Evaluation of Swedish Ice Cleat Distribution Programs

From Program Design to Ice Cleat Use

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Abstract

Winter conditions, characterized by snow and lowered temperatures, can make travel by foot difficult. Older adults aged 65 and above are especially at risk of slipping and falling on icy or snowy surfaces. Minor falls can result in severe injuries due to their frailty. Traditional methods of reducing this risk, like plowing or using sand and salt, may not always be effective preventive measures. Several municipalities in Sweden have taken action to combat this issue and introduced subsidized ice cleat distribution programs for older adults. It is unclear how these programs are designed and whether they are effective in promoting the use of ice cleats. This thesis uses a mixed-method approach drawing on data collected from multiple sources to analyze and evaluate the programs. Paper I presents a program theory model, outlining the essential components required for implementing a program and describing the causal connections from the program's introduction and necessary conditions to its anticipated impact. Survey data from intervention municipalities suggest that about 40% of the target group participated by retrieving a pair of devices, and 90% of all ice cleats were eventually distributed. Paper II presents an outcome evaluation suggesting that individuals exposed to a distribution program increase ice cleat use. Analyses of the self-reported data on ice cleat use show an increase of 7.5 percentage points. Estimations suggest that general use could be 17.3% if one pair of cleats were distributed to all eligible citizens. Future research is needed to investigate the programs' effect on fall-related injuries on ice and snow. In addition, in-depth interviews with program policymakers should be considered to provide further insights into the design and implementation of these programs.

Sammanfattning

Vinterförhållanden, som kännetecknas av snö och låga temperaturer, kan göra det svårt att resa till fots. Äldre vuxna, i åldern 65 och äldre, löper större risk att halka och falla på isiga eller snöiga ytor, där även mindre fall kan leda till allvarliga skador på grund av deras sårbarhet. Traditionella metoder för att minska denna risk, som snöplogning eller spridning av sand och salt, kanske inte är tillräckligt effektiva. Flera kommuner i Sverige har vidtagit åtgärder för att bekämpa detta problem och infört subventionerade program som delar ut broddar till den äldre befolkningen. Det är oklart hur dessa program är utformade och om de är effektiva när det gäller att främja användningen av broddar. Denna avhandling använder en blandad metod som bygger på data som samlats in från flera källor för att analysera och utvärdera programmen. I Paper I presenteras en programteoretisk modell som beskriver de väsentliga komponenter som krävs för att implementera ett program och beskriver orsakssambanden från programmets introduktion och nödvändiga förutsättningar till dess förväntade effekt. Undersökningsdata från interventionskommuner tyder på att cirka 40 % av målgruppen deltog i programmen genom att hämta upp ett par broddar, och 90 % av alla halkskydd distribuerades. Effektutvärderingen som presenteras i Paper II tyder på att exponering för ett distributionsprogram ökar användningen av broddar. Självrapporterade data om användning av halkskydden tyder på en ökning med 7,5 procentenheter, och ytterligare skattningar visar att den totala användningen kan bli 17,3 % om ett par broddar distribuerades till alla berättigade medborgare. Framtida forskning behövs för att undersöka programmens effekt på fallrelaterade skador på is och snö. Dessutom bör djupintervjuer med programpolitiska beslutsfattare övervägas för att ge ytterligare insikter om utformningen och genomförandet av dessa program.

List of papers

I. Holmberg, R., Gustavsson, J. & Bonander, C. (2021). Evaluation of the design and implementation of municipal ice cleat distribution programs for the prevention of ice-related fall injuries among older adults in Sweden. PLoS ONE 16(6): e0253054. https://doi.org/10.1371/journal.pone.0253054

II. Holmberg, R., Gustavsson, J., Svensson, M. & Bonander, C. (2022). Ice cleat distribution programs and ice cleat use among older adults: repeated cross-sectional evidence from 63 municipal interventions in Sweden. Injury prevention: https://injuryprevention.bmj.com/content/28/6/539

CONTENTS

1. Introduction

To walk is as common as the air you breathe. Every journey begins and ends with walking. Most people who live in populated areas have to share the road they tread on with other road users. However, since the introduction of motor vehicles, the road system has consistently been maladapted for pedestrians. In the process of expanding and making automobile transportation accessible to all, city planners have historically prioritized the expansion of roads that favor automobiles. In parallel, the car industry has focused injury prevention strategies on those inside the car, drivers and passengers. Violent car incidents can explain why injury prevention strategies have historically garnered attention in this field. This means that the prevention of other traffic-related injuries, such as pedestrian fall injuries, have fallen between the cracks (Oxley m.fl., 2018), and has been doing so for many years (Björnstig m.fl., 1997). In fact, in the field of transportation, the occurrence of fall injuries is more common than harmful car incidents (Saveman & Björnstig, 2011). A closer look at the data on pedestrian fall injuries makes it clear that the older adult population stands out as a high-risk group (Rod m.fl., 2021).

Narrowing down the observations to Sweden, on an annual basis, around 100,000 people in the age group 65 years and older are injured so badly in a fall that they have to seek medical care (The National Board of Health and Welfare, 2022). The same age group shows a significant increase, in hospitalization per 100,000 person-years (years 2006 to 2020), with the eldest population accounting for the most significant growth[1]. It is quite well known that the most common place for a fall injury to occur is indoors. Despite this, a significant amount of fall injuries happen outdoors. According to a recent study from Sweden, seventy-seven percent of all pedestrian fall injuries happen during wintertime, and slippery surfaces such as snow, ice, leaves, gravel, and uneven pavements cause about 75% of pedestrian fall injuries (Amin m.fl., 2022). Walking on surfaces with snow and ice more than doubles the

[1] For more information about fall incidences in the age group 65 years and older, please visit Public Health Agency of Sweden.

risk of slipping (Elvik & Bjørnskau, 2019). Despite using traditional approaches like salting roads, spreading gravel, and removing snow to prevent slips and falls on ice and snow, falls still occur. These methods are not always adequate, and perhaps other measures are needed. Recent years, in an attempt to battle the seasonal rising of falls on ice and snow, some Swedish municipals have begun distributing ice cleats to their older citizens. These interventions are promising since ice cleats have previously been shown to reduce the risk of ice-related fall injuries when exposed to such conditions (Berggård & Johansson, 2010; McKiernan, 2005). However, little is known about the effects of ice cleat *distribution*, which also depends on the impact on ice cleat use in the population.

To say anything about program effectiveness, one must conduct a proper program evaluation. It is a logical conclusion that municipalities, as the entities responsible for implementing programs for the distribution of the cleats, also bear the responsibility of evaluating the outcomes of such programs. Unfortunately, like in the cases of Swedish ice cleat distribution programs, systematic evaluations are rarely performed in practice, and the reasons for this are not clear. It is possible that the need for a multidisciplinary team of experts and scientists with diverse skills (McClure, Turner, & Yorkston, 2005) to execute an effective evaluation process could be a contributing factor, and municipalities may struggle to acquire these necessary resources. It has been reported that municipalities are facing challenges in terms of both financial resources and expertise (Holmberg & Gustavsson, 2020), which impede their ability to conduct a thorough evaluation prior to the implementation of a program.

This thesis focuses on examining the impact of ice cleat distribution programs in Swedish municipalities and analyzing their effectiveness. Conducting a large-scale evaluation of such interventions in various natural settings can yield significant and relevant results. Such evaluations not only help determine program effectiveness but also address administrative requirements (Thompson & Sacks, 2001). To provide valuable insights for decision-makers, it is important to consider additional factors like program characteristics, reach, and barriers to implementation success (Gielen & Sleet, 2003). The aim of this thesis is to deepen the understanding of this subject and potentially assist municipal decision-makers in improving or implementing future programs.

2. Background

Older adults and their vulnerability to external forces

The literature has established that sudden exposure to external energy can result in physical harm when the force of impact exceeds an individual's body's capacity (Haddon, 1980; Rivara m.fl., 2001), but people have varying levels of tolerance to physical injury. Incidents with negative outcomes, irrespective of their nature, are disproportionately frequent among older adults (Andersson, 2012), who are more vulnerable due to factors such as decreased muscular strength, arthritis, cardiovascular diseases, inadequate balance, osteoporosis, or other illnesses that become more common with age (Bergland m.fl., 2003; Boyé m.fl., 2013; Florence m.fl., 2018; Gillespie m.fl., 2012). Involuntary falls with low-impact energy can be disastrous in terms of morbidity and mortality, underscoring the multifactorial etiology of such events (Deandrea m.fl., 2010; Gyllencreutz m.fl., 2015). Falling is a frequent occurrence, with approximately 28-35% of individuals aged 65 and above experiencing a fall annually (World Health Organization, 2008), and are the primary cause of injuries and injury-related fatalities (Kannus m.fl., 2005; Stevens m.fl., 2008). Unfortunately, the prevalence of falls increases with age (Moreland m.fl., 2020) due to the deterioration of motor functions and human abilities (Gao & Abeysekera, 2004), indicating a growing vulnerability. Fall-related injuries can reduce an individual's mobility, making older adults more dependent on others and adversely impacting their quality of life (Ambrose m.fl., 2013; Stevens & Sogolow, 2005). As the number of older adults is expected to rise rapidly in the coming years (SCB, 2014; United Nations, 2017), it is reasonable to anticipate that fall-related injuries will continue to increase, posing a significant public health burden.

Winter environments and pedestrian falls

It was early pointed out by Gordon (1949) that pathological and injury events follow patterns based on geographic, socioeconomic and environmental factors, suggesting that if we can predict events, we can also prevent them. Although winters and their associated undesirable events, such as falls on ice and snow, can present some difficulties, they are still somewhat manageable. In Sweden, pedestrian falls typically occur in urban areas and on roads owned by municipalities (Amin m.fl., 2022). Approximately 75% of all pedestrian fall injuries are caused by slippery surfaces like snow, ice, leaves, gravel, and uneven pavements. The risk of slipping is more than double when walking on surfaces covered in snow and ice (Elvik & Bjørnskau, 2019). In fact, the majority of pedestrian fall injuries (77%) occur during winter time in Sweden (defined as September 1st to April 30th) (Amin m.fl., 2022). Pedestrians exposed to winter conditions have an increased risk of slipping and falling and are more likely to suffer injuries when hitting the ground (Björnstig m.fl., 1997; Eriksson & Sörenssen, 2015). The risk of sustaining an injury upon impact on ice and snow is approximately five to ten times greater than a fall on bare ground, and the following hospital stay is on average almost twice the length after falls on ice and snow compared to injuries on bare ground (Eriksson & Sörenssen, 2015; Wallman m.fl., 1997). Older adults have the highest injury rate when slipping on ice and snow (Björnstig m.fl., 1997), and fractures are the most common type of injury that requires hospitalization (Gyllencreutz m.fl., 2015). As the number of older adults continues to rise, it is crucial to address the issue of pedestrian fall injuries during the winter and take preventative measures to reduce the risk of injury and improve the overall safety and well-being of older adults.

Countermeasures to prevent pedestrian falls on ice and snow

In Sweden, the Swedish Transport Administration is responsible for the state-owned transport system, while municipalities have the legal responsibility for maintaining municipally owned roads to prevent health-related inconveniences (as stipulated by SFS 1998:814). Given that around 88% of Sweden's population lives in urban areas[2], the municipalities carry the majority of the responsibility for road maintenance. Countermeasures that are commonly employed include the application of salt to icy surfaces to reduce the likelihood of slipping, the scattering of sand on footpaths to increase traction, and the removal of snow and ice through shoveling and plowing (Holmberg & Gustavsson, 2020). Maintaining roads during the winter season has proven to effectively reduce ice-related falls (Schepers m.fl., 2017). When the walk-

[2] See Statistics Sweden for more information.

ing surfaces are equal to the summer conditions, the number of fall injuries decreases significantly (Elvik & Bjørnskau, 2019). Ideally, perfect winter maintenance would ensure that there is not a single patch of ice or snowflake on the ground, but this is practically unattainable. Temperature fluctuations, which create black ice, are a recurring problem, especially when the temperature fluctuates around 0°C, resulting in hazardous traffic situations (A. Andersson & Chapman, 2011; Eriksson & Sörenssen, 2015). Maintaining safe winter conditions can be challenging, especially during irregular snowfalls and heavy precipitation (MSB, 2010; Öberg, 2011), but even more troublesome when the temperature fluctuates around the freezing point (A. Andersson & Chapman, 2011). Keeping up with winter maintenance can be difficult when the temperature is fluctuating around the freezing point and there are irregularities in snowfalls. Municipalities facing financial constraints make snow removal a lower priority in certain areas (Holmberg & Gustavsson, 2020). These factors can make it challenging to maintain safe walking conditions, as pedestrians face an elevated risk of slipping and sustaining injuries from falls. While people of all ages are susceptible to these hazards, older adults are especially vulnerable (Amin m.fl., 2022; Gyllencreutz m.fl., 2015).

Older adults and winter environments

Insufficient road maintenance has a particularly detrimental impact on older adults, as studies indicate that it heightens their fear of falling and results in them being less inclined to leave their homes (Faskunger, 2007; Rantakokko m.fl., 2009, 2010). The lack of road maintenance can severely disrupt the daily activities of older adults, such as grocery shopping, visiting loved ones, and pursuing hobbies. As a result, their quality of life may be significantly reduced. When seniors develop a fear of falling, they tend to limit their outdoor activity and remain indoors (Wijlhuizen m.fl., 2007), which can lead to negative impacts on their health and well-being (Kerr m.fl., 2012; Scheffer m.fl., 2008; Sun m.fl., 2013). This creates a vicious cycle where their fear of falling worsens, leading to further limitations on their outdoor activity and quality of life. This reduced level of physical activity can result in a decline in overall physical fitness, thus increasing the risk of falls. In addition, the lack of physical activity can lead to social isolation, which may have adverse effects on one's mental and emotional well-being (Matthews m.fl., 2008; Harvey m.fl., 2015). As emphasized by a systematic review conducted by Warburton and Bredin (2017), studies have shown that physical activity can be beneficial for older adults, particularly those who have a sedentary lifestyle (Owen m.fl., 2010). Outdoor walking is a convenient and environmentally friendly way to improve strength, balance, flexibility, reduce cardiovascular diseases, strengthen muscles and joints (Morris & Hardman, 1997; Tschentscher m.fl., 2013), all of which can help to reduce the risk of falling. Increasing daily walking can greatly benefit the health of older adults, especially those who live less active lifestyles (Lee & Buchner, 2008). In addition to the physical benefits, increased walking can also have psychological advantages, including stress relief and increased serotonin levels in the brain (Johansson m.fl., 2011; Young, 2007). An active lifestyle not only reduces the risk of falling but also has positive long-term effects on non-communicable diseases (Reiner m.fl., 2013). By engaging in physical activities such as low to moderate-intensity outdoor walking throughout their lives, older adults are more likely to live longer, have an improved quality of life, and overall healthier well-being (Daskalopoulou m.fl., 2017; Faskunger, 2007; Fisher & Li, 2004).

A potential counter-measure: Use ice cleats

Perhaps, as a step in the right direction, suggestions have been made that utilizing slip protection, such as ice cleats, could serve as a beneficial addition to tackling the issue of slipping on ice and snow (Björnstig m.fl., 1997; Amin m.fl., 2022). The utilization of ice cleats itself has been used to prevent injuries for many years. Perhaps the earliest records of a pair of ice cleats were found in Alnö, Sweden, in the province of Medelpad (circa AD 800-1100) and were used by the Vikings[3]. The devices were made of iron and equipped with spikes pointing downward toward the ground. They tied these devices around their leather shoes, which penetrated the snow and ice when walking, creating enough friction to make it easier for people to tread over winter-like slippery surfaces. Today's ice cleats have developed to fit modern shoes (Larsson m.fl., 2019), yet the purpose of these devices stays the same as 1000 years ago. As a means to complement traditional winter

[3] Visit Swedish National Heritage Board for more information.

measures, decision-making bodies have implemented large-scale ice cleat distribution programs for their older and vulnerable residents. The use of ice cleats as a countermeasure has gained traction among Swedish municipalities, and in recent years such distribution programs have proliferated across Sweden.

Using ice cleats: an active countermeasure

Haddon (1980) theorized about injury prevention, emphasizing that countermeasures comes in two forms; passive or active. Active measures are less desirable as it forces individuals to take preventive actions. The utilization of ice cleats requires the user to take preventive measures against the risk of falling on ice or snow by attaching the cleats to their shoes. Passive measures are preferable in injury prevention policies and programs alike, as the intervention is integrated into the environment and requires no action taken by the individual. Such an example is the intervention of passengers' side airbags that explode to reduce the impact in the event of a car crash (Gielen & Sleet, 2003). In reality, passive strategies are not always readily implemented and, in some cases, not possible to fully implement. Consequently, a combination of measures is recommended (Williams, 1999). Public health researchers agree with this, pointing out that environmental and behavioral changes are important factors to address for injury prevention programs to be successful (Green & Kreuter, 1991). It becomes more important to affect the individuals' subjective perception of risk to motivate protective behavior (Gielen & Sleet, 2003). In the end, the individual holds the final decision on whether to apply ice cleats to their shoes.

Earlier studies on ice cleat use

Earlier studies have assessed the design and effectiveness of ice cleats available in Sweden, focusing on user experiences (Gard & Lundborg, 2000, 2001; Gard & Berggard, 2006; Gard m.fl., 2018; Larsson m.fl., 2019). These studies provided adults with a variety of samples of ice cleats, which were categorized into three groups; cleats that either covered the heel, forefoot, or whole sole of their shoes. In a controlled environment, the test subjects walked on various surfaces, including gravel, sand, salt, snow, and ice, to simulate real-world conditions. The users' preferences were then evaluated based on their perceptions of the cleats' walking safety, gait, and balance. Although the studies were carried out under supervision, they still provide valuable insights from users indicating a preference for devices that cover either the whole foot or the heel of their shoes. Berggård & Johansson (2010) took a step further by testing ice cleats in their natural environment. They provided devices to a sample of participants, instructed them on how and when to use the cleats, and asked them to report their daily walks. The intervention group, who received the cleats, walked longer distances per day and reported fewer falls compared to the control groups. While the actual number of falls did not differ significantly between groups, the study suggests that providing individuals with ice cleats and instructions on their use increases the likelihood of using them.

In one randomized controlled trial, McKiernan (2005) followed 109 fall-prone older adults where participants were randomly equipped with a pair of ice cleats and a control group was used for reference. The group that used the cleats experienced a significant decrease in the incidence of slips and falls, with relative risk (RR) reductions of 50% and 42% respectively. Out of a total of ten recorded outdoor falls resulting in injuries, only one occurred in an individual using ice cleats. Despite extensive research on injury prevention in older adults (McClure, Turner, Peel, m.fl., 2005) and previously published research on user experiences (Gard & Lundborg, 2000, 2001; Gard & Berggard, 2006; Gard m.fl., 2018; Larsson m.fl., 2019; Berggård & Johansson, 2010), there is a lack of evidence on the effects of ice cleat distribution in a large-scale population. To my understanding, there is only one case study that estimated the impact of a large-scale ice cleat distribution program, in Gothenburg, Sweden (Bonander & Holmberg, 2019). The municipality distributed subsidized ice cleats to its older adults via coupons and 62% of eligible recipients claimed a pair. The first year saw a 45% reduction in emergency department visits due to slips on ice and snow, but the effects decreased in later years. The apparent impact of the program demonstrates a reduction in fall-related injuries on ice and snow, signaling program compliance for at least some segments of the target population who began using ice cleats as a consequence of the program.

Municipal ice cleat distribution programs: a growing trend

The ice cleat distribution program implemented in Gothenburg served as a model for other municipalities in Sweden to follow. However, there might be insufficient planning by decision-makers in terms of assessing program objectives and evaluating its effectiveness. Additionally, it is crucial to evaluate the essential requirements needed to achieve the intended outcomes of a program. The number of municipal initiatives launched is unclear, and their varying designs indicate that their effects may differ.

Although previous studies provide encouraging findings on ice cleat use (Berggård & Johansson, 2010; McKiernan, 2005; Bonander & Holmberg, 2019), such effects can be locally restricted. Long-term compliance with the program may also vary among municipalities. Hence, more in-depth analysis is required to arrive at any general conclusions. However, for this to work and achieve injury reduction, there are mechanisms of behavior change that determine whether the programs succeed or fail (Gielen & Sleet, 2003).

Promoting safe behaviors requires behavior change

Creating new behavior patterns among older adults can be a difficult task to address. Their attitudes towards change may pose a challenge than younger cohorts (Jenkins, 2003). Despite these difficulties, some studies indicate a behavior change when risk-reduction measures for fall injuries are implemented. Fall-preventive interventions and their adherence to program participation have proven to be effective in a stated-risk population (Daskalopoulou m.fl., 2017; Reiner m.fl., 2013; Sun m.fl., 2013). Physical activity is perhaps the most effective countermeasure to reduce the risks of falling (ibid), and individuals who partake in such interventions do so by free will. The success of the interventions could be attributed to the use of multiple strategies to encourage the target group to actively participate. Behaviorists agree with this (Jenkins, 2003) and underline that for a behavior change to occur, it is crucial to educate the public on the issue of slip-related injuries caused by icy road surfaces and promote the desired behavior change of using ice cleats long-term. This can be achieved by highlighting the expected benefits of the behavior change, such as prolonged use of ice cleats can reduce the risk of fall injuries. An appropriate procedure for encouraging program participation would be to use examples of positive incentives (see e.g. (Bonander & Holmberg, 2019)) and disincentives in events of non-participation. The behavior can be reinforced further by seeking for inspiration from individuals or communities that are willing to share their experiences of ice cleat use.

Other personal perspectives also need to be considered to establish behavior change. The way a person behaves can be shaped by various factors, including their perception of potential health threats, such as the fear of falling (Rantakokko m.fl., 2009; Scheffer m.fl., 2008; Tennstedt m.fl., 1998), their evaluation of the advantages associated with taking action, such as using ice cleats, as well as their perception of obstacles that may prevent them from taking action (Champion & Skinner, 2008). If an individual perceives the threat of slipping and falling on ice and snow as high and believes that using ice cleats is an effective and feasible way to reduce the risk, they are more likely to use them. Therefore, in order to promote the use of ice cleats, it may be useful to provide information on the risks of slipping and falling on ice and snow, as well as education on the effectiveness and feasibility of using ice cleats as a protective measure. This may help to increase individuals' perception of the threat and increase their likelihood of using a pair of cleats to reduce slips on ice and snow. Moreover, repeated successful performance of a specific behavior can boost a person's confidence in their ability to perform it (Bandura, 1990). Successfully using ice cleats to prevent slips on ice and snow can result in positive reinforcement, encouraging long-term use. This is similar to other situations where exposure to a risk and use of protective equipment results in positive reinforcement of the behavior (Betz & Li, 2007; Lipscomb, 2000).

Importance of program evaluation

Since the distribution programs are widespread, it becomes more important to evaluate the effect of such programs. With evaluation, we can determine the effectiveness of a program in achieving its intended goals (Rossi m.fl., 2019). Program evaluation helps identify areas for improvement in program design, implementation, and outcomes. This can lead to changes in the program that make it more effective and efficient, as well as better tailored to the needs of the target population

(Saunders m.fl., 2005). The knowledge generated can provide decision-makers with valuable information to determine whether to continue, modify, or terminate the programs. This is especially important for public programs that use taxpayer money, as it ensures that resources are used effectively and efficiently (Rossi m.fl., 2019). Evaluation ensures accountability and transparency by providing evidence-based information about the programs' performances. This information can be used to communicate program achievements to stakeholders, as well as to identify areas for improvement and take corrective action. Finally, program evaluation of these initiatives will contribute to the field of knowledge about effective interventions aimed at older adults in winter conditions. The knowledge provided can be used to inform the development of similar programs in other settings and to advance the field of public health (Saunders m.fl., 2005), but also be used as a foundation for future impact estimates on injury prevention.

3. Aims

In later years, several Swedish municipalities implemented subsidized ice cleat distribution programs for their older adults. Research on this topic is currently scarce, and it remains unclear whether these initiatives have produced the desired outcomes. It is important to assess the effectiveness of these programs, as they play a significant role in affecting the target audience to partake in municipal initiatives. This thesis aims to assess these programs to better comprehend why they may have been successful or not. I utilize the evaluation framework put forth by Rossi et al. (2019) with a strong focus on process- and outcome evaluation, with an emphasis on program compliance and changes in behavior. The program evaluation could potentially provide decision-makers with enough evidence to make informed choices about whether to maintain, terminate, modify, or implement similar future distribution programs.

The aim of this thesis is to analyze the municipal programs designs and estimate their effects on ice cleat use. The objectives for each study are listed below.

Study I: To describe and analyze the logic and design of Swedish municipalities' ice cleat distribution programs by conducting a summative process evaluation with a particular focus on behavior change.

Study II: To estimate the effects of ice cleat distribution programs on self-reported ice cleat use.

The research in this thesis also contributes to the overall aims of a broader research project evaluating the implementation, effects, and cost-effectiveness of ice cleat distribution programs in Sweden (Karlstad University, 2022). Other papers related to this project, in which I have participated, include an evaluation of the program's impact using Gothenburg as a case study (Bonander & Holmberg, 2019), a study on economic modeling (Bonander m.fl., 2021), and an evaluation on the programs' impact on ice-related injuries using data from 73 municipalities (Eklund et al., 2022, *submitted manuscript*).

4. Program evaluation framework

In order to assess the ice cleat distribution programs, my evaluation primarily utilizes the theoretical framework developed by Rossi et al. (2019). As mentioned earlier, programs are sometimes implemented without proper evaluation of the requirements necessary to achieve the intended outcomes. Similarly, efforts to evaluate the effects of a program may also lack a proper plan for assessing its objectives. It would be unfair to deem the incorporation of ice cleats in municipal distribution programs a failure in the absence of adequate evaluation. Evaluating programs is essential in determining their success or failure and identifying areas for improvement if the programs are to be continued.

Randomized controlled trials have been established as the best method for evaluating interventions and establishing causal inference (Cartwright, 2009; Sibbald & Roland, 1998). However, there are practical issues associated with this approach when evaluating large-scale community-based programs, such as problems with generalizability (Hariton & Locascio, 2018), cost (World Health Organization, 1998), lengthy timelines, loss of follow-up, and potential exaggeration of treatment effects (Schulz m.fl., 1995). To evaluate social interventions, such as distribution programs, it is often more practical and generalizable to apply a quasi-experimental approach to estimate effectiveness (Morgenstern, 1995). Deviations from program guidelines are expected in large community-based initiatives, which may not occur in an experimental setting, and accurate real-world program effects can still be estimated without randomization as long as careful considerations are made in the design and analysis of the study (Armijo-Olivo m.fl., 2009).

Types of evaluation

The Centers for Disease Control and Prevention provide a helpful overview of various program evaluation types, which can be utilized in different evaluation scenarios (CDC, 2001). The selection of the evaluation type is dependent on the program's development stage and activities, see Table 1 for further details.

Table 1. Different evaluation types can be used depending on what is being evaluated.

Evaluation types	When to use	What it shows	Why it is useful
Formative Evaluation Evaluability Evaluation	-During the development of a new program. -When an existing program is being modified or is being used in a new setting or with a new population.	-The extent to which an evaluation is possible, based on the goals and objectives. -Whether the proposed program elements are likely to be needed, understood, and accepted by the population you want to reach.	-It allows for modifications to be made to the plan before full implementation begins. -Maximizes the likelihood that the program will succeed.
Process Evaluation Program Monitoring	-As soon as program implementation begins. -During operation of an existing program.	-How well the program is working. -The extent to which the program is being implemented as designed. -Whether the program is accessible and acceptable to its target population.	-Provides an early warning for any problems that may occur. -Allows programs to monitor how well their program plans and activities are working. -Can be both summative and formative, where the latter may help improve ongoing implementations.
Outcome Evaluation Objectives-Based Evaluation	-After the program has made contact with at least one person or group in the target population.	-The degree to which the program is having an effect on the target population's behaviors.	-Tells whether the program is being effective in meeting its objectives.
Economic Evaluation: Cost Analysis, Cost-Effectiveness Evaluation, Cost-Benefit Analysis, Cost-Utility Analysis	-At the beginning of a program. -During the operation of an existing program. -At the end of a program.	-What resources are being used in a program and their costs (direct and indirect) compared to outcomes.	-Provides program managers and funders a way to assess cost relative to effects. "How much bang for your buck."
Impact Evaluation	-During the operation of an existing program at appropriate intervals. -At the end of a program.	-The degree to which the program meets its ultimate goal of reducing slip-related fall injuries.	-Provides evidence for use in policy and funding decisions.

The table is primarily inspired by The Centers for Disease Control and Prevention which summarizes the different types of program evaluation (CDC, 2001). It has also been supplemented by my interpretations of Rossi et al. (2019).

According to Rossi et al. (2019), it is essential to assess the efficacy of programs during the early stages of implementation and to continue monitoring them throughout the program. The ideal approach involves collaboration among behavioral scientists, health promotion specialists, epidemiologists, health economists, the target population, and government officials (McClure, Turner, & Yorkston, 2005). Nevertheless, due to a lack of resources or expertise, some Swedish municipalities may not be able to conduct comprehensive program evaluations on their own. In such cases, external support to evaluate these programs would be advantageous for both decision-makers and program beneficiaries. As the municipal programs have been introduced and some are still ongoing, it is suggested that an appropriate approach is to use a process evaluation with a summative design. This type of evaluation enables the collection of program information and data about the target population's perspectives without disrupting ongoing programs (Rossi m.fl., 2019). Such a procedure enables an analysis of the initiatives and an understanding of why the programs succeed or fail. Additionally, an outcome evaluation is suitable for assessing the program participants' use of ice cleats and estimating the programs' effects on ice cleat use. In both cases, evaluations can contribute to the research gaps and assist future decision-makers in determining whether such efforts should continue, be modified, or be discontinued.

Program theory

An effective procedure to evaluate claims of effectiveness is by creating a causal model, also referred to as a logic model, program model, outcome line, or causal map (Cartwright, 2009). Program theory, which is a more established term in the evaluation literature (Rossi m.fl., 2019), involves a systematic approach that explicitly represents the logic of a program from its inception to its causal links to program impact. Depending on the scope of the intervention, the model for a program theory can consist of several underlying components, as illustrated in figure 1. This model outlines key components, such as the process theory which includes program activities, and their relationships between program inputs, activities, and outputs, which is followed by an impact theory that outlines the expected outcomes, including short- and long-term outcomes. Program theory is commonly utilized to establish a clear and comprehensive understanding of the program's logic and to serve as a framework for program evaluation. The theory can, for instance, guide evaluation efforts by helping to identify indicators of program success, find hidden assumptions that lack good rationale or evidence, and decide which outcomes to measure. The model is typically developed during the initial planning phase before program implementation and is regularly updated throughout the program's lifecycle. As a result, the program theory may undergo changes and is not a static model.

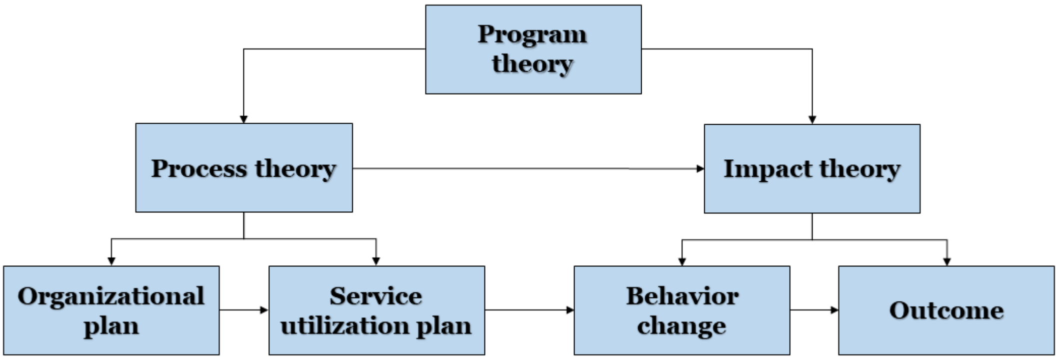

Figure 1. Visualizes the components of a program theory in the context of a municipal ice cleat distribution program.

In the upcoming sections, I will give a concise outline of these elements, focusing particularly on ice cleat distribution programs. I begin by providing a brief overview of process theory components and then give a comparable description of an impact theory.

Process theory

The process theory refers to understanding how the programs and interventions operate and how they lead to their intended outcomes. The underlying mechanisms, from program introduction to its activities and delivery of service, are examined and assessed to create an understanding of whether they are functioning as intended. It is recommended to collect and analyze data using a mixed-methodological approach (Weiss, 1998; Saunders m.fl., 2005; Creswell, 2009). Input from both program facilitators and program beneficiaries can help to identify the mechanisms through which the program operates, as well as any unintended consequences or unforeseen barriers to program success. This can be particularly useful in complex interventions or programs where the relationships between program activities and outcomes may not be straightforward. Evaluators can better understand the underlying mechanisms through which a program operates and identify areas for improvement to enhance program effectiveness. The process theory consists of two components, an organizational plan, and a service utilization plan. Together, they articulate the fundamental assumptions and expectations needed for program staff to implement and facilitate the intervention. Figure 2 shows an example of a process theory based on Rossi et al. (2019).

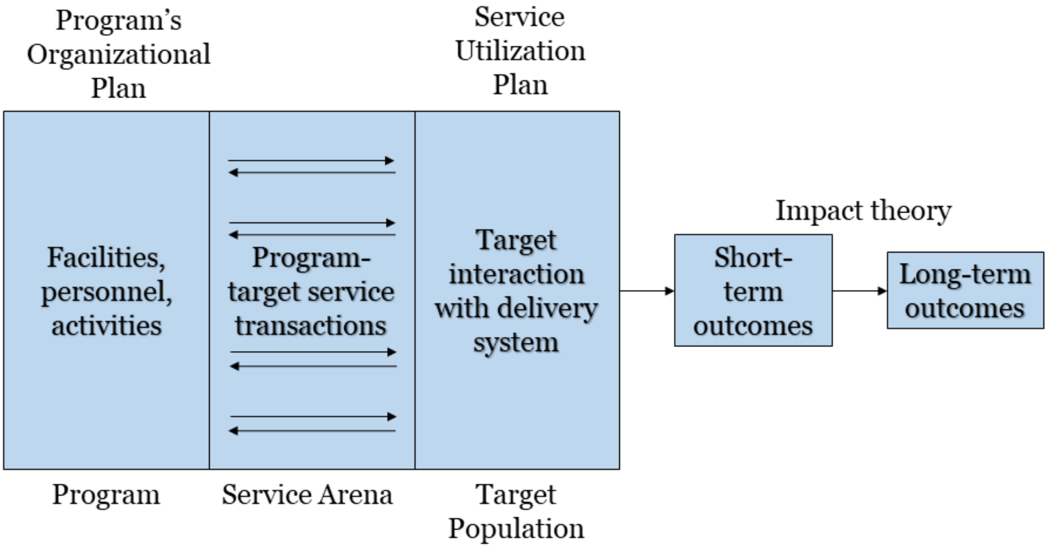

Figure 2. Shows an overview of a process theory. Source: Rossi et al. (2019).

The organizational plan consists of a set of propositions that establish the necessary conditions for a program's success. A well-resourced program, supported by sufficient funds, experienced staff, and knowledge of the implementation process, along with a well-designed strategy to engage the target population, is more likely to achieve the desired impact. The service utilization plan is the second component and details the effectiveness of delivering the intervention to the intended beneficiaries and how they engage with the program's delivery system. The program's success in achieving the desired impact can be facilitated by the availability of adequate facilities for distribution, effective communication to the intended audience, and clear information on pick-up sites.

Impact theory

A well-designed process theory makes it easier for program activities to be executed. When facilitators carry out these accordingly, then program outcomes are to be expected. The hypothetical causal link of this process is theoretically described in Figure 3, which depicts a simplified impact theory model for a municipal ice cleat distribution program. In the simplified model, the program participants are assumed to be engaged in the program by actively picking up a pair of cleats and using the provided devices when needed. The prolonged use of the cleats is theorized to impact the number of fall-related injuries on ice and snow.

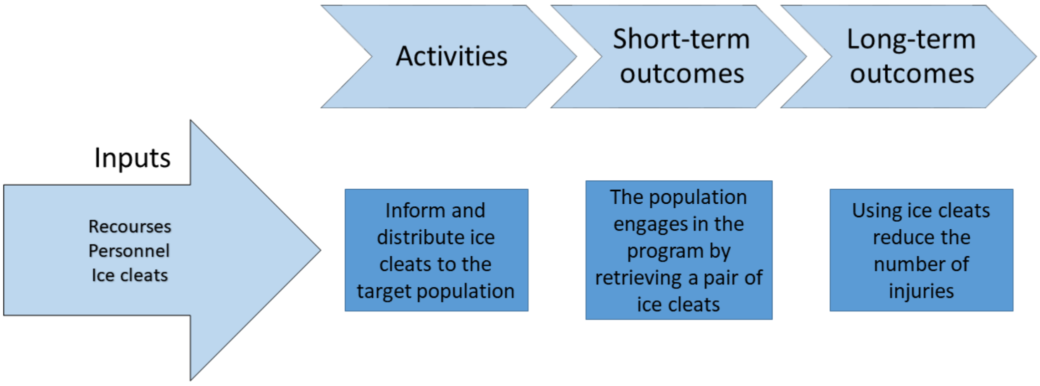

Figure 3. Illustrates a theoretical impact model of an ice cleat distribution program, which is a part of the program theory. When the program is active and distributing ice cleats, the short-term effect is the target audience will engage in the program by retrieving a pair of devices. The long-term outcome is transformed into a behavior change that the devices are continually being used and thus reduce the number of ice-related fall injuries.

The process theory is important in a way that it helps evaluators to understand why a programs impact theory did, or did not, end in its expected outcome. Likewise, a poorly designed impact theory does not provide insight into the most appropriate outcomes to measure. In the case of ice cleat distribution programs, it is understandable that the design of a process theory, and its associated content of an organizational plan and a service utilization plan, are defined by the conditions of each municipality. In other words, this suggests that the process theory may be unique for each municipality, making it hard to design one fits-all-municipalities type of process theory.

5. Methods

In the process of studying and understanding public health interventions, one should break down and deconstruct the logic behind the programs (Rossi m.fl., 2019; Saunders m.fl., 2005; Weiss, 1998). Such deconstruction can help highlight potential areas for improvement if the programs were to continue or provide insight into whether the programs did not work as previously thought. Understandably, when evaluating community-based programs of this kind, data collection should be across the entire line of operations. This means that it is necessary to take a broad perspective to gather information. In this case, data from policymakers and program facilitators to the actual program beneficiaries are all crucial parts of the retrieval process in the steps for future analysis. As suggested in large-scale data curation of this kind (Creswell, 2009; Rossi m.fl., 2019; Saunders m.fl., 2005; Weiss, 1997, 1998), we approached this with a mixed-method approach. By leveraging the strengths of both qualitative and quantitative data collection, we could fully integrate the different types of information each provides to expand the utility of the evaluation findings. A table of selected designs for each study is summarized in Table 2. I provide further details on data collection and methods of analysis for each study in the following sections.

Table 2. An overview of the selected methodological procedures for each study.

Paper	Design	Methods	Data collection	Methods of analysis
I	Explorative, Descriptive	Mixed-methods	Municipal questionnaire, Focus-group interviews, Statistics Sweden, Newspapers articles, Municipal websites	Descriptive statistics, Content analysis, Process evaluation, Program theory analysis
II	Cross-sectional	Quantitative	Municipal questionnaire, Statistics Sweden, repeated cross-sectional data from the Swedish Civil Contingencies Agency	Outcome evaluation, Linear probability model, Logistic regression

Study I

Data collection

According to the program evaluation literature (Rossi m.fl., 2019; Saunders m.fl., 2005; Weiss, 1998), a vital part of analyzing the designs of community-based programs of these kinds is to create a program theory of the municipal distribution programs. To fulfill this requirement, and as a first step in the process, I conducted a literature review focusing on program evaluation and behavior change. This was complemented further by gathering data from three sources: an electronic survey sent to all Swedish municipalities (n=290), interviews with decision-makers and program facilitators (Holmberg & Gustavsson, 2020), and conducted focus-group interviews with potential ice cleat users. This allowed examining the underlying assumptions necessary for the distribution program to achieve its intended impact and identify potential barriers to successful implementation.

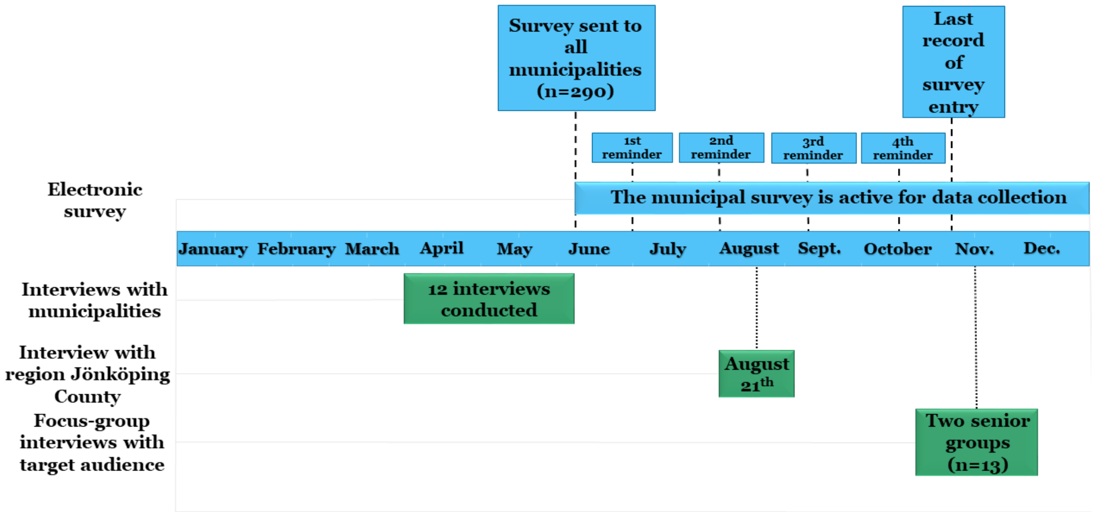

Figure 4. Illustrates a summarized timeline of the conducted data collection.

Electronic survey

Another essential procedure to the data collection was to retrieve data about the municipal ice cleat distribution programs. The gathering of data from municipalities on the existence and specifics of their ice cleat distribution programs was critical. To obtain this information, we conducted an electronic survey. The survey included questions to determine if such programs were currently in place or had been implemented in the past, the number of ice cleats distributed, the types available, locations of distribution, details of program costs, the duration of the programs, etc. In addition, survey participants were given the option to provide additional comments or feedback using an open-text field at the end of the questionnaire. The survey program used for this was the web-based Survey & Report.

The survey was then constructed accordingly and scrutinized within the group. Before finalizing the questionnaire, we validated the survey by sending it to a handful of participants for testing. The feedback resulted in a few corrections in outline and question-wording before being sent to all Swedish municipalities' municipality-specific official e-mail addresses (n = 290). Every municipality has municipal administrators that read e-mails sent to them and are responsible for forwarding correct correspondence. The municipal respondents were also given the opportunity to reply with supplementary information regarding their programs via e-mail. The first survey wave was sent on June 10th, 2019. Following the methods of using a questionnaire for data retrieval (Fricker, 2008; Trost & Hultåker, 2016), we sent four waves of reminders to non-responding municipalities July 1st, August 16th, September 10th, and October 16th. The last entry was registered in November 2019. In total, 229 municipalities participated in the study (79% response rate); 165 (72%) participated in the survey, and 64 (28%) responded via e-mail. Two municipalities explicitly declined to participate in the survey.

The accuracy of the self-reported municipal data was verified by cross-referencing it with official municipal documents and online sources such as local newspapers and municipal websites. If any discrepancies were found, the municipalities were contacted again through phone or email to confirm the data. In most cases, minor modifications were made to the data regarding the number of ice cleats distributed and program dates. This was often due to personnel changes who managed the programs or the lack of information available in municipal records. The procedure was also applied to municipalities that responded to not having ice cleat distribution programs.

Data from the electronic survey were used in analyzes for Study 1 and Study 2 respectively, but for different purposes (I describe this in more detail in the sections that follow below). We also complemented the data by retrieving municipality-specific data on the Swedish population from Statistics Sweden.

Interviews with municipal staff members

In conjunction with another research project (Holmberg & Gustavsson, 2020), twelve municipalities were interviewed, each with members of the staff responsible for traffic safety for vulnerable road users. While collecting data for the other project, we could, at the same time, gain insight into program implementation from both decision-makers and program facilitators alike. During these interviews, which took place from April to May of 2019, we gathered perspectives from decision-makers and program facilitators regarding their views on ice cleat distribution programs, their experiences with active or past programs, and the design of such programs to reach their intended population. Each interview had one or two participants from the municipality. During the data collection process, we learned that Region Jönköping County[4] had initiated a program to distribute ice cleats to senior citizens, becoming the first region in Sweden to do so. This presented an opportunity to supplement the data further, and the decision-maker of Region Jönköping County kindly agreed to participate in a short interview about their implementation. I conducted this interview alone in August of 2019, using a semi-structured set of questions as a guide while taking thorough notes of the discussion.

Target population on the design of distribution programs

The perspective of senior citizens on public interventions like ice cleat distribution programs is uncharted territory. To gain a comprehensive understanding of the program recipients' views, conducting interviews with potential program participants was deemed the most suitable method for data collection. The interviews were designed to center around a hypothetical ice cleat distribution program to avoid potential

[4] The Swedish municipalities (n=290) are divided into 21 different regions. Region Jönköping County consists of 13 municipalities.

bias due to differences in program designs across municipalities. By engaging in focus-group interviews with the target population who have not yet been part of any distribution programs, we aimed to understand their attitudes, perceptions, and preferences towards such programs and their use of ice cleats in snowy conditions. The social dynamics of the group are a distinctive feature of focus-group interviews, which leads to a more profound and comprehensive range of data that is often not obtained through individual interviews (Thomas m.fl., 1995). These insights would add valuable and nuanced information to the program theory, enriching our understanding of the target population's perspectives and their possible behavior change when being exposed to a program (Gielen & Sleet, 2003; Jenkins, 2003; Rossi m.fl., 2019).

During this period, the retrieval of data from the municipal electronic survey was still active (see Figure 4). By briefly reviewing the survey data, we were able to form a rough understanding of the program designs. This enabled us to have iterative conversations regarding the program designs before reaching a consensus on what should be addressed during interviews with future participants. Based on these discussions, we developed a semi-structured interview battery (Wibeck, 2010) (found in the supplementary appendix of paper 1).

The next phase of the process involved recruiting interview participants. We approached older adults residing in a Midwestern city in Sweden and asked if they were interested in participating in interviews to discuss ice cleats and the design of distribution programs. Two groups showed interest: a physically active gymnastics group and a less active Bridge group. We scheduled the interviews for November 2019 without knowing the exact number of participants. The project group had no involvement in the sampling process as the participants were coordinated separately by the two groups (Krueger & Casey, 2014). A total of 13 individuals participated in the focus group interviews, with ten from the active group and three from the Bridge group, averaging 73 years of age. There was an overrepresentation of women in both groups, with nine women and four men. All participants provided written consent, and the interviews were recorded for content analysis.

Before the interview sessions, we agreed that two of us would conduct the data collection and take on two roles. Based on recommendations from the literature (O.Nyumba m.fl., 2018; Gill m.fl., 2008), we determined that one of us would lead the focus-group interviews as this person had more experience and skills in conducting interviews and moderating group discussions. On the other hand, I acted as an observer and interview assistant, responsible for recording the material. I carefully took notes on the conversations and, when necessary, asked participants to provide additional clarification.

Methods of analysis

Descriptive statistics & estimation of program reach

The data collected from the municipal survey was analyzed using descriptive statistics to summarize the initiatives and provide an overview of program differences. According to the evaluation literature, program reach is a crucial factor in determining program success, as it measures the extent to which the intended population benefits from the program (Rossi m.fl., 2019; Saunders m.fl., 2005). In Paper 1, program reach was calculated by dividing the number of target population members who received ice cleats by the number of targeted residents in each municipality. This calculation was made using data from Statistics Sweden and the electronic survey.

Since no municipality had established a standard for a successful program, a distinction was created by dividing the number of distributed ice cleats by the targeted population. This allowed programs to be categorized into two groups: above-average reach and below-average reach. In cases where municipalities didn't have enough ice cleats to meet the full needs of the targeted population, an alternative variable was created that accounted for the number of distributed ice cleats relative to the number of purchased ice cleats. This variable provided valuable input for designing a successful implementation program by indicating the demand for the cleats given the program's design.

Inductive content analysis

We conducted focus group interviews with the aim of exploring participants' attitudes, perceptions, and preferences regarding ice cleat distribution programs in snowy conditions. The recorded interviews were transcribed, and we followed Bengtsson's (2016) recommendation to approach the material with an open mind and without bias. We then independently read through the transcriptions several times, decontextualized the text inductively, and identified meaning units that were used for later recontextualization into codes (see Graneheim & Lundman, 2004). Our findings were compared and triangulated to begin the categorization of the data. Using this procedure, we identified three key themes: "*risk-aware and in control*", "*ice cleats - a necessity*", and "*appreciation for municipal ice cleat programs*".

Program theory

The entirety of the data, i.e., the literature, the interviews, and the municipal survey was used to analyze and assess the quality of the programs. Without disrupting the implementation of the programs, a summative evaluation was conducted (Rossi m.fl., 2019). After several sessions of discussion about the programs, a consensus was reached on how a program would be designed to influence a meaningful share of the targeted population. A generalized program theory of a successful municipal ice cleat distribution program was created. Potential factors that could have a negative impact on the programs were also identified.

Study II

The purpose of Study 2 was to estimate the impact of ice cleat distribution on ice cleat use. We retrieved individual-level survey data from The Swedish Civil Contingencies Agency and combined this with our electronic survey to match individual data on ice cleat use with data on program exposure.

Data collection

Cross-sectional survey data from Statistics Sweden

The Swedish Civil Contingencies Agency has historically commissioned Statistics Sweden to retrieve information about the Swedish citizens' perceptions and behaviors related to safety and security. Statistics Sweden intended to collect data on the subject by sending questionnaires to the Swedish population. As a result, four cross-sectional surveys were designed and sent to the population using a stratified random sampling design, targeting adults with different backgrounds, aged 18-79, and living in Sweden during the years 2007, 2010, 2014, and 2018 (the number of survey samples was about 7 million people each survey year). Swedish municipalities were also allowed to purchase a municipality-specific survey in addition to the national data collected by Statistics Sweden. For this, the survey samples were 600 per municipality each year. Respondents within a stratum had the same probability of being included in the sample, and measures were applied to not double-count survey participation. In summary, a total of 169 721 respondents were asked to participate in the surveys, and a total of 88 676 respondents participated which corresponds to a 52.2% response rate.

Statistics Sweden also linked a battery of sociodemographic characteristics to the survey data using register linkage via personal identification numbers. This data allowed us to identify the respondents' municipality of residence, age, sex, place of birth (native, non-native), and educational attainment (secondary education or less (≤12 years of schooling, postsecondary education (>12 years of schooling)). The data were de-identified before being provided to the research group.

Each survey wave contained a question about ice cleat use. In the survey years 2007 and 2010, there was a question that asked survey participants the following: ”How often do you do the following for your own safety?”, and for the years 2014 and 2018 it was asked: ”Do you use any of the following safety equipment?”. In all survey waves, there was a sub-question that asked whether the survey participants use ice cleats as a protective countermeasure against falls when exposed to icy conditions. Our intention was to use this data to estimate the association between municipal ice cleat distribution and ice cleat use. (If you want to read more about how differently the questions were formulated in the survey waves, see supplementary table 2 in Paper II). We combined our electronic survey data with these variables to classify ice cleat users and non-users (our outcome measure) and exposed and not exposed to ice cleat distribution (program exposure measure).

Recodification of the outcome variable

To classify ice cleat users and non-users uniformly across the four surveys, we had to recode the original data due to variations in the number of response alternatives to the questions about ice cleat use. In the survey years 2007 and 2010, the questionnaires used an ordinal scale in the self-reported outcomes on ice cleat use (different options ranging from never, seldom, sometimes, often, to always), while the remaining two survey waves, the years 2014 and 2018, used the answering options of yes or no. We homogenized the data for the survey years 2007 and 2010 by coding the variables for ice cleat use into binary outcomes (much like the survey waves of 2014 and 2018). In detail, we classified those who reported using ice cleats sometimes, often, or always, as ice cleats users. Participants who reported using ice cleats as seldom or never were classified as non-users (we also considered an alternative definition including seldom users as ice cleat users in a sensitivity analysis). We could then match the survey data from Statistics Sweden with our electronic survey to identify respondents that were exposed or unexposed to ice cleat programs.

Program effectiveness and program exposure classification

In real-life scenarios, program participants may sometimes withdraw from an ongoing intervention. The reasons for this vary. For instance, some choose not to comply with the program, others migrate to neighboring municipalities, a few do not see the program as appealing, and sadly a handful dies during the program is active. However, we address these issues pragmatically, as in any other well-structured intention-to-treat analysis (Armijo-Olivo m.fl., 2009), meaning that it is, more or less, expected that program participators will deviate from the program under natural societal settings. Despite not knowing whether participants were active in the programs, for unknown reasons, our primary variable of exposure was defined as respondents exposed to a program if they (i) lived in a municipality that had or has an ongoing program, (ii) belonged to the municipality's eligible age group, and (iii) participated in a survey wave after ice cleat distribution. Regardless of whether eligible respondents reported using ice cleats or not, we still define them as individuals exposed to a program—which is consistent with the analysis of intention-to-treat effects (Armijo-Olivo m.fl., 2009). This allows us to obtain more accurate estimates of the programs' effectiveness on ice cleat use in their natural environments.

Program efficacy

We were also interested in investing the efficacy of the programs should the programs have a perfect reach. To estimate efficacy, we defined a secondary variable using our estimate of program reach from Study 1. The variable was coded on a scale from 0 to 1, where 1 indicates that one ice cleat pair was distributed per eligible citizen. This allows for analyses of the dose-response relationship between reach and ice cleat use, as well as estimation of the expected impact in a scenario where one ice cleat pair is distributed per citizen.

Methods of analysis

Descriptive statistics

As described above, we began by merging the datasets and, much like in Study 1, tabulated the characteristics using the information from the four survey waves. To further demonstrate the effects of distribution programs on ice cleat use, we visually plotted the self-reported ice cleat use in a scatter plot by aggregating individuals by age group and exposure to ice cleat distribution.

Linear probability model

Regression modeling is a valuable tool for assessing the impact of an experiment in natural settings (Angrist & Pischke, 2014). This technique involves using predictive modeling to identify a relationship between a dependent variable and one or more independent variables. In our study, we were interested in the binary outcome of self-reported ice cleat use (yes=1, no=0). However, other factors and confounding variables may impact ice cleat use. To address this, we used multiple independent variables, such as age, gender, Swedish-born status, educational attainment, municipality of residence, and survey year, to develop a linear probability model, which recently was demonstrated by

Gomila (2020) is the best strategy for estimating intervention impacts treatments with binary outcomes[5].

When all the variables were in place, we could then build our regression model, which can be expressed as:

$$Y_i = \beta_0 + \tau D_i + \sum \beta_j X_j + \varepsilon_i,$$

where Y_i is a binary variable indicating if respondent i is an ice cleat user (1=yes, 0=no); β_0 is the intercept of the regression line; D_i is a dummy variable also binary coded indicating if the respondent is exposed to an ice cleat distribution program (1=yes, 0=no). The term $\sum \beta_j X_j$ includes the following adjustment variables: native born or not (1=yes, 0=no), educational attainment (postsecondary school or greater are coded as 1, otherwise as 0), sex (1=man, 0=woman), a categorical age group variable (5-year age groups), a categorical variable for municipality of residence, and a categorical survey wave variable. The coefficient of interest is τ, which gives the difference in probability of ice cleat use between exposed and unexposed respondents (adjusting for the other variables in the model). In a secondary specification, we replaced the binary exposure variable D_i with a continuously coded variable representing reach (the number of distributed ice cleat pairs per eligible citizen) to estimate dose-response effects. Following Roth et al. (2022), we applied clustered standard errors at the municipality level to obtain valid statistical inferences.

Sub-group analyses

Although we report estimates of the average usage rates on eligible age groups, there may be user differences in between groups. To check whether there were heterogeneous effects, subgroup analyses were conducted (Varadhan & Seeger, 2013). Survey data were categorized into four groups with subgroups within each group on the parameters:

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[5] Gomila (2020) uses the term “linear probability model” when referring to linear regressions with binary outcomes. In a sensitivity analysis (see below), I also applied a conventional logistic regression analysis.

5-year age groups (65-69, 70-74, 75-79), gender (male, female), and education level (post-secondary education, secondary education or lower), and place of birth (born in Sweden, not born in Sweden).

Sensitivity analyses

Ice cleat users were dichotomized into two groups; main users and alternative users. The main definition for ice cleat users were the respondents who reported using ice cleats (i.e. “always”, “often” or “sometimes”), while alternative users were those who responded using ice cleats infrequently (i.e. “rarely” or “very rarely”). To account for the varied frequency of ice cleat use, a sensitivity analysis was performed using the whole range of self-reported ice cleat use. A standard logistic regression was also conducted as a second predictive model to calculate the probability differences.

Negative controls

Respondents whose age ranged from 1-15 years below the eligible threshold for program participation and who lived in a municipality that reported a program were used as negative controls[6] (Lipsitch m.fl., 2010). The control groups had differing ages because the age requirements for program participation varied between the municipalities. The most frequently established age limit was 65 years or older, leading to the majority of negative controls being in the age range of 50-64.

[6] Negative controls are also synonymously referred to as placebo tests.

6. Results

In this section, I briefly report the main findings from the studies. For in-depth detailed results, I refer to the full articles.

Study I

Figure 1 summarizes the 231 municipalities participating in the electronic survey. Just over half of the Swedish municipalities, 153 to be

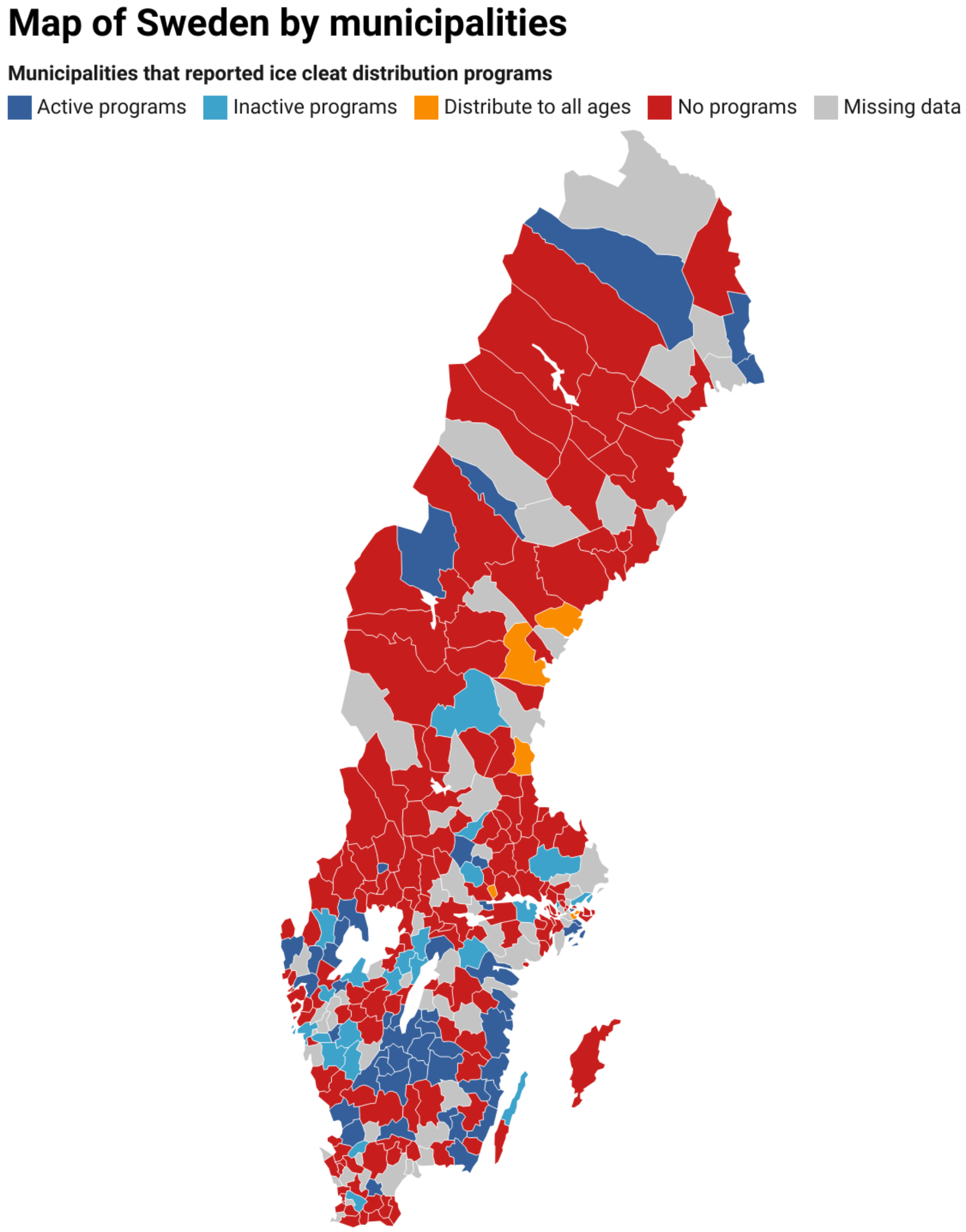

Figure 5. Map of the Swedish municipalities that participated in the electronic survey reporting ice cleat distribution programs.

specific, reported having no programs, 27 notified that they once had programs (indicated as inactive programs in the figure), and a further 51 municipalities have active programs. Five municipalities[7] reported distribution to all ages and were excluded from the analyses as they are not within the scope of this thesis.

Description of programs

Earlier it was mentioned that no municipality has established a clear definition of what constitutes a "successful" program. To address this, the distribution of ice cleats was compared to the size of the targeted population and averaged 40.5% across program municipalities [95% CI: 34.5, 46.5, Median: 45.3][8]. This calculation was then used to categorize programs into those with above-average and below-average reach. By doing so, it can be determined whether a program has been successful in terms of engaging the target population to pick up ice cleats, as outlined in Table 3.

It is common for municipalities to use multi-channel campaigns to convey and inform the population about the program, but also influence them to take action by participating in the programs (Aldoory & Bonzo, 2005). This ought to be the first step of the intervention programs to affect the targeted recipients' process of long-term behavior change in using ice cleats when needed (Rossi m.fl., 2019). Some municipalities send coupons to the targeted population which can be exchanged for a pair of ice cleats (Bonander & Holmberg, 2019), other municipalities modified their programs by offering a pair of devices at a discounted price, and others see older adults get a free lunch, or coffee, at one of the municipally-owned restaurants if they present a receipt showing they have bought a pair of ice cleats. The choice of distribution sites tends to be municipally owned buildings, which is followed by stores and other businesses that provide devices. When it comes to which type of ice cleats the municipalities distribute, most of them

[7] The five municipalities reporting distribution to all ages are: Kramfors, Sundsvall, Söderhamn, Nacka and Hallstahammar. Söderhamn and Nacka reported having active programs during the data retrieval.
[8] The municipality of Västervik was the only municipality that reported a reach that exceeded the target population (108.8%). The reason for such a high number is that the recipients could continuously exchange old broken ice cleats for a new pair.

Table 3. Descriptive statistics of municipal ice cleat programs for older adults based on a survey of 228 (out of 290) municipalities in Sweden.

	All programs (n = 73)	Below-average programs (reach <40.5%) (n = 29)	Programs above-average (reach >40.5%) (n = 44)
Free or to a discounted price (in percent)			
Free hand out	84.9	86.2	84.1
At a discounted price	6.9	6.9	6.8
"Free" in exchange for buying lunch/coffee	8.2	6.9	9.1
Communication strategy (in percent)[α]			
Traditional media	60.3	62.1	59.1
Social media	46.6	51.7	43.2
By mail	16.5	13.8	18.2
Personal communication	30.1	37.9	25
Other[β]	21.9	31	15.9
Average number of communication channels	1.75	1.96	1.61
Distribution points (in percent)			
Stores, pharmacies other businesses that provide ice cleats	23.3	17.2	27.3
Municipal owned buildings, like libraries or city halls	45.2	58.6	36.4
Pensioner organizations	4.1	10.3	-
Other locations[†]	27.4	13.8	36.4
Type of ice cleats (in percent)			
Whole foot devices	72.9	70.4	74.4
Heel devices	2.9	7.4	-
Forefoot devices	2.8	3.6	2.3
Unknown	8.6	3.7	11.6
Whole + Heel	2.7	-	4.6
User's choice	11.4	18.5	7
Eligible age-groups (in percent)			
65 years and older	84.9	89.7	81.8
70 years and older	9.6	3.5	13.6
75 years and older	4.1	6.9	2.3
80 years and older	1.4	-	2.3
Total number of eligible individuals	492 388	219 942	272 446
Total distributed pairs of ice cleats[ǂ]	217 572	32 719	184 853
Average distributed pairs of ice cleats	3 296.5 (8 838.2*)	1 128.2 (1 932.7*)	4 996 (11 464*)
Share of purchased ice cleats that were distributed (in percent)[§]	89.9 (19.9*)	89.9 (23.8*)	89.9 (17.1*)
Average program duration (in days)	836 (791.5*)	920.2 (904.3*)	779.2 (711.2)
Average reach of the targeted population in the municipality (in percent)	40.5 (24.6*)	17.7 (11.7*)	58.3 (15.5*)
Average cost per pair of ice cleats (in SEK)	62.4 (45.9*)	87 (56.9*)	46.6 (28.4*)

Notes: Survey data were collected between June to November 2019. Five municipalities were excluded as they distributed ice cleats to all citizens (all ages), which is beyond the scope of this study. Four municipalities distributed ice cleats before the region of Jönköping took over the distribution (the region consists a total of 13 municipalities), and their pre-region distribution data were excluded from the data in the table (reach to target population ranged between; 1.5% - 53%).

α = Percentages presented on these rows do not sum to 100% because the categories are not mutually exclusive.

β = Posters, brochures, senior organizations, meeting points for seniors, etc.

† = Fall-preventive weeks, senior meetings, health care centers, dedicated workshops, country stores, etc.

ǂ = Based on municipalities that reported the amount of distributed ice cleats (n=66).

§ = The relative reach is based on the municipalities that both reported their purchased amounts and distributed ice cleats (a total of 49 observations).

* = Std. Dev.

distributed whole-foot devices (72.9%), which is in line with previous preference studies that suggest that whole-foot and heel devices are the preferred types of ice cleats (Gard & Berggard, 2006; Gard & Lundborg, 2001; McKiernan, 2005).

Survey data shows an average of 0.51 [95% CI: 0.42, 0.59, median 0.45, Min-Max 0.01-1.12] ice cleats distributed per eligible citizen[9]. A total of 46 municipalities responded with program costs, which corresponds to SEK 62.4 per pair of ice cleats [95% CI: 48.8, 76.0, median 50, Min-Max 22.9-240]. The demand for the ice cleats were evidently high as 89.9% of all the purchased ones were picked up by the population.

Feedback from no-program municipalities

The electronic survey also provided input as to why municipalities do not introduce programs (n=57). There are several issues behind such a decision[10]. For example, it is not within the municipal responsibilities to distribute ice cleats (n=19), policymakers see that the money could be put elsewhere (n=13), they lack the monetary means (n=9), the political motion was rejected (n=9), ice cleat distribution programs lack scientific evidence (n=7), or municipal laws prohibit them from distributing ice cleats to a specific group of residents (the principle of equality (Kommunallag 2017:725)) (n=6).

The target audience about distribution programs

The interviewees identified themselves as an age group that is vulnerable to slips and falls on ice and snow. Despite this, they shared the perception that a sedentary lifestyle can have a negative effect on their health and well-being. While they welcome municipal distribution programs, they also shared the principle that ice cleats are not one-type-fits-all. Ultimately, it is the individual who chooses which type of ice cleats to use. The devices must be user-friendly, easy to apply and remove and have long durability (the cleats could wear down after two weeks of use). If not, sturdy shoes with good traction were an alternative.

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[9] This number is based on the 66 municipalities that provided data on the number of ice cleats that were purchased by the municipalities.
[10] Municipalities could report multiple reasons as to why they do not introduce programs.

Region Jönköping county

Before implementing the program, the region used staff to sample a selection of ice cleats before deciding to buy from a company that met their financial requirements. The Region Jönköping County did not have the monetary resources (a total budget of SEK 2.000.000) to purchase the number of ice cleats that could fully reach their targeted population (72.000 residents aged 65 years and older). Because of this, they restricted the distribution by targeting 57 percent of the audience (41.000 pair of devices). According to the region, they used anthropometric calculations, based on a normal distribution, of the residents' shoe sizes to estimate the diversity of ice cleat sizes. The region decided the best place for distribution was at the regional health care centers (about 50), at the same time as the target group voluntarily applied for influenza vaccination. In total, 36.000 cleats were distributed.

Before the program was activated, the shipment of ice cleats was stuck in customs, causing the region to delay its communication with the target audience. When the program was launched, they received mixed responses from population. For instance, some of the ice cleats were of wrong sizes, and the ice cleats were reported to come loose, especially when walking on asphalt.

Program theory analysis of ice cleat distribution programs

Program theory

There are important elements in a causal chain of processes that must be incorporated into the program for its successful implementation. This has been summarized and illustrated in the program theory model (Figure 5) using input from the municipal survey data, interviews, and relevant literature. The figure is divided into two halves, the top half shows the necessary conditions that are needed for a municipal program to have an effect on the target populations' health and well-being. The elements in the bottom half are not needed for the program to be implemented, however, they describe the conditions that can enhance and modify the programs' impact. The model is further divided into two parts, a *process theory* and an *impact theory*. This is summarized briefly in the sections below.

Process theory

The process theory contains the processes and services that must be incorporated into the program and carried out by program facilitators in order for the program to reach the right target group (Rossi m.fl., 2019). First, it includes efforts that require political support for programs to be implemented. Decision-makers ensure that resources are available such as funds, ice cleats, staff, set up plans, etc. for the program to move to the next phase of the implementation process. Secondly, the program sets forth in the next step which is for facilitators to execute *activities*. At this stage, it is about reaching out, creating awareness, and communicating with the target population about the municipal intervention. The expected effect of program activities is that the population has internalized the information they received and converted this into a behavior – a willingness to participate in the program intervention (Jenkins, 2003). Finally, in a later stage of the program, presented as outputs in the model, the behavior of the individual should lead to a decision by actively picking up a pair of ice cleats. The cleats should also be accessible to program recipients, meaning that locations for pick-up are easily attainable and result in a distribution to a meaningful proportion of the population.

Impact theory

The second part of the model, the impact theory, presents the expected long-term effects of the program, in other words, the cause-and-effect, should the program be implemented as intended (Rossi m.fl., 2019). The expected long-term result should result in a change in behavior, which, in addition to actively picking up a pair of ice cleats, should also manifest itself in increased use of ice cleats. The next step in the causal chain is to expect a decrease in fall injuries among ice cleat users. The impact of the programs should also lead to an increase in walking, which in the long term, should benefit health and well-being (Lee & Buchner, 2008; World Health Organization, 2011).

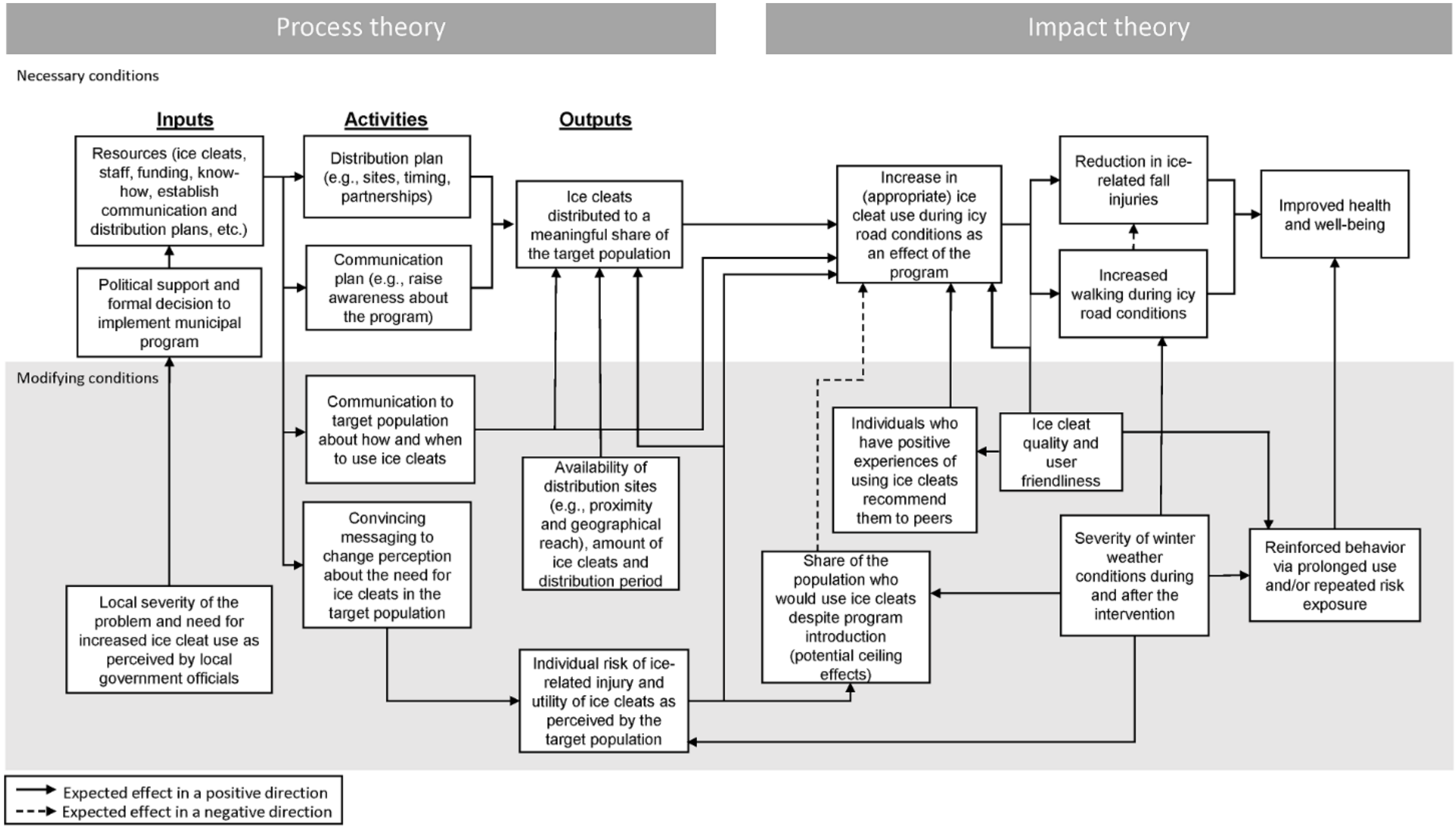

Figure 6. Program theory of a Swedish ice cleat distribution program. The figure highlights the process theory and impact theory of a successful distribution program. It illustrates the various prerequisites that must be met, and their causal processes, for a program to be implemented successfully. It also shows the expected long-term impact theory should the program be implemented as intended.

Study II

A total of 88.676 respondents participated in Statistics Sweden's cross-sectional survey data and were matched with the electronic municipal survey. This resulted in a match for residents living in 63 out of 73 municipalities who reported ice cleats programs. However, 25,442 respondents were excluded from the sample as they were residents of municipalities that did not participate in the electronic survey. The final sample used for analysis consisted of 63,234 participants, out of which 2,507 were classified as exposed to a program[11] as they met the age eligibility criteria for program distribution and 2,192 participants were used as negative controls (see Figure 6 for a summary of the selection process).

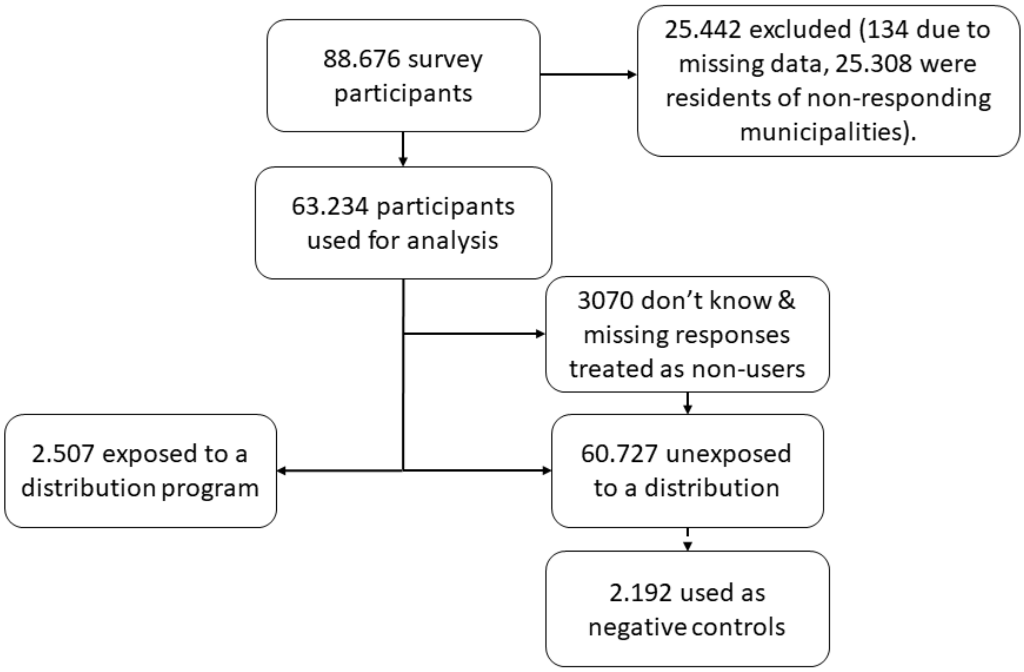

Figure 7. Flow chart of the selection process of the participants in Statistics Sweden's national survey matched with the municipal electronic survey. The participants are used to estimate the program effects on ice cleat use.

[11] The municipalities had different thresholds for residents to participate in the distribution programs (some had a minimum of 65 years, while others had a minimum age of 70, etc.), which was also taken into account in the analyses.

Descriptive statistics

Table 4 provide input to sample characteristics. It can be observed that the later survey waves indicate a higher number of individuals who were exposed, suggesting that the programs in question were implemented in more recent years. The highest prevalence of self-reported ice cleat use was observed among individuals aged 65 years and older who reside in municipalities where the distribution program was implemented (62.9%).

Table 4. Full sample characteristics by exposure to ice cleat distribution program.

	All ages	18-64 years			Negative controls*	65+ years			
	Entire sample	Entire sample	Unexposed to program	Exposed to program	Entire sample	Entire sample	Unexposed to program	Exposed to program	P-value
Sample size - n	63 234	45 328	25 117	20 211	2 192	17 906	15 366	2 507	
Age mean (SD)	52.0 (16.7)	44.4 (13.4)	44.6 (13.4)	44.3 (13.3)	57.3 (4.5)	71.1 (4.2)	71.1 (4.2)	71.5 (4.1)	<0.001
Women - %	53.1	53.7	53.8	53.7	53.3	51.5	51.8	50.3	0.17
Survey wave - %									<0.001
2007	18.0	19.7	18.7	20.6	0.2	14.0	16.2	0.3	
2010	29.3	31.3	31.9	30.6	3.8	24.4	27.7	4.1	
2014	28.3	27.4	28.1	26.5	9.2	30.8	34.5	8.0	
2018	24.3	21.7	21.2	22.4	86.9	30.8	21.6	87.6	
No post-secondary education	64.9	60.6	60.5	60.6	62.8	75.9	76.6	71.4	<0.001
Born in Sweden - %	86.3	85.6	86.2	84.9	87.1	88.1	87.7	90.3	<0.001
Ice cleat user, main† - %	29.5	20.0	21.6	18	32.4	53.5	51.9	62.9	<0.001
Ice cleat users, alternative‡ - %	34.0	24.3	26.1	22.1	33.0	58.4	57.6	63.7	<0.001

P-value for group differences in characteristics between exposed and unexposed respondents in the 65+ age group. Based on χ2 tests for categorical variables and t-tests for continuous variables.

* Negative controls (placebo) are those who are (i) 15 years below the eligible age limit for participating in the program and (ii) residing in a municipality that reported an ice cleat distribution program.

† Respondents who replied “sometimes”, “often”, or “always” use of ice cleats were classified as ice cleat users in this definition (survey years 2007 and 2010).

‡ Respondents who replied “rarely” or “very rarely” use of ice cleats were defined as ice cleat users in this definition (survey years 2007 and 2010).

The same age group displays a lowered use of ice cleats when living in no-program municipalities (51.9%). Individuals between the ages of

18-64 reveals a lack of widespread usage of ice cleats among respondents who reside in municipalities where the intervention is in place. The municipal average of distributed ice cleats per person was 0.38 (Min-Max: 0.01-1.09, SD 0.22, 95% CI: 37, 38.8)[12].

Linear probability model

Table 5 displays output of the regression on survey participators self-reported ice cleat use.

Table 5. Associations between ice cleat distribution programs and ice cleat use.

	Linear probability models		Sensitivity analyses		
	I: Age adjusted	II: Fully adjusted	III: Alternative outcome*	IV: Logistic regression	V: Negative controls †
Sample size	63.234	63.234	63.234	63.234	60.727
Exposed to program	0.106 (0.054 to 0.158)	0.075 (0.042 to 0.109)	0.066 (0.034 to 0.099)	0.044 (0.016 to 0.072)	-0.023 (-0.055 to 0.010)
Program reach ‡	0.269 (0.184 to 0.353)	0.173 (0.112 to 0.234)	0.149 (0.090 to 0.208)	0.103 (0.050 to 0.156)	-0.004 (-0.087 to 0.080)

Notes: All models, except for column I, were fully adjusted for place of birth (native, non-native), educational attainment (postsecondary education, no postsecondary education), sex, age (All groups are divided into 5-year groups, except for the age group 18–24 years.), survey and municipality fixed effects. Estimates in cells reflect probability differences in the proportion of ice cleat users between respondents exposed and eligible to a municipal ice cleat distribution program versus those who were not; 95% CI (clustered by municipality) are presented in parentheses. Coefficients from the logistic regression reflect marginal effects (ie, probability differences) estimated via the margins command in Stata. The exposed to program (primary exposure) and program reach (secondary exposure) were modelled separately. An examination of the independent variables was conducted to assess the presence of multicollinearity, and no significant correlation among independent variables was detected.

* Respondents who reported “rarely” and “very rarely” use of ice cleats were defined as regular ice cleat users in this definition.

† Analyses coding respondents between 15 years and 1 year under the age threshold for programmes as the ‘treated’ age group. Sample size is smaller because those who were actually exposed are excluded from the analysis.

‡Distributed ice cleat pairs per age-eligible citizen, coded as zero for unexposed respondents.

Self-reported ice cleat use was found to be 10.6% higher among individuals exposed to a program compared to those living in municipalities where the program was not implemented, after adjusting for age (Table 5). If one pair of ice cleats were distributed per citizen, then the model suggests an estimation that around 1 in 4 people would use ice cleats. When fully adjusted, the outcome is slightly diminished, to 7.5% and 17.3% respectively.

[12] This number reflect a dose response should distribution be continuous. Based on eligible citizens (n=2.507) living in 63 municipalities that reported distribution programs. Municipalities with greater number of observations provides more weight to the estimated average.

In the sensitivity analyses, the inclusion of respondents who self-reported infrequent use of ice cleats (i.e. "rarely" or "very rarely") into the model, suggests a lightly decreased rate of 6.6%. The conventional logistic regression analysis revealed somewhat weaker associations. An analysis of negative age groups (i.e. those who are 1-15 years below the eligibility age) revealed a lack of significant associations in relation to the use of ice cleats among individuals residing in municipalities where the program is in effect. This finding serves to further support the conclusions drawn from the primary analyses.

Subgroup analyses

Table 6 offers a more detailed examination of ice cleat use in relation to specific subgroup characteristics. The output depicted demonstrates that the confidence intervals for the probability difference overlap, making it difficult to determine any significant outcome measures.

Table 6. The table presents the proportion of respondents who reported using ice cleats among those who were exposed and unexposed to ice cleat distribution programs. It also provides the adjusted association between the programs and self-reported ice cleat use, as determined through the application of linear probability models.

Subgroup	**Ice cleat users, unexposed (65+ years)**	**Ice cleat users, exposed (65+ years)**	**Adjusted probability difference (exposed vs unexposed)**	**Sample size**
Age group				
65-69	0.471	0.546	0.034 (-0.024, 0.093)	7 255
70-74	0.541	0.650	0.053 (−0.006 to 0.112)	9 197
75-79	0.570	0.716	0.091 (0.025 to 0.157)	4 454
Sex				
Men	0.402	0.526	0.101 (0.057 to 0.145)	29 634
Women	0.628	0.732	0.053 (0.018 to 0.089)	33 600
Educational attainment				
Postsecondary education	0.553	0.644	0.065 (0.007 to 0.124)	22 190
Secondary education or lower	0.509	0.624	0.076 (0.042 to 0.109)	41 044
Place of birth				
Sweden	0.534	0.633	0.069 (0.034 to 0.104)	54 582
Other	0.417	0.597	0.109 (0.035 to 0.184)	8 652

Notes: Analyses were adjusted for place of birth (native, non-native), educational attainment (postsecondary education, no postsecondary education), sex, age (All groups are divided into 5-year groups, except for the age group 18–24 years.), survey and municipality fixed effects. Cluster-robust 95% CI (clustered by municipality) are presented in parentheses. The subgroups were modeled separately.

Nevertheless, certain patterns can be discerned from the point estimates. Specifically, it appears that ice cleat use increases with age, and men are more likely to use the devices after being exposed to a distribution program. Additionally, individuals born outside of Sweden show a stronger association with ice cleat use. The association seems to be similar in both types of educational attainment groups.

7 Discussion

The aim of this thesis was to analyze the design of municipal ice cleat distribution programs and to estimate the effects of program implementation on ice cleat use among older adults. These aims were achieved by performing process- and outcome evaluations with a focus on behavior change.

Paper I provides a comprehensive overview of the Swedish municipal ice cleat distribution initiatives. Multiple sources of data were gathered and used to construct a program theory model, as described by Rossi et al. (2019), which outlines the causal relationships within a hypothetical municipal ice cleat distribution program. To determine the success of these programs, an indicator of program reach was generated using the aggregated data on ice cleat distribution per eligible person. While a good program reach indicates successful implementation, the effectiveness of the programs is ultimately determined by the individual user and their utilization of ice cleats. Thus, paper II investigated this point further by assessing the outcome of the distribution programs on actual ice cleat use. To gauge the effect of the programs, an outcome evaluation was conducted to compare the self-reported ice cleat use of the target population in program versus non-program municipalities.

Program designs

The results from Study I shows that certain requirements had to be met for the implementation of ice cleat distribution programs. Obtaining political support was identified as a crucial factor that affected all municipalities and was fundamental in establishing a distribution program. Once this factor was addressed, the programs were customized according to the specific conditions of each municipality. These conditions may be influenced by factors such as resource allocation, financial investments, or program personnel responsible for implementing the intervention. Other factors, including communication strategies, distribution sites, program duration, etc., may also affect the program's scope.

Program reach

Despite differences in conditions among municipalities, the overall outcome of the programs' reach could be estimated. The results show that the municipalities, on average, were able to reach 40.5% of their target population, indicating a significant reach of the programs. In comparison, earlier studies on health campaigns show minor effects on target groups' behavior change when mass-mediated channels are used as campaigns to affect a target group's behavior (Snyder m.fl., 2004), and contemporary meta-analysis goes in line with these findings (5% adherence) (Anker m.fl., 2016). Our findings are not consistent with theirs, and one possible explanation for this difference is that our study participants self-identified as being at higher risk and therefore were more receptive to the intervention. Another factor could be that the distribution of cleats in the municipal programs was subsidized, most of them free (84.5%), which may have served as an incentive for participation.

When looking at the programs with lower reach, it is clear that they have 86.7% higher costs (SEK 87 versus SEK 46.6 per pair of ice cleats). Therefore, it becomes more important to take into account the demand for the ice cleats that were purchased as part of a comprehensive assessment of the distribution effects. According to the data, around 90% of the purchased ice cleats were eventually distributed, suggesting that the economic budget constraints may have limited the municipalities from reaching a wider audience.

Include beneficiaries when designing distribution programs

Behaviorists believe that modifying a particular health behavior requires an ongoing effort to engage the relevant community in the change effort (Jenkins, 2003). It is crucial to seek and incorporate their input in order to establish change. Policymakers should take the targeted population into consideration when creating distribution programs. The importance of involving the target group at an early stage before the implementation of the program cannot be emphasized enough. Such engagement is crucial in providing valuable insights to policymakers in creating an effectively designed program (Brandon m.fl., 1993; Rossi m.fl., 2019). Illustrative examples from the data can be provided to reinforce the point. For instance, in the case of Jönköping County, staff members were used for ice cleat sampling. A more effective approach would be to include the target individuals for testing and seek their feedback before ordering a large shipment of devices. This is not an isolated instance, with nearly 90% of all municipal programs determining the type of ice cleats eligible for recipients to receive. Data collected from interviews indicate that program recipients are often dissatisfied with the idea of others deciding what they wear when they go out. This suggests individual preferences should be respected.

Importance of user-friendly devices

Policy-makers should take into account the factor of the ice cleats' ease of use in their decision-making process. According to the results of the interviews conducted, user-friendly ice cleats are crucial for maintaining consistent use, as indicated by previous research studies (Gard & Lundborg, 2000; Gard m.fl., 2018). An ill-fitting ice cleat may negatively impact an individual's gait (Gard & Berggard, 2006), and reduce the likelihood of being used. It should be noted that a standardized type of ice cleats may not be favored by all, as personal preferences play a role in selection. Ultimately, the choice of the most appropriate type of ice cleats should be left to the discretion of each individual. Failure to consider this factor may result in recipients retrieve the cleats, but not used as intended.

Individuals' sense of free choice

Perhaps the design of distribution programs should consider offering multiple options of cleats to recipients at designated pickup sites, promoting a sense of free choice. One successful example is the municipality of Gothenburg which offered its inhabitants a selection between two alternatives of ice cleats (devices covering the heel or the whole foot) at no cost, leading to a successful reach with 62% of the intended demographic obtaining a set of the devices (Bonander & Holmberg, 2019). However, empirical data from the municipal survey challenge the effectiveness of such programs. The distribution rates in municipalities that allow for individual choice in ice cleat selection tend to have lower average participation compared to other program designs. Overall, only 11.4% of municipal programs adopted this approach. External factors like financial limitations or program duration may have contributed to the low outcomes. Nevertheless, no indications allowing beneficiaries to choose from a set of cleats resulted in an increased ice cleat use in the program municipalities.

Continued distribution

It is equally important to acknowledge that if a program limits individuals to acquiring only one pair of ice cleats during its operational time frame, then the occurrence of fall-related injuries may be limited to the wear and tear of the devices (Bonander & Holmberg, 2019). The matter of the durability of ice cleats is widely recognized as a subject of concern. Jönköping County received complaints about the durability of the devices, and similar complaints were documented in the municipal survey. This issue was stressed further as the interviews with the older adults also discussed this problem. If resources are available and the aspirations are high, perhaps decision-makers can seek influence from other program designs, as in the example of Västervik municipality. They offered the population a new pair of devices, in exchange for the old broken ones, which was reported to be appreciated among program recipients. Such an endeavour led to surpassing their target group (108.8% reach, or 1.08 ice cleat pairs distributed per targeted citizen). However, it is unknown whether such program designs are more effective at reducing fall-related incidences.

As noted earlier, the majority of municipalities offer ice cleats for free, which can be beneficial for those with limited financial resources. Nevertheless, there are differences in how the cleats are distributed, and the procedure used to promote and create awareness of the program can have a significant impact on its success. If the intended audience is not informed about the initiative, it may result in fewer cleats being distributed. To address this issue, distribution programs can be designed like the one in Gothenburg, where coupons were sent by mail to eligible individuals and showed high uptake (Bonander & Holmberg, 2019). This approach is supported by other research (Barat & Ye, 2015) which suggests that coupons can motivate people to actively seek out a desirable offer.

Program effects on ice cleat use

On average, the implemented programs distributed 0.38 ice cleats per person according to our municipal survey. As noted earlier, it is crucial to consider the demand for the purchased ice cleats as a more comprehensive approach to evaluating the distribution effects. The data indicate that roughly 90% of the purchased ice cleats were eventually distributed. Despite such outcome, it does not say anything about the cleats being used by the recipients. It has previously been noted that the frequency of ice cleat use is greater in high-risk groups even without intervention (Gustavsson m.fl., 2020), and exposure to ice and snow can work as a driver for individuals to apply ice cleats to their shoes. Thus, it is fair to question if the individuals who collected ice cleats during the municipal distribution efforts would have bought and used a pair anyway. Reassuringly, the results from Paper II show that eligible individuals living in municipalities with programs reported an average use of 62.9% compared to 51.9% among non-exposed individuals in the same age group. This constitutes an eleven percent difference, which provides the possibility that exposure to a program may increase ice cleat use. Although the programs' outcomes indicate an average increase of 7.5% in ice cleat use, the effectiveness of the programs was further reinforced by analyzing the negative control groups (Lipsitch m.fl., 2010). The analysis indicated no significant associations with ice cleat use, which adds to the credibility of the programs' effects. Zooming in on the sub-groups, it is apparent that the greatest increase (18%) is seen among participants born outside of Sweden, and people with lower education are recognized to increase their use (11.5%), which indicates that certain socio-economic groups can benefit more from such distribution programs. Although the analyses provide interesting results, they are not statistically significant.

Gustavsson et al. (2020) suggested that individuals residing in northern regions of Sweden have a higher tendency to use ice cleats compared to other demographics, possibly due to their prolonged exposure to winter conditions. Consequently, the impact of ice cleat distribution programs on ice cleat use in these areas may be limited by ceiling effects, as the number of users has already reached saturation. Municipalities should also recognize the importance of spreading user recommendations, as this seems to increase the likelihood of ice cleats being used, as indicated in a previous study by Berggård & Johansson (2010).

It is also relevant to recognize that individuals participating in the programs are more likely to be physically active, in good health, and capable of obtaining a set of ice cleats on their own. Thus, it can be assumed that a considerable portion of the demographic may choose not to participate due to health constraints. The demographic number unable to access the devices due to health considerations is unknown.

Cost-benefit analyses

There is an ongoing debate about whether the costs of ice cleat programs aimed at preventing fall injuries should be paid by municipalities or Swedish Regions. From a societal perspective, it is a trivial issue for citizens as both sources are funded by taxpayers' money. Our previous publication (Bonander m.fl., 2021) employs data from McKiernan's (2005) randomized controlled trial to estimate the costs of fall injuries (The Swedish Transport Administration, 2020). Although the estimates are based on only one randomized controlled trial with limited observations (McKiernan, 2005), the analysis yields some noteworthy findings. From a Swedish societal perspective, if one pair of ice cleats are distributed to the target group, the programs will be cost-beneficial if as little as 0.15% of the target population wears ice cleats that prevent fall injuries. To further reinforce this point, the National Board of Health and Welfare conducted similar cost-benefit analyses on ice cleat distribution (Socialstyrelsen, 2022b, 2022a), but with limited cost data, and found that regardless of the size of the municipality, the costs of implementing such programs are lower than the costs associated with fall injuries.

Strength and weaknesses

Adopting a mixed-methods approach has allowed for a broad spectrum of data collection (Creswell, 2009). Of the 290 intended municipalities, 231 participated in the survey, further supplemented by interviews with older adults about their perceptions of program designs. The data collection process was enhanced by incorporating cross-sectional data from four nationwide surveys that included a total of 88,676 participants. By matching this data with the electronic municipal survey, it became possible to identify participants who were either exposed or unexposed to the distribution programs, thereby enabling the estimation of program associations on ice cleat use. This extensive collection of data provided a thorough evaluation of the programs (Rossi m.fl., 2019; Weiss, 1998). This broad spectrum of data retrieval made it possible to create a program theory (logic model) of Swedish ice cleat distribution programs. To my understanding, this model is the first of its kind. However, a significant drawback of the program theory is that the process theory, which is a fundamental element of the model, is customized for the unique circumstances of each municipality. Consequently, developing a process theory that is universally applicable to all municipalities is challenging. Nevertheless, the theorized impact theory, with its expected outcomes, remains the same, regardless of the municipality's perspective.

Using an observational study approach ensured that the findings reflected real-world outcomes. Some segments of the intervention groups may not use the cleats, and the reasons for this can be unknown, but treatment dropouts are expected in large-scale populations (Armijo-Olivo m.fl., 2009). The outcome evaluation still provides estimates on ice cleat use in natural settings. We adjusted for multiple variables to mitigate bias in the outcome evaluation. Comparison with negative controls revealed that program exposure resulted in higher user rates of ice cleats, which helped to provide credibility to our findings.

Although we followed a thorough and extensive data collection procedure, there is still uncertainty about the reliability of the data. Given the conditions we encountered, the studies presented in the thesis may be subject to bias. It is crucial to note that the accuracy of the collected data relies heavily on survey respondents reporting their data correctly (Bauhoff, 2011; King & Bruner, 2000). We relied on self-reports of ice cleats use for our findings, both in Statistics Sweden's survey and the municipal survey. A potential issue with the municipal survey is that respondents often provided estimates for critical program details. They reported that the individuals responsible for program implementation had either left their positions or changed roles, indicating that the municipalities may have inadequate documentation records, and correct program details may still be unknown. While we made significant efforts to scrutinize the data from municipalities through surveys and internet searches, there is still a possibility that some existing or past programs may have been missed. While the self-reported data on ice cleat use that we obtained from Statistics Sweden's nationwide survey may be subject to bias (King & Bruner, 2000), I find it highly unlikely given that the variable was collected in a larger context where respondents were asked about their perceptions of safety and security. It is unclear if the survey respondents participated in all four survey waves as the data provided to us was aggregated at the municipal level. Therefore, we were unable to match the survey data with individual participants. While we cannot establish direct causal effects, the data enabled us to estimate program effects on ice cleat use.

There are also risks of bias in the sampling process of focus-group interviews, and it is suggested that the research team or an independent party should conduct the sampling process to minimize such bias (Krueger & Casey, 2014). However, in our study, we did not interfere with the recruitment process and allowed the groups to recruit participants on their own, which may have resulted in intentional or unintentional exclusion of certain individuals or groups, thereby contributing to sample bias. Despite our attempts to approach and assess the transcribed material independently and without bias or prior experience (Graneheim & Lundman, 2004; Bengtsson, 2016), the analysis of such material will inevitably be subject to some degree of bias (Krueger & Casey, 2014). The data collected from the focus-group interviews should not be extrapolated to a broader population, and additional data collection is required to support any generalizations.

Closing reflections

A crucial step in the objective to successfully distribute ice cleats is to raise awareness of the intervention and motivate the audience to participate in the program. I often refer to the Gothenburg case study (Bonander & Holmberg, 2019) as a successful example. To encourage the target population to participate in the intervention, they generated interest by sending the audience a personalized coupon informing them about the program and offering them a pair of free ice cleats. Their procedure is supported by a meta-analysis that shows that lucrative coupon offers can motivate people to seek out attractive offers (Barat & Ye, 2015), which I believe is the critical first step in encouraging a significant audience to use ice cleats. Providing clear information to users is also crucial to ensure proper usage of the cleats. A distribution program is more likely to be successful if the ice cleats are easily accessible and close enough for the beneficiaries to retrieve. The ideal program, although challenging to attain, should have no financial limitations, making it possible for the facilitators to replenish their inventory continuously. That way people can discard old broken ones for a new pair. As emphasized by our interviewees and supported by prior research (Gard m.fl., 2018; Gard & Lundborg, 2001; Gard & Berggard, 2006; Gard m.fl., 2018), the crucial factor for utilizing ice cleats and maintaining their use is the devices' user-friendliness. People also have different walking patterns, which suggests that distributing one type of ice cleat does not suit everyone. Instead, I suggest letting the audience choose from a variety of options.

8 Conclusions

A well-designed distribution program can increase ice cleat use among older adults in a Swedish municipal context. While more work is needed to fully understand the optimal design and impacts of ice cleat distribution programs, the experiences documented in this thesis suggest that they can be a good complement to conventional strategies for reducing ice-related injuries.

Future research

This thesis provides valuable insights that can aid future interpretations and estimations of the effects of ice-related fall injuries. Ice cleats used on a large scale of people may reduce fall-related injuries, but further research is needed to confirm this.

There are still unknown aspects regarding facilitators and policymakers of these programs, as well as the individuals exposed to and participating in them. More in-depth interviews with parties residing in different locations in Sweden could provide nuanced insights into individual perceptions of program designs (Robson m.fl., 2001). Such an approach can also identify unintended outcomes and contribute to recommendations for the design of future subsidy programs. Perhaps combining ice cleat distribution programs with heated roads (Öberg, 2011; Öberg m.fl., 1996) could be an effective strategy to prevent fall-related injuries on ice and snow. The outcome of the latter has been suggested to be investigated further (Amin m.fl., 2022).

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After dipping my toes into program evaluation, my perspective has broadened, and I have come to appreciate the importance of incorporating mixed-methods approaches in research. Without program evaluation, we would not be able to determine the impact of our work and make data-driven decisions. It is a fascinating and rewarding field, and there is a certain thrill in uncovering insights and trends from complex data sets, connecting the dots, and seeing the big picture. I believe that program evaluation provides an opportunity to make a real difference in people's everyday lives. By evaluating programs and interventions, we can ensure that resources are allocated effectively and look closer into whether programs achieve their intended outcomes. The information provided through evaluation is used as a basis for future decisions, and it plays a vital role in driving positive change and making our world a better place. I believe program evaluation is a crucial and rewarding field that deserves more recognition and appreciation. This experience has been invaluable in expanding my understanding of evaluation methods, and I am deeply grateful for it.

During this time, I faced personal challenges that tested my resilience. Alone and distanced from others, I struggled with feelings of worthlessness and despair that do the opposite of bolstering one's creativity. A quality trait that I believe defines a good researcher from another. Fortunately, I was able to lean on the shoulders of giants. For that, I am grateful. So thank you, Carl Bonander and Johanna Gustavsson, for being that quality and your time and effort supervising my work. Johanna, I feel privileged to have had the opportunity to witness your equilibristic skills in conducting interviews. I was impressed by your ability to effortlessly guide the discussions in the right direction and maintain a delicate balance throughout. Carl, I do not doubt that you are one of the most brilliant minds in our field. Your visionary thinking and sharp analytical skills are unmatched by others. Thank you for your unwavering commitment to excellence in your mentorship.

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Evaluation of Swedish Ice Cleat Distribution Programs

Several Swedish municipalities have introduced subsidized ice cleat distribution programs to combat the risk of fall-related injuries on icy or snowy surfaces, especially among older adults aged 65 and above. Using a mixed-method approach and data collected from multiple sources, the thesis evaluates the effectiveness of these programs. The thesis presents a program theory model outlining the components required for implementing a program and its anticipated impact. Survey data from intervention municipalities show that 40% of the target group participated in the programs by retrieving a pair of devices, and 90% of all ice cleats were distributed. The outcome evaluation suggests that exposure to a distribution program increases ice cleat use by 7.5 percentage points. If one pair of cleats were distributed to all eligible citizens, about 17.3% would use the devices. The thesis calls for future research to investigate the programs' effect on fall-related injuries and suggests in-depth interviews with program policymakers to provide further insights into the design and implementation of these programs.

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