to a general argument that agricultural stakeholders can reasonably be expected to be supportive of initiatives, such as the NRRP, that have been shown to save farmer lives. This support can be seen through quotes in which stakeholders express their appreciation for the NRRP and agree that it would be beneficial to fully implement it.

“I mean because if we covered every tractor out there, there would be a lot less you know, fatalities or even injuries from it.” (Participant #10)

“So I think overall the program was well thought out and is having an important role.” (Participant #11)

“I find everybody that I contact realizes safety is important. But I also know that we continue to have tragedies.” (Participant #9)

Despite the sociocultural elements promoting general and unspecified support of the NRRP implementation, the human discursive constructions presented in the data demonstrated the denial of personal responsibility for the NRRP implementation by several stakeholders. Under this implementation viewpoint, the NRRP hotline staff, American Farm Bureau Federation, various levels of government, and two key champions (both of who serve on the NTSC steering committee and are university-based engineers) serve as implementation leadership and are implicated as responsible for the implementation.

“I think that leaders that influence the National is [university-based engineer] and [university-based engineer] and the folks there out of the [blinded]. I think they have been champions across the whole nation, as far as talking to the people to invest in it.” (Participant #7)

“If ever you’re thinking of implementing this system in Canada you would have to work with them or also to work as a, how could I say, health subsidy to them. And I’m not sure that it would work in Canada in terms of gathering... of gathering money from organizations as you do into the US, one because it is already taken by the public government in Canada.” (Participant #13)

In addition to human discursive constructions, non-human discursive constructions of the situation indicate that the purpose of the NRRP is unclear, as is the administration of it. On its own, this point is extremely important, and serves as a theme in itself, as previously described. As a result of the varying viewpoints related to the purpose of the NRRP, it becomes unclear who the NTSC is, and what the Coalition’s role is in implementing the NRRP.

“I think it’s just that I don’t understand the purpose of the coalition perhaps. And so it’s... and that maybe again part of this transition but it’s hard for me to see how I can contribute because I... I don’t really know... I don’t have a firm understanding in what the purpose of the coalition is.” (Participant #3)

The discursive constructions, both human and non-human, help us understand the stakeholders’ conscientious decisions about the implementation; however, given the contradiction in these discursive constructions, they do demonstrate some level of doubt over the implementation strategy. Looking further into the data, this doubt comes from a variety of situational elements that relate to back to perceived feasibility, including economic, political, and spatial elements, as well as major issues and debates.

From an economic standpoint, stakeholders repeatedly expressed concern over the difficulty in securing funding for the Program; however, few had actually attempted fundraising. In some respects, the concern over fundraising also related to political elements influencing implementation. Though many indicated that political support for the NRRP is needed in order to obtain funding and move forward with the implementation, few knew of politicians who knew of and supported the NRRP. Further, concern was raised that while the NRRP should be presented as a bipartisan issue, that any political conversation about it could easily result in disagreement between politicians and their supporters, thus derailing the effort.

“It seems like everything that I’ve tried to do, and not this strictly, you know related to agriculture safety, seems like funding is always... like the first hurdle.” Participant #9)

“It’s a sense of... collective sense of distrust between... almost in a sense of a tribe. If you’re not one of us you’re against us type thing. I don’t know. If one political party supports it, then the other one’s going to bash it because it’s opposite of what they want. They’ll flip-flop on that whole issue. If you’re for this than I’ve got to be against it. I don’t know why in the culture we see today and on the news and in interaction with different people you see a very big divide and a lack of a sense of civility between people that discuss issues and working for the common good but it’s like we’ve separated off.” (Participant #7)

In addition to the economic and political elements impacting implementation, several stakeholders also referenced spatial elements: perceived local barriers to launching the NRRP. Often, these perceptions focused on the lack of need or desire to have the NRRP in a particular region. Thus, the bigger picture of the NRRP was often ignored in favor of local solutions to agricultural safety and health challenges.

“Um, but down here in the South given... I mean you just don’t see any rollover issues because of the terrain. It’s more flat, and so um you don’t just hear about the fatalities down here as you might see, you know, in the Northeast, or up in the Northwest. So I am only trying to promote it from that perspective. I mean if that counts as an involvement.” (Participant #8)

In an effort to remain involved, despite feelings of limited feasibility, several stakeholders referenced the need to continue education with farmers surrounding the topic of tractor overturn fatalities and ROPS. This is despite research demonstrating that education relating to this issue is ineffective in creating change.

“They see the fair number of activities like this so ‘let’s do a ROPS promotion or let’s educate this, educate that.’” (Participant #2)

“I think it’s good, um, if nothing else it raises the awareness. There’s a big social media component and uh, that can raise awareness.” (Participant #12)

Despite the doubt expressed over the feasibility of implementing the NRRP, and the limited engagement by stakeholders, temporal elements related to the NRRP and implementation had the potential to reduce doubt and increase engagement and enthusiasm. Stakeholders who had witnessed firsthand the impacts of either tractor overturn fatalities or the NRRP were more likely to actively engage in the NRRP implementation in whatever way they felt able and depending on their view of how the NRRP should be implemented (i.e. the NRRP as a support tool, or a centralized model). Thus, the presence of “small wins,” especially those that were local to stakeholders, were important to engaging stakeholders.

“It encourages me to participate more. 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.” (Participant #7)

In some instances, where stakeholders had witnessed these small wins, but had not yet been able to take action, some level of guilt was observed, suggesting that additional barriers were still in place.

“Yeah, it’s just hard to be real supportive. I just feel like I kind of let it down, the Council down, the Coalition, sorry.” (Participant #4)

Paper #1: A Scoping Review of T0-T4 Research in Agriculture, Forestry and Fishing OSH Research

Discussion/Conclusions. Though the results of this review may have been surprising, they shed light on an important topic, and provide a realistic view of the translational trajectory of AgFF research efforts. To ensure that the research community is making an impact on health and safety outcomes, an effective model to monitor progress on this front must be developed, and used, to remove institutionalized

barriers to success. Moving forward, it will be necessary for funders to require evidence of substantial progress toward the T4 phase, and for researchers to refocus their intervention development, and consider at the beginning of the intervention development phase (T1) how their research can be integrated into workplace practices. This is especially true in regard to widespread implementation efforts. Such efforts are likely to require more time, coordination, funding, and other resources than have previously been anticipated or made available. Additionally, efforts to understand what works and what does not work (and why) in the T3 phase, especially, must be made. Together, the AgFF research community will need to work to identify ways to make the process of widespread worker adoption attainable if the group hopes to meet its long-term goal of significantly reducing work-related injuries and fatalities among farmers, foresters, and fishermen.

Paper #2: Using CFIR to Monitor the Intervention Implementation Process

Discussion/Conclusions. In the following sections we will link the identified themes with the CFIR-framework. Across the themes identified from participant interviews, many CFIR domains and constructs can be seen. Within theme #1 (implementation strategy developed inconsistently across stakeholders), structural characteristics (inner setting) and engaging (process) are the most important to consider. This theme highlights two distinct viewpoints of the NTSC: one of which focuses on the [blinded] as the inner setting and all other stakeholders as outer setting, and one which places local, state-based champions in the inner setting with the [blinded] in the outer setting. These models are then reliant on engaging leadership and champions, respectively. Both viewpoints contradict the intended implementation structure, which places both the [blinded] and all members of the NTSC in the inner setting. These viewpoints also relate to individuals' identification with the organization (characteristics of individuals) and cosmopolitanism (outer setting), as both of these constructs relate to individuals' willingness or ability to cooperate with the NTSC in implementation activities.

In the first viewpoint, which involves local, state-based champions, design quality and packaging (intervention characteristics), as well as available resources and access to knowledge and information (both inner setting) also become relevant. These constructs all relate to the champions' ability to identify and access quality resources to assist them during the implementation process. This model can be beneficial, as it demonstrates interest in and support for the Program by local partners who are more likely to be known by funders. While this can be helpful, there is also a greater likelihood of inconsistent messaging between the NRRP hotline staff and the local champions if they are not in close communication.

The second viewpoint, which relies on the [blinded] to implement the NRRP, also highlights the role of self-efficacy (characteristics of individuals) in implementing the Program. This is shown in the data by stakeholders expressing their concerns for participating in implementation activities that are outside of their primary expertise (for example, fundraising). While this model allows for the most consistent messaging, it can be more difficult for hotline staff to connect with potential funders outside of their own state or region, thus hindering fundraising efforts. In addition, this model raises several logistical challenges, including time and financial resources of the hotline staff.

Theme #2 (stakeholder engagement as a function of perceived feasibility and "small wins") relates to all CFIR domains. Immediately, this theme relates to engaging implementation leadership and external change agents (process) as primary stakeholders impacting the implementation. Similarly, external policy and incentives (outer setting) is related, in that policy issues related to the NRRP plays a major role in this theme. The cost of the NRRP, evidence strength and quality, and relative advantage

(intervention characteristics) all contribute to stakeholders' perceptions of the NRRP. In addition, several inner setting constructs (structure, networks and communication, and tension for change) further impact stakeholders' perceptions of how the NRRP works and how they can be involved in the implementation. This then relates to the individuals identification with the organization, individual stage of change, and other personal attributes (for example, guilt), which are all characteristics of individuals.

Despite progress toward full implementation of the NRRP, this goal has not yet been reached. The results of this study highlight what is going well, and not so well, and therefore what is likely needed to improve implementation of the NRRP. In general, two areas needing improvement were identified: 1) appropriateness and feasibility of inner setting stakeholder engagement, and 2) receptivity of outer setting stakeholders and potential funders.

Based on the feedback collected during these interviews, inner setting stakeholder engagement may benefit from task-oriented stakeholder roles, tailored communications, and the engagement of localized champions. The current implementation model, which places both the NRRP hotline staff and all NTSC members in the inner setting was shown to be too general based on these interviews. Stakeholders often expressed confusion over their roles, and felt that they did not have clear guidance or tools to move forward. Thus, by having clear roles and responsibilities for each member of the inner setting and tailoring project communications to those roles, it is likely that stakeholders will feel more able to participate. This includes both stakeholders who can provide assistance and guidance across all states (e.g. engineering support, fundraising guidance), as well as state-based champions who can work directly with potential funders. By modifying the current structure of the NTSC in this way, all members of the inner setting would have a clear role that they are comfortable in and the overreliance on others to implement the NRRP would be reduced. In addition, this modification would align better with the intended purpose of contextual inner settings, which are reserved for active roles in the implementation process^{32,42,123}.

In addition to benefiting the implementation team, such modifications would also provide the foundation for local, state-based champions to take the lead on interesting outer setting stakeholders and potential funders in the NRRP. This, in turn, can help improve how these outer setting individuals view the NRRP, as local and known program promoters may be viewed as more trustworthy information sources¹²⁴.

Strengths and Limitations. A strength of this study is that several steps were taken to increase the trustworthiness (credibility, dependability, transferability, and confirmability)¹²⁵ of the data collection, analysis, and presentation. First, credibility was increased by inviting stakeholders representing various perspectives and roles to participate in the interviews, thus widening the experiences captured. Second, follow-up interviews were conducted in order to determine how experiences changed over time, thus improving the dependability of this study. Third, every effort was made to thoroughly describe the context of this study in order to enhance transferability. Finally, confirmability was increased by including a diverse research team with varying connections to the NRRP.

As with most qualitative studies, the sample size was quite small, thus limiting the diversity of responses. In addition to including as many viewpoints as possible, interviews continued until saturation was reached. As described, an additional quantitative study focused on measuring changes in CFIR constructs over the implementation period was also conducted (Tinc et al., forthcoming).

Paper #3: Cost Analysis of the NY ROPS Rebate Program

Discussion/Conclusions. The cost of preventing overturn fatalities and injuries is a one-time expense in the form of a ROPS retrofit installation. Once installed, a ROPS requires little to no maintenance and continues to protect the operator as long as the tractor functions. There is little objective information on how long a tractor remains operational, although observations of farms suggest that it can be decades. As indicated previously, in the initial years of the NY ROPS Rebate Program researchers calculated program costs and compared these with associated savings incurred by the prevention of injuries and fatalities.⁶⁸ Program savings were based on the number of overturns identified by ROPS program participants using a decision-tree analysis and data from previous ROPS incident studies.^{126,127} Associated fatality and injury costs were based on estimates from Leigh¹²⁸ and Viscusi.¹²⁹ The conclusions from this earlier cost analysis predicted savings from 2006-2016, as a result of the ROPS Program, would total \$2,229,766 (CPI adjusted to 2017 dollars).⁶⁸

Given the ten-year span between the launch of the program and today, a reassessment of original estimates is timely. As our calculations indicate, the total savings as a result of the program are nearly 3-times greater than originally estimated. This striking difference is likely due to continued installation of ROPS on NY tractors over the past ten years, decreased program costs due to the implementation of program efficiencies, and the continued accumulation of potentially fatal vignettes from participants.

However, these studies are not the first to look at the issue of occupational health and safety investments from a prevention perspective. More than 25 years ago, NY researchers used data provided by family members of tractor overturn victims to estimate average expected income lost.¹³⁰ At that time, associated income costs were estimated to be close to \$250,000 per death (CPI adjusted figures indicate this number is closer to \$450,000 in 2017). In 1992, the projected total loss of income due to tractor overturns in New York was calculated to be \$2 million annually (\$3,570,000 in 2017). A prior paper published by the same author examined the long-term impact of overturns on the financial viability of the farm.¹³¹ Follow-up interviews with families of overturn victims indicated “less than five years after the accidents, 67% of the families who operated the farms where the accidents occurred no longer operated them and 44% no longer lived on them”.

Other economic estimates of the social costs of fatal and non-fatal tractor overturns come from Myers, Cole and Westneat¹³² and Pana-Cryan and Myers.¹²⁷ In these studies, research team looked at overall costs of injuries and fatalities in the U.S. over a 25 year period using annual overturn incidence estimates from 1992-2002 for both ROPS and non-ROPS tractors. These estimates indicate that if all of these events had occurred on tractors equipped with ROPS, the estimated savings to society between 1997 and 2021 would have totaled roughly \$1.5 billion in 2006 dollars (\$1.9 billion in 2017 dollars). Further estimates explored various ROPS strategies by comparing the costs and benefits of an “install ROPS” strategy and a “replace tractor strategy”. Cost and benefit calculation comparisons for each strategy indicated that the “install ROPS” strategy, such as the one utilized in the NY ROPS Rebate Program, are far more cost-effective.

Building on the economic evidence for ROPS installations programs, NIOSH’s Cost-effective ROPS (CROPS) designs may provide even greater opportunities for optimizing cost to benefit ratios for ROPS installations.¹³³ These ROPS designs were developed and tested by NIOSH engineers to help farmers build their own ROPS or to assist companies that may be interested in expanding into the ROPS manufacturing market. Estimates of out-of-pocket costs to build a ROPS using these designs is around \$500, a much more cost-effective option than ROPS manufactured by original equipment

manufacturers (OEM) (average cost of \$635 plus shipping and installation) or after-market (AM) ROPS manufacturers (average cost of \$1,254 plus shipping and installation).¹³⁴ Previous research on ideal ROPS price points has demonstrated that farmers are willing to pay around \$300-\$500 for ROPS, which makes CROPS designs an affordable option for farmers even without a rebate.¹³⁵ This option could also increase competition in the ROPS manufacturing market, which could reduce the price of commercially available ROPS, given the relatively small number of AM ROPS manufacturers (n=4). However, tractor manufacturers are vociferously opposed to this option, citing concerns about substandard ROPS construction and liability in the event a farmer or custom-fabricated ROPS fails. However, Canadian researchers are working on ways to increase ROPS installations using the provision of ROPS designs.¹³⁶ Although, the option of custom-fabricated or farmer constructed ROPS is obviously a controversial one, our analysis demonstrates that even greater costs benefits could be derived by decreasing the price tag of ROPS equipment.

Public Health Implications. Since piloting this intervention model in NY, it has been adopted by a number of additional states (Pennsylvania, Vermont, Massachusetts, New Hampshire, Wisconsin, and Minnesota). Although ROPS installations have increased significantly in states where rebate funding is available, many high-risk states and industry groups have chosen not to contribute state-based or industry funds for ROPS rebates. However, as our research indicates, this intervention model is effective from both a public health and economic standpoint.

Paper #4: Important CFIR Constructs in Implementation Research

Discussion/Conclusions. CFIR survey items that are highly correlated with all three outcomes may be the most important in moving forward with the NRRP implementation. These CFIR survey items include 1) NTSC members' belief that part of their role is to raise funds for the Program (CFIR survey item six), and 2) NTSC members' active role in submitting funding applications (CFIR survey item seven). This is intuitive, in that the short-term outcomes and the success of the Program reflect fundraising for rebate dollars. As such, those states with pre-established funding (regions 1, 2, and 3) were, expectedly, the most successful in terms of outcomes. Despite this, some small successes occurred in other regions, including movement toward higher progress scores and a handful of intakes in each region for each time point. Progress scores above zero indicate that the efforts put forth to implement the NRRP have been marginally successful. However, it is also important to note that securing funding (i.e. reaching a progress score of 4 or 6) for this type of initiative can take longer than the time allotted in this study. Thus, if reassessed after another year, it is possible that progress scores would be higher.

Once state-allocated rebate funding has been secured, the social marketing campaign can be implemented in that state, thus triggering additional farmers to complete intakes and subsequently retrofit their tractors. Though there are intakes reported in each study region, the numbers are much lower in regions 4 through 10. Still, these marginal successes indicate farmer interest in the NRRP, as without direct advertising in unfunded regions, farmers could only have discovered the Program as a result of their own attempts to retrofit tractors.

In addition to CFIR survey items related to fundraising, the item "Program materials are engaging" (item one) was highly correlated with all outcomes. This finding suggests that such materials (including both those that are targeted at stakeholders who can help secure state-allocated funding as well as farmers who may participate) may motivate stakeholders to take action by fundraising, signing up for the NRRP themselves, or further disseminating NRRP materials to others, and make those actions easier. This is supported by the basic premise of the construct¹³⁷, as well as principles of social marketing^{138,139}, which

suggest that materials that are easier to engage with are more likely to promote the anticipated behavior. This principle was demonstrated in developing the social marketing messages to increase farmer participation in the ROPS Rebate Programs ^{77,79}.

Finally, the CFIR survey item “stakeholders understand their role to include providing feedback about implementation activities and fundraising,” (item four) was also highly correlated with all three outcome measures. In these cases, individuals who are providing feedback about Program implementation and fundraising may feel a greater sense of ownership, thus motivating them to be further involved. Ownership has often been cited as a key motivator for employees, stakeholders, and other populations ¹⁴⁰⁻¹⁴³, as it facilitates the transformation of individuals’ roles and responsibilities within an organization or organized effort ¹⁴³. In the public health sector, community coalitions have focused on ownership as an indicator of increased engagement and improved health outcomes ¹⁴⁴.

Two CFIR survey items were highly correlated with at least two outcome measures, again, indicating practical significance. Two measures of leadership engagement, “the NTSC steering committee encourages members to be involved in implementing the Program,” and “the NTSC steering committee is supportive of the Program,” (items two and three) were both highly negatively correlated with progress and retrofits. This is perhaps the most surprising finding, in that one would expect the opposite to occur – a more highly engaged leadership should be correlated with improved outcomes. In a qualitative portion of this study (Tinc et al., forthcoming); the study team explored this finding in interviews with steering committee, general NTSC, and non-NTSC stakeholders who identified two possible explanations. First, it was suggested that because the steering committee is comprised of well-known and well-respected individuals in the agricultural research community, the Program may be seen as a “top-down” approach. Thus, others may be less motivated to engage in the implementation process by raising funds or promoting the Program in their state. This is consistent with the stakeholder engagement literature, which recommends collaborative partnerships, reciprocal relationships, and co-learning, among other strategies for increasing engagement ^{145,146}. However; some psychology research contradicts this observation by suggesting that individuals are more likely to engage in behaviors (such as being involved in the NRRP implementation) that are promoted by authority figures, which could include members of the steering committee ¹⁴⁷. Second, it was suggested that the states with active and sufficiently funded programs may have gotten to that point without the help of steering committee members. Thus, those who have state-allocated funding in place may not place value on steering committee members’ contributions.

The CFIR survey items “NTSC updates are helpful in allowing me to reflect upon progress toward implementation of the Program” and “participation in implementation events (perceived role),” (items eight and five) were both highly correlated with intakes, but not with the other two outcome variables. This might suggest that both of these activities are enough to encourage stakeholders to spread the word about the Program to the target population, but do not motivate stakeholders to dedicate time to fundraising activities.

The results of this study are immediately important, in that they provide guidance for continuing the implementation of the NRRP. Based on these results, it is important to consider barriers to stakeholder engagement and how to remove those barriers, especially for NTSC members and stakeholders in regions with low numbers of intakes and retrofits. In addition, the alarmingly high negative correlations between CFIR survey items related to steering committee engagement and outcome variables suggest that more needs to be done to encourage full-NTSC communication and excitement about the NRRP. A

social networking analysis focused on NTSC member interactions is currently underway and will provide valuable information related to NTSC member communications and collaboration.

In addition to the primary findings of this study, it is also relevant to comment on the utility of the CFIR in occupational safety settings, such as this one. A prior study by the research team demonstrated that while the CFIR was applicable in agricultural safety settings, there were some challenges applying the CFIR to scale-up initiatives versus single site implementation studies⁷³. This sentiment was echoed in a review of CFIR use published in 2016⁷². The results of this study indicated that initial assessments of the utility of the CFIR within agricultural safety settings were accurate. However, further assessment of the CFIR's utility using other occupational safety interventions would be important in confirming this finding.

Limitations. There are four main limitations to this study. First, only constructs described by the CFIR were evaluated for correlation with ROPS outcomes and only a portion of the total possible CFIR constructs were included in this portion of the study. Thus, there may be additional factors relevant to the implementation of the NRRP that were not explored in this study. However, additional constructs would have made the survey longer and impacted response rates, so the decision was based on achieving a balance between these potential research design challenges. Additionally, qualitative interviews with NTSC members and non-members have been used to elicit additional information about the Program implementation and clarify survey responses (Tinc et al., forthcoming).

Second, the sample size for this study is quite small, which is primarily due to the size of the NTSC and location of its members. NTSC members do not exist in all states, and thus survey responses were also not available for all states and so regions were used as the units of analysis. It is possible that if study results were to be compared between individuals or states, the analyses presented here might result in different outcomes. Thus, these conclusions should be considered in light of this fact.

Third, the average response rate for the CFIR surveys was only 57%. While this is a relatively promising response rate on such surveys, it is possible that the results presented here could differ from the results had all NTSC members responded to the various survey requests. In particular, the individuals who did not respond to the survey requests may have drastically different viewpoints of the implementation process. It is also possible that, had all NTSC members responded to all survey requests, the correlations presented here may have been different.

Finally, it should be acknowledged that the study, being observational in nature, cannot establish cause and effect. Whether or not a change in a CFIR item will produce a change in outcomes such as intakes and retrofits, cannot be established with certainty.

Paper #5: Grounded Theory Situational Analysis of Stakeholder Perspectives

Discussion/Conclusions. The results of this study focus largely on the feasibility of the current NRRP implementation strategy, compared to strategies that may prove to be more feasible and successful. By addressing the key “sticking points” presented by participants, it is likely that improvements can be made to increase the overall success of this implementation project. Similarly, other researchers and practitioners attempting their own large-scale implementation studies are likely to benefit from these findings, as they provide guidance in navigating some of the challenges that may present.

In the future, it would be beneficial to compare progress made during this 18-month study period to that of a comparable period after the implementation strategy has been modified. In this way, the research team will be able to confirm the success level of such modifications.

Publications

Cunningham T, Tinc P, Guerin R, Schulte P. [2020]. Translation research in occupational health and safety settings: Common ground and future directions. *Journal of Safety Research* Sep;74:161-167.

Tinc PJ, Jenkins P, Sorensen JA, Weinehall L, Gadomski A, Lindvall K. [2020] Key factors for successful implementation of the National Rollover Protection Structure Rebate Program: A correlation analysis using the consolidated framework for implementation research. *Scandinavian Journal of Work and Environmental Health* 46(1):85-95.

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Dissertation/Thesis

Tinc PJ. [2019]. Raising the (Roll)Bar Exploring Barriers and Facilitators to Research Translation in US Public Health. Ph.D. Thesis, Umea University, Umea, Sweden.

Cumulative Inclusion Enrollment Table:

PHS Inclusion Enrollment Report

This report format should NOT be used for collecting data from study participants.

OMB Number: 0925-0001
Expiration Date: 3/31/2020

*Study Title (must be unique): Putting ROPS Research into Practice: Paving the Way for a National Program

* Delayed Onset Study? Yes No

If study is not delayed onset, the following selections are required:

Enrollment Type Planned Cumulative (Actual)

Using an Existing Dataset or Resource Yes No

Enrollment Location Domestic Foreign

Clinical Trial Yes No

NIH-Defined Phase III Clinical Trial Yes No

Comments:

Racial Categories	Ethnic Categories									Total
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			
	Female	Male	Unknown/Not Reported	Female	Male	Unknown/Not Reported	Female	Male	Unknown/Not Reported	
American Indian/Alaska Native	0	0	0	0	0	0	0	0	0	0
Asian	0	0	0	0	0	0	0	0	0	0
Native Hawaiian or Other Pacific Islander	0	0	0	0	0	0	0	0	0	0
Black or African American	0	0	0	0	0	0	0	0	0	0
White	0	0	0	0	0	0	0	0	0	0
More than One Race	0	0	0	0	0	0	0	0	0	0
Unknown or Not Reported	0	0	0	0	0	0	0	0	125	0
Total	0	0	0	0	0	0	0	0	0	125

Report 1 of 1

To ensure proper performance, please save frequently.

Materials available for other investigators.

- CFIR DATA COLLECTION SURVEYS AND MODERATOR GUIDES
- GROUNDED THEORY/SITUATIONAL ANALYSIS MODERATOR GUIDES
- STAKEHOLDER SURVEY AND INTERVIEW DATA
- RESEARCH DISSEMINATION PLAN: PUBLICATIONS (LISTED) AND SCIENTIFIC PRESENTATIONS (PROVIDED UPON REQUEST)

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