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EPIDEMIOLOGY AND PREVENTION OF DROWNING IN NORTHERN IRAN: A COMMUNITY BASED PROGRAM

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ABSTRACT

Background: Drowning in developing countries is a major, but often neglected, public health problem. However, due to a lack of reliable or statistical data concerning the impact of drowning in Iran, the need for drowning-prevention measures has not been recognized. The prevention of drowning requires adequate knowledge of its epidemiological characteristics and associated risk factors, and effective interventions.

Aim: The overall aim of this thesis is to analyze the magnitude and burden of drowning events, using both epidemiological and economic studies, and to evaluate the feasibility of a drowning intervention package in northern Iran.

Material and methods: The geographical range of the studies mainly encompassed water-recreation areas near the Caspian Sea in northern Iran. The main focus of the studies was on describing factors associated with drowning among residents and tourists in northern Iran from 2005/6 through to 2008/9. Four studies were undertaken. The incidence of drowning fatalities in northern Iran was investigated in a cross-sectional household survey. Age group, gender, place and date of occurrence, and external causes were assessed (Paper I). A capture-recapture analysis was performed to estimate the incidence of drowning using two data registries (Paper II). The costs of drowning were assessed on the basis of case studies in northern Iran. The main cost elements were income, as adjusted by family and years, income impact on the family, and cost of treatment (Paper III). A quasi-experimental design was used to evaluate the feasibility of an intervention package, including pre- and post-observations, in both an intervention and a comparison community, in a water-recreation area by the Caspian Sea in northern Iran and in a residential population near the Caspian Sea coastline. Cross-sectional data were collected at pre-intervention and post-intervention in the study areas (Paper IV). Data for the four studies were derived from Iran's Death Registry System and Forensic Medicine System, national weekly reports, household surveys, and focus group discussions.

Results: During the first year of investigation, 342 unintentional drowning deaths (4.24 per 100,000 residential population) occurred in the study area. More than one-third of all victims were under the age of 20, and the male-female risk ratio was 6.4:1 (Paper I). The capture-recapture method estimated that the Forensic Medicine System covered 54% of cases, and the Death Registry System 70% (Paper II). When additional information was considered, the estimated economic burden increased dramatically. In fact, the drowning cost of one drowned victim was equivalent to 17 times the country's per-capita gross domestic product (Paper III). The risk of death from drowning was observed to be greater during the pre-intervention period than during the implementation period (OR= 1.15 versus 0.24) in a water-recreation area by the Caspian Sea in northern Iran. The fatal drowning rate in the studied resident population, in two provinces, fell from 4.24 per 100,000 residents at baseline to 3.04 per 100,000 residents at endline. Drowning rates for tourists could not be computed since denominator data were incomplete. The knowledge and practice of drowning prevention in the resident population increased from 22% at baseline to 35% at endline. Overall, the all-risk factors associated with drowning incidents declined to a greater extent in the intervention area than in the control area (Paper IV).

Conclusions: The intervention package, developed through research, was found to be feasible in the community considered. However, we need a longer time interval for impact analysis, and adjustment for seasonal variation, to be able fully to evaluate the effectiveness of the intervention. We also need to test the package in other, similar communities before we can recommend spread of the package. Further studies are needed to provide a standard instrument for drowning prevention.

Keywords: Drowning, prevention, cost, capture-recapture method, evaluation, Iran.

LIST OF PUBLICATIONS

- I. Davoudi- Kiakalayeh A, Mohammadi R, Stark- Ekman D, Yousefzade Chabok S, Jansson B. Unintentional drowning in northern Iran: A population-based study. *Accident Analysis and Prevention* 2008; 40:1977-1981.
- II. Davoudi-Kiakalayeh A, Mohammadi R, Stark- Ekman D, Yousefzade - Chabok S, Behboudi F, Jansson B. Estimating drowning deaths in Northern Iran using capture-recapture method. *Health Policy* 2011; 100(2-3): 290-296.
- III. Davoudi-Kiakalayeh A, Dalal K, Yousefzade- Chabok S, Jansson B, Mohammadi R. Costs related to drowning and near-drowning in northern Iran (Guilan province). *Ocean and Coastal Management* 2011; 54: 250-255.
- IV. Davoudi-Kiakalayeh A, Mohammadi R, Yousefzade- Chabok S, Jansson B. The implementation of a community based drowning prevention program in northern Iran (submitted).

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LIST OF ABBREVIATIONS

AAOPC	American Academy of Pediatrics Committee
AAOPCSM	American Academy of Pediatrics Committee on Sports Medicine
CPAP	Continual Positive Airway Pressure
CDC	Centers for Disease Control and Prevention
CPR	Cardio Pulmonary Resuscitation
CPS	Canadian Pediatric Society
CR	Conference Report
CRCS	Canadian Red Cross Society
DRS	Death Registry System
FMS	Forensic Medicine System
GBD	Global Burden of Disease
HIC	High Income Countries
IAFY	Income Adjusted by Family and Years
ICD	International Classification of Diseases
IDDO	Income adjusted by family and years, Deprivation costs, Death costs, Other costs
IIF	Income Impact on the Family
Intergov-WA	Intergovernmental Working Party on Swimming Pool Safety
LMIC	Low and Middle Income Countries
LMO	Legal Medicine Organization (Iran)
LS	Lifesaving Society
MOHME	Ministry of Health and Medical Education
PFD	Personal Flotation Device
PHC	primary health care
SCOI	Statistical Center of Iran
USCG	United States Coast Guard
WHO	World Health Organization

1 INTRODUCTION

Drowning is a serious public health problem. A recent Global Burden of Disease (GBD) study reveals global mortality from drowning to be 7% of all injury-related deaths (WHO, 2010). Drowning affects all age groups, but over half of the global mortality is among children less than 15 years of age. Overall, the majority of all deaths from drowning (98%) occur in low and middle income countries (Peden et al., 2008). However, information on the magnitude of and risk factors for drowning in these countries is lacking. Therefore, policy-makers do not recognize it as a public health problem in these countries (Rahman et al., 2010; Naghavi, 2004).

In Iran, in 2001, the mortality rate due to drowning was 2.6/100,000 population, with wide variations (range = 0.9-4.1 per 100,000 population) among Iran's 30 provinces (Naghavi, 2002). Reliable information on the incidence and nature of drowning is generally unavailable in Iran, due to a lack of accuracy in reporting and the extent of under-reporting. Therefore, it is important to validate and select adequate data sources for drowning research, and also calculate the economic burden of drowning on society as a basis for developing policy making and effective intervention strategies (Soori and Naghavi, 1999; Akbari et al., 2006).

The studies in the framework of this thesis describe the risk factors associated with the cases of drowning that took place in northern Iran during the years 2005/6 to 2008/9. All natural bodies of water were considered. The presence of strong undertow, clip currents and occasional high-wave action in the Caspian Sea creates hazards for even the strongest swimmers in this location. It is reasonable to assume that people who participate in activities on natural bodies of water in northern Iran will be at risk of drowning.

The various drowning-prevention measures, including pool fencing (Fergusson and Horwood, 1984), parental education (Coffman, 1991), close supervision by parents or lifeguards (Lassman, 2002; Avramidis, 2009), and cardiopulmonary resuscitation (American Academy of Pediatrics Committee, 2000), that have been implemented in high income countries may be applicable to low and middle income countries like Iran. Parental education and close supervision by parents have already been examined in rural settings in low and middle income countries, such as Bangladesh and China (Rahman et al., 2010; Ya et al., 2007).

This thesis presents a drowning prevention program for residents and visitors in northern Iran, based on the analysis of risk factors and the economic burden imposed by drowning on society. An evaluation of Iran's registry systems was also included. At the final phase, the information obtained was used to design, implement and evaluate a prevention package on drowning.

2 BACKGROUND

2.1 Drowning as a global injury problem

Injuries due to traffic crashes, drowning, violence, falls and burns are responsible for 9% of all deaths and 16% of all morbidity in the world (WHO, 2008).

Drowning incidents have been reported since ancient times in many places (Avramidis, 2005). They are an important cause of death in many countries. In 2002, an estimated 376,000 people drowned worldwide, making drowning the third leading cause of unintentional injury death globally after road traffic injuries and falls. Global Burden of Disease (GBD) figures underestimate all drowning deaths, since they exclude drowning in floods (cataclysms), boating and water transport. Also, drowning statistics are based on hospital records and, if non-hospital records were included, the global rate would be higher (Connolly, 2008). Further, under-reporting has been identified in the USA, Australia, and China (Passmore et al., 2007; Ya et.al., 2007). Such under-reporting means that drowning is one of the leading causes of death among cases of fatality where the manner of death remains undetermined in official registry systems (Lunetta et al., 2003). The vast majority (approximately 98%) of all drowning deaths occur in low and middle income countries (WHO, 2008). Table 1 shows estimates of drowning fatalities in different regions, as reported by WHO in 2004. Drowning is the leading cause of unintentional death in the rural areas of countries like Sri Lanka, China and Bangladesh (Barss et al., 1998).

Table 1: Numbers of cases and rates of drowning in the WHO regions: estimates for 2004 (WHO, 2008).

Region	Total deaths	Rate(per 100,000 population)
Africa: LMIC *	62,000	4.8
Americas: HIC **	4,000	1.2
Americas: LMIC *	19,000	3.5
South-east Asia: LMIC*	100,000	6
Europe: HIC**	4,000	1
Europe: LMIC *	30,000	6.3
Eastern Mediterranean: HIC**	2,000	6.4
Eastern Mediterranean: LMIC*	28,000	5.7
Western Pacific: HIC **	7,000	3.4
Western Pacific: MIC*	132,000	8.6
Total	388,000	6

* LMIC: Low and Middle Income Countries

** HIC: High Income Countries

Location of drowning and type of body of water in which this type of injury occurs also play an important role in injury outcome. For example, in Japan, bathtubs are the major source of accidental drowning, especially among young children and older adults (Warneke and Cooper, 1994; Mizuta et al., 1993). By contrast, in developing countries,

drowning events are associated with ponds, rivers and dams (Riley et al., 1996). Other studies have shown that unfenced bodies of water, lack of supervision of children, and lack of awareness of drowning risks on the part of parents are common risk factors for drowning among young children (Liller et al., 1993).

Social patterning in drowning injury risk is also a complex phenomenon. It often involves factors like education, occupation, income and sociocultural milieu. For example, in many recreational activities, such as boating or fishing, participants should be able to buy or rent the necessary equipment. Level of education is used in many studies as a proxy for social background in order to assess socioeconomic differentials in injury risk. Although the existing data are somewhat controversial, there is evidence to suggest that a higher level of parents' education engenders a higher level of awareness of the environmental risks faced by their children. Therefore, one should always consider the influence that the socioeconomic triangle – education, occupation, income – exerts on the quality of parental supervision, and hence drowning risk during childhood (Tiikkaja et al., 2009). Sociocultural milieu is important in explaining post-traumatic stress symptoms among victims' families.

2.1.1 Definitions and types of drowning

In the past, the pathophysiology process of drowning was described in terms of aspiration; cases of drawing liquid into the lungs were referred to as “wet drowning”, while cases where this did not apply were referred to as “dry drowning”. “Active drowning” refers to the victim making some kind of motion, while the terms “passive drowning” and “silent drowning” have been used when the victim is found motionless in water and no-one has seen the victim enter the water. The term “secondary drowning” has been used to describe unrelated events, e.g., seizure, cervical spine injury or heart attack, that result in the victim's submersion and subsequent drowning (Modell et al., 1999; Lunetta et al., 2004; Centers for Disease Control and Prevention, 2004). “Immersion is the involuntary entry of a person into a body of water while submersion occurs if the person comes to lie under the water surface. Therefore, submersion occurs after a period of immersion” (Bierens et al., 1995, p. 40).

However, drowning was finally defined in 2002 by the World Congress of Drowning as follows: “Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid. Furthermore, drowning outcomes should be classified as: death, morbidity, and no morbidity” (Idris et al., 2003). Drowning events should be assessed against the outcomes of the injuries incurred. Classification of outcomes can be into death or survival, and the quality of survival should also be ascertained for people who experience such events. Only through the use of classification systems and rigorous evaluation will we be able to identify the effects of prevention measures on the burden of drowning.

2.1.2 Pathophysiology of drowning

The drowning phenomenon has been divided into different stages by many authors. The main etiologic for physiological derangements in the drowning process is anoxia, where the victim's airway lies below the surface of the liquid; water is introduced into the back of the oropharynx and larynx, which results in laryngospasm, at which point the victim is unable to breath gas. This results in oxygen being depleted and carbon

dioxide not being eliminated. The victim then becomes hypercarbic, hypoxemic and acidotic (Modell et al., 1966). During this time, the victim's respiratory movements may become very active, but there is no exchange of air due to the obstruction at the level of the larynx. When the victim's arterial oxygen tension drops further, laryngospasm abates, and the victim actively breathes liquid. As a result of this anoxic insult, the victim loses consciousness and becomes submerged, and further anoxia ensues (Miller, 2000; Modell et al., 1976; 1967; Halmagyi and Colebatch, 1961). This is known as "wet drowning". In other cases, 10-20% muscular relaxation does not occur. The victim remains unconscious and anoxia continues, but the laryngospasm persists and water does not enter the lungs. This form of submersion injury is known as "dry drowning". Also, there are difference in the mechanisms of drowning according to whether fresh water or salt water is involved (Modell et al., 1976; 1967; Halmagyi and Colebatch, 1961).

2.2 INJURY PREVENTION STRATEGIES

Different injury prevention strategies can be applied in drowning prevention programs. First, the public health approach is helpful in determining the magnitude and characteristics of injuries and in providing analysis of the risk factors that can guide decision-making throughout the entire process, i.e., from identifying a problem to implementing an intervention (Elvik and Vaa, 2004). Another approach involves the so-called "3 Es". It has three components: 1) Enforcement of safety regulations, 2) Education and training for at-risk groups, and 3) Engineering (which is sometimes partnered by Environmental control). The literature assessing the relative importance of education, enforcement, and engineering on injury prevention programs stresses, however, that no single approach can in itself be regarded as effective (Carlson-Gielen and Girasek, 2001; Segui-Gomez and Baker, 2003).

The Haddon matrix provides a compelling framework for better understanding of the origins of injury. Risk factors can be identified before, during and after events. At the pre-event phase, all factors that might prevent event occurrence are identified, and then associated with the countermeasures that might prevent injury from occurring and reduce its severity if it should occur. Finally, the post-event phase involves all the activities that might reduce the severity and adversity of outcome of the event after it has occurred. The model has also generated ten suggested strategies for injury prevention: eliminate, separate, isolate and modify the hazards, supervision, rescue, repair, warn, train and instruct (Haddon et al., 1964). In Table 2, we apply Haddon's framework to the case of drowning in northern Iran.

Table 2: Potential interventions for the prevention of drowning in northern Iran on the basis of the Haddon model.

Time frame	Focus	Intervention
Pre-event	Community Child Non-protected area bu the Caspian Sea River, lake	Campaign, drowning vigilance Swimming skill, education Lifeguard service Fencing, grill
Event	Not clear	Future study
Post-event	Community, Health system, Red Crescent Society	Resuscitation skills, Drowning management

Finally, a safety promotion approach can focus on developing optimal quality of life. This can be defined as “a process that aims to ensure the presence, and maintain the conditions, that are necessary to reach and sustain an optimal level of safety”. Safety promotion also relies on a multiplicity of activities, including regulatory processes, community-based programming, and ongoing surveillance (Svanström et al., 2004; Mohammadi et al., 2006).

2.3 DROWNING IN IRAN

Like many other middle income countries, Iran is currently passing through an epidemiological transition, where communicable diseases have begun to decline, but, on the other hand, non-communicable diseases and other factors are now appearing as major causes of deaths (Naghavi, 2002). For the population as a whole, the primary causes of mortality in Iran are cardiovascular disease, unintentional injury, and cancer. The most common injury-related deaths in Iran are due to road traffic injury, followed by burns and falls, but in northern Iran, drowning is the second leading cause of injury-related death (Naghavi, 2002). There is a lack of statistical data on the impact of drowning in Iran (Soori and Naghavi, 1999; Akbari et al., 2006).

In Iran, from March 2001 to March 2002 (a period coinciding with the Iranian calendar year), the mortality rate due to drowning ranged between 0.9 to 4.1 per 100,000 population (average 2.6 per 100,000 population), with wide variations among Iran’s 30 provinces (Naghavi, 2002; 2004). Iran is a vast country, and has different climates. There is desert in central Iran, and there are mountainous areas in the west and north-west; the climate varies between arid and semi-arid in the south and the Caspian climate in the north. Access to the sea and water bodies in the north and south of the country is greater than in other areas. Therefore, we expected to see the highest incident rates of drowning in particular areas. Central Iran has the lowest rate of drowning, which is due to the desert climate and less exposure in that part of the country.

Figure 1 shows the drowning rate per 100,000 population-year in the whole country by Iranian calendar year. The highest rate per 100,000 population-year was seen in 2005/6 (3.1 cases per 100,000 population), and the lowest rate in 2002/3 (2.4 cases per 100,000 population). There is no evidence showing why the trend is upwards, but one possible reason is that data collection was improving during the period in question.

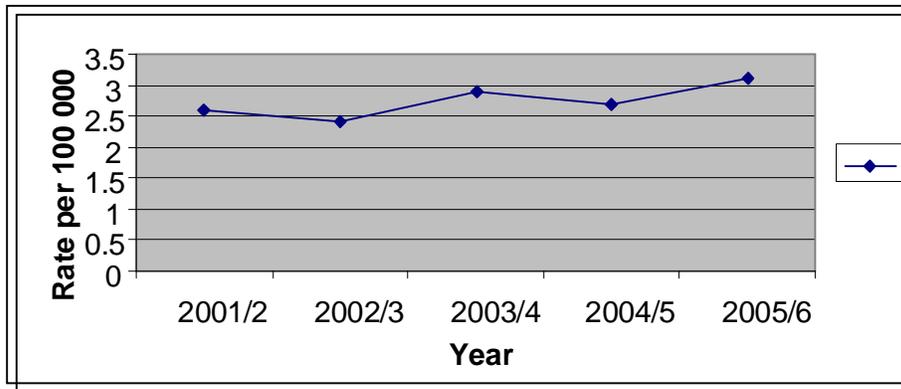


Figure 1: Trend in average rate of drowning in Iran by year (2001/2-2005/6), from Naghavi, 2004 and Legal Medicine Organization, 2011.

Drowning events in northern Iran are more prevalent in the unprotected areas by the Caspian Sea, where emergency services are not readily available (Kiakalayeh et al., 2008). For some victims of fatal drowning events, additional underlying medical problems may contribute to the drowning episodes, particularly among older victims (Smith et al., 1991). Drowning is a multifaceted and complex event that varies widely in relation to age and location. It is clear that prevention is the only means to reduce drowning mortality.

2.4 LITERATURE REVIEW

A literature review was performed by searching MEDLINE, Pub Med, Sport Discus and Social Sciences Full Text and the Cochrane Database (from 1940-2009/01), with the aim of identifying drowning prevention programs. The key words included were risk factors for drowning, drowning prevention, drowning and near-drowning. These terms were searched in all fields of publication (e.g., title, abstract, and key words). Several websites relevant to drowning were searched: the Centers for Disease Control's National Center for Injury Prevention and Control, www.cdc.gov/ncipc), Safe Kids Canada, www.safekidscanada.ca, the World Health Organization, and various international injury prevention centers. The search identified over 6,500 articles initially, and 1,700 of these publications were selected on the basis of title screening. The abstracts of these 1,700 publications were screened for relevance. The inclusion criterion was that the article discussed risk factors or intervention in the field of drowning. Overall, 39 papers were identified that discussed risk factors associated with drowning, and 27 that discussed interventions related to drowning prevention. These 66 articles were reviewed critically using a standard review form. The results of the review are presented below.

2.4.1 Risk factors for drowning

2.4.1.1 Age

A large number of studies have shown different patterns of drowning in accordance with age. Among the various age groups, children under 5 years of age have the highest drowning mortality rates worldwide (Li and Baker, 1991; Coffman, 1991; Myntti et al., 1991; Centers for Disease Control and Prevention, 1990; Weinstein and Krieger, 1996). A review by the World Health Organization indicated that drowning is the leading cause of child death in many countries in the western Pacific and in some countries in south-east Asia (WHO, 2008). Recent research studies in Asia have also shown that drowning is the leading cause of injury death among children aged 1-14 years in China and in Bangladesh, and that 20% of all deaths among children aged 1-4 years are due to drowning (WHO, 2008). Other studies have emphasized that locations of drowning as a risk factor vary by age group; bathtubs and buckets have been the most common places of drowning for infants, while older children are more likely to drown in fresh bodies of waters. Children aged 1 to 4 years are most likely to drown in swimming pools, whereas over the age of 5 years the most likely sites are natural freshwaters, such as rivers and lakes (Brenner et al., 2001; Canadian Red Cross Society, 1994; Centers for Disease Control and Prevention, 2003).

2.4.1.2 Pre-existing disease

Underlying diseases, such as heart failure among adults and epilepsy among children, have been reported as contributing factors in relation to drowning (Centers for Disease Control and Prevention, 2003; Jansson and Ahmed, 2002).

2.4.1.3 Gender

Males drown more often than females. This is generally attributed to higher exposure to the aquatic environment and a higher consumption of alcohol (leading to decreased ability to cope and impaired judgment), and to a disposition among males towards higher risk-taking activities (Howland et al., 1996). Several studies have documented that the drowning rate is significantly higher for males than for females (Lifesaving Society, 2000, 2003; Canadian Red Cross Society, 2002; Ellis and Trent, 1997). Iran shows a similar pattern regarding the gender of victims (Naghavi, 2004). Although males are less likely to use a personal flotation device (PFD) (Nykolshyn et al., 2003; Quan et al., 1998), consuming alcohol, falling into a body of water, diving into shallow water were identified as risk factors for drowning, especially among males aged 15-64 years (WHO, 2004). In Iran, the high-risk group consists of young males, and therefore prevention activities can be prioritized for that target group.

2.4.1.4 Swimming ability

One prevention strategy that may be beneficial for persons of all ages and under nearly all circumstances consists in the promotion of swimming ability, through some form of

swimming instruction. Although data are limited, the available evidence suggests that many drowning victims are able to swim (Barss, 2000; Waller, 1985; Schmidt, 1999; Patrick et al., 1979; Hassall, 1989). Recent studies have shown that swimming lessons do not protect against drowning, especially among children under 4 years of age (Canadian Pediatric Society, 2003; American Academy of Pediatrics Committee, 2000). That good swimmers are not immune to drowning is shown by the presence of a subset of swimmers in the drowning statistics every year (Canadian Red Cross Society, 1996). Although non-swimmers or poor swimmers make up a high proportion of the persons who drown (Spyker, 1985), there is no well-grounded evidence that swimming skills have a role to play in preventing drowning and near-drowning (Asher et al., 1995; Brenner, 2005). However, swimming ability is considered as an important factor in drowning prevention in Iran. The Ministry of Education has started planning for swimming lessons in elementary schools in some pilot areas.

2.4.1.5 Alcohol

The World Health Organization (WHO) states that alcohol consumption prior to swimming is a major risk factor for drowning among older children and adults in many countries (WHO, 2004). One study reported that high temperatures (above 40 °C) in spas, especially in combination with alcohol consumption, may cause unconsciousness and, consequently, drowning (Press, 1991). Alcohol is prohibited in Iran under Islamic Law, except for non-Muslims who can legally consume alcoholic beverages in private. Therefore, it is hard to consider level of alcohol consumption in an intervention program in Iran.

2.4.1.6 Lack of supervision

When children drown, it is often the result of a lack of supervision or of brief supervisor distraction. The WHO states that a lapse in adult supervision is the largest contributor to child drowning (WHO, 2004). Parents may find a substitute for sibling supervision, which is known to be inadequate. One study found that all cases of bathtub drowning among children less than 5 years of age were associated with supervision by a sibling less than 7 years of age (Jensen et al., 1992). Areas without lifeguards are also associated with higher drowning rates.

A Center for Disease Control and prevention report states that trained, professional lifeguards have positively influenced drowning prevention in the USA (Branche et al., 2001). Findings from our first study (Kialalayeh et al., 2008) of drowning prevention programs supports the view that lack of adequate supervision is strongly associated with drowning in the study area, especially among pre-school (the youngest) children.

2.4.1.7 Swimming in unprotected areas

The absence of adequate fencing surrounding swimming pools, rivers, lakes, dams, canals and other waterways is the main contributing factor in drowning (Pearn et al., 1976). The unprotected areas of the Caspian Sea present similar drowning risks.

2.4.2 Interventions

While the literature review pointed to many methods for preventing drowning that have been adopted around the world, the main measures may be broadly divided into: supervision, environmental design changes, legislation, swimming lessons, and aquatic safety education. Most of these measures have been implemented in high income countries. Overall, 27 papers that discussed interventions related to drowning prevention were identified.

2.4.2.1 *Adult supervision*

Recent studies show that victims supervised by lifeguards have a lower case fatality rate, particularly where there is constant, physical proximity in relation to visual or auditory cues (Lassman, 2002; Morrongiello and House, 2004). In cases of bathtub drowning during incidents of adult supervision (Fenner, 2000), there is usually a pattern of leaving the infant unattended or with another child (such as a sibling). Some researchers have concluded that adult supervision of public swimming areas may be associated with injury reduction (Towner et al., 2001; Canadian Pediatric Society, 2003). One study in Iran has shown that lack of adequate supervision by parents is associated with drowning in rural settings (Naghavi, 2002). Our first study (Kiakalayeh et al., 2008) also shows that drowning among children is associated with lack of parental supervision.

2.4.2.2 *Lifeguard supervision*

The United States Lifeguards Association (USLA) has reported that more than three-quarters of deaths by drowning occurred in areas where beaches were unguarded (Branche et al., 2001). Recent studies in Brazil and Singapore showed the presence of the lifeguard as being a fundamental factor in the prevention of drowning (Szpilman, 1999; Ong et al., 2003). There is no evidence that lifeguard supervision prevents drowning in Iran, but this thesis suggests that a combination of lifeguards (who are aquatic experts in drowning prevention using professional equipment) and lifesavers (who are member of the general public and know how to initiate a rescue even without professional equipment) may be effective in the prevention of drowning in the study area.

2.4.2.3 *Pool fencing*

Construction of four-sided, self-latching fencing units is one of the most important factors in preventing swimming pool drowning incidents, especially among children (Pitt and Balanda, 1991; Thompson and Rivara, 2004; Haddon, 1970). Several systematic reviews have shown that erecting pool fencing is the best strategy for reducing the risk of drowning (Ross et al., 2003; Flood and Nutter, 2002; Wintemute, 1992; Inter-WA, 1988; Fergusson and Horwood, 1984; Harborview Injury Prevention and Research Center, 2004). There has been no examination of fencing around pools, lakes, canals and other waterways in Iran. However, this thesis suggests, based on the statements of rural residents, that the government should be responsible for fencing in hazardous environments around lakes, canals and other waterways.

2.4.2.4 Personal flotation devices (PFDs)

Although no rigorous study has confirmed the effectiveness of personal flotation devices (PFDs) in preventing drowning, many studies have effectively estimated the number of potential lives saved by PFDs (Groff and Ghadiali, 2003; United States Coast Guard, 2000). A few countries require that bathers wear a PFD while engaged in boating or recreational water activities. For example, in the USA and Australia, use of PFD is mandatory for all children under 13 years of age. The author is of the opinion, however, that legislation should target all ages and cover all types of bodies of water (Quan et al., 1998; American Academy of Pediatrics Committee, 2000). The use of life vests (also known as personal flotation devices, PFDs, or life jackets) has been found to reduce childhood drowning when boating or playing by open water reservoirs in Sweden. Increasing the availability of life vests at water sites was one component of a program that decreased drowning among children (Bergman and Rivara, 1991). PFDs might be provided for popular swimming areas on the Caspian Sea coastline, on a loan basis, on ground that this intervention has been successfully implemented in Sweden for many years (Bergman and Rivara, 1991).

2.4.2.5 Certification in cardiopulmonary resuscitation (CPR)

The ability of people attending to drowning victims to perform cardiopulmonary resuscitation (CPR) has not been rigorously explored in most studies, but much of the literature refers to mandatory CPR certification in the countries where it has been taken up (Wintemute and Wright, 1991). The Iranian Red Crescent has started planning for CPR education for young adults in resident populations around the Caspian Sea.

2.4.2.6 Swimming lessons

Several recent studies provide evidence that swimming lessons are not an effective prevention measure for children less than 4 years of age (Canadian Pediatric Society, 2003; American Academy of Pediatrics Committee on Sports Medicine, 2000).

Analysis of the drowning literature demonstrates that there are few population-based registry studies of drowning incidents or prospective clinical studies of prognostic factors and the outcomes of drowning, either in Iran or in general. Evaluation of potential preventive interventions has been limited. After reviewing the body of literature related to drowning prevention, we concluded that many of the previous interventions could be considered and adapted for the planning of a new intervention. In our view, nine works were compatible with and applicable to our own work (see Table 3).

Table 3: Potential interventions appropriate for the study area.

Authors	Intervention strategy	Findings
Szpilman, 1999	Efficacy lifeguard	Two lifeguards per 500 m. of beach in Brazil.
King Decree, 1973; Decree Law, 2000).	Efficacy lifeguard	On Greece, one lifeguard per 600 m. of beach.
Pearn , 1977	Resuscitation	Children with a favorable outcome were 4.75 times more likely to have a history of immediate resuscitation than children with a poor outcome (95% CI 3.44-6.06, p = .0001).
Wintemute, 1991	Cardiopulmonary resuscitation (CPR)	Mandatory CPR certification in the countries taken up.
Present, 1987	Isolation fencing vs. three-sided fencing (access from house, or no fencing)	Logistic regression showed a non-significant negative relationship between isolation fencing and drowning.
Groff , 2003	Mandatory PFD wear legislation	PFD “wear” legislation is the most effective way of increasing PFD use.
Stevenson , 2003	Pool fencing regulations	Fatality rate in the area without a law was nearly double the rate in the area with a law (14.3 vs. 7.7 per 100,000).
Towner, 2001	Increasing PFD use via education and social marketing	Significant increase in PFD wear rates.
Bennett, 1999	Campaign awareness, change in ownership and use of life vests	Life vest use by children on docks and beaches, or at pools increased from 20% to 29% (p<0.01) and life vest ownership for children increased from 69% to 75% (p = 0.06).

2.5 RATIONALE FOR THE STUDIES

2.5.1 Epidemiology and accuracy of figures

In many settings, due to a lack of convincing data, policy-makers have failed to recognize the importance of taking necessary measures. As interest in and investigation of drowning events grow, it becomes increasingly important to count and classify these events so that the magnitude of the problem can be quantified. Only through use of classification systems and rigorous evaluation will we be able to identify the effects of prevention measures on drowning incidence. Drowning victims have usually been ascertained as persons who seek medical care or die following their submersion. However, the life-guarding industry uses rescues as a measure. It may be that rescues represent the real drowning population since the airways of the rescued have been perceived to be at risk. Because the number of rescues is likely to be much larger than the number of hospitalized or dead drowning victims, the population of rescues might provide better statistical opportunities for testing the effectiveness of interventions. The

real difficulty here is that the number of rescues is very difficult to ascertain. Defining and counting the numerator, such as the number of drowning deaths, are not always straightforward. Counting deaths requires committing to one cause of, or etiologic mechanism for, each death. For example, if a person drives into a river and drowns, the mechanism could be classified as either a drowning or a traffic crash. One way to deal with this is to use multiple cause-of-death files. The International Classification of Diseases, 10th Revision (ICD-10) helps to obtain quality in the determination of causes (WHO, ICD 10, Version 2010). In most cases, the cause of a drowning death is clear. However, in some cases, the mechanism may not be obvious. Difficulty in classifying tends to arise in the cases of adults who have pre-existing medical conditions with the potential to cause sudden death or an altered mental state, and which leave no obvious sign at autopsy. Some victims have new cardiac arrhythmias from previously undetected causes. Drowning may be classified by intent, into unintentional versus intentional, of which the latter includes homicide and suicide. However, the majority of cases of drowning are unintentional or accidental, and intent may be difficult to determine. There is just one published data source concerning Iran, which show that during 2002-2006, the unintentional drowning rate in Mazandran Province (northern Iran) was 95%, which compares with suicide (4%), homicide (0.3%) and undetermined (0.6%) (Anary, 2010). Drowning data from most low and middle income countries are not available, because most cases of drowning occur before medical treatment is provided. They are much less likely to be reported in hospital-based data systems, including death registration systems and forensic-medicine registers. Most statistics understate the true burden of drowning, especially in low and middle income countries. Hospital-based surveillance systems suffer from a number of shortcomings, which entail that they tend to underestimate the incidence of drowning. Deaths due to drowning that occur outside the hospital environment will not be covered by such systems; they also fail to capture injuries that do not receive hospital attention, either because the injury is not severe enough to warrant medical treatment or because help is sought elsewhere.

A registry system includes a functional capacity for data collection, analysis, and dissemination that is linked to a public health problem. Registry systems based only on mortality statistics underestimate the frequency of drowning. If under-ascertainment does not vary over time, such registry systems remain useful for detecting epidemics or clusters, and for assessing trends over time, and variations in space and between populations. There is a need, however, to develop registry systems for drowning that do not underestimate incidence or prevalence. The capture-recapture method has been shown to be useful in estimating the number of missing cases, and thus the real number of cases.

In particular, use of capture-recapture methods can provide a clearer picture of drowning in the Islamic Republic of Iran. Such methods have been used to estimate the true frequency of cases of injury in a population, both reported and unreported (Wittes et al., 1974; Hook and Regal, 1992; Hilsenbeck et al., 1992; Tillisekar and Deming, 1949; Ng et al., 2001; Crowcroft et al., 2002; Razzak and Luby, 1998).

2.5.2 Why calculate costs of drowning for families?

When using registry data in cost calculations, there is a lack of contextual information on family income losses and intangible costs. The direct and indirect costs incurred by the family of a drowning victim or survivor may be far greater than those of the victim alone, since the impacts of drowning fatalities or injuries on affected families can include job loss and productivity loss, both of which may have a strong economic effect. In analyzing the costs of such injuries, direct charges for long-term care, measures of loss of productivity and death costs, and also other indirect costs, should be included. However, several cost elements of importance in family income losses during drowning events have still not been explored. Accordingly, it has been argued that surveys at the level of the household, as a site of both production and reproduction, would better capture implications for poverty. In addition, economic data regarding the overall cost of drowning help to describe the burden of the event, and can be used to promote interest in prevention programs.

All Iranians are eligible for community-based preventive public health, and limited curative health services, financed and provided through the country's primary health care (PHC) network. During 2005-2007, Iran spent an estimated 4.2 percent of its GDP on health (Iran; Economist Intelligence Unit, 2008). Accordingly, the costs of drowning are generally thought to be very important in any analysis of any drowning prevention program and the formation of drowning policy. In high income countries, it is required that any appraisal of new drowning-prevention schemes and policies includes estimation of the costs of drowning. In Iran, on the other hand, rational decisions on the allocation of resources to drowning do not take into account either the explicit costs of drowning the implicit values of drowning events. Accordingly, a cost-benefit analysis has not been carried out in Iran. In this thesis, the current researcher is trying to explore the specific economic impacts of drowning on victims and the victims' families in northern Iran.

2.5.3 Research efficacy and community organization

Rothman and Tropman (1987) presented three models of community organization: Locality Development, which is process-oriented; Social Planning, which is heavily task-oriented; and Social Action, which is both task- and process-oriented. All are based on increasing the problem-solving ability of the community (Cox et al., 1987). Consideration of sociodemographics in the study area led to the decision to pursue a Social Action model, as constituted by the studies in this thesis. This involved the use of focus group discussions, brainstorming, and interviews.

A conceptual framework, inspired by a policy model developed by Richmond and Kotelchuck (1983) (see Figure 2) is related to drowning events in northern Iran. The model shows how drowning prevention programs and public policy and individual practice patterns are interconnected. There are three levels to the model: 1) the knowledge base, here referring to information gathered on drowning prevention around the Caspian Sea coastline; 2) social strategy, which contains a set of plans for transforming the knowledge base into a drowning prevention program, here, for example, using FGDs, brainstorming and interviews with key informants in the resident population to construct a revised intervention package for drowning prevention; and 3)

political will, as measured here, for example, by whether institutional support for the drowning prevention program was successful. In this study, interviews with key individuals showed that the program effectively increased the rate of implementation of prevention strategies and optimized the participation of other organizations engaged in promoting safety activities, such as local government, police, and tourism organizations.

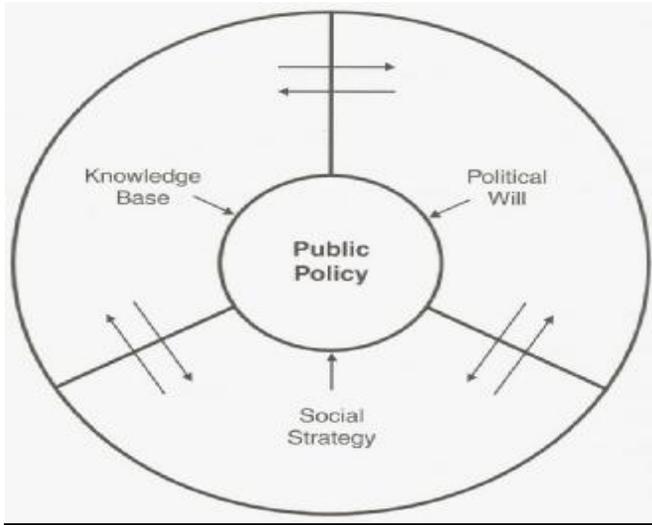


Figure 2: The development of public policy: a three-part health policy model, from Richmond and Kotelchuck (1983).

3 AIMS AND OBJECTIVES

3.1 OVERALL AIMS

The overall aims of this thesis are to analyze the magnitude and burden of drowning events, and to evaluate the feasibility of a drowning intervention package in northern Iran.

3.2 SPECIFIC OBJECTIVES

- To review data from injury registry systems and household surveys addressing drowning deaths in all age groups in northern Iran in order to identify factors associated with deaths to both residents and visitors (Paper I).
- To analyze records of drowning deaths from two injury surveillance systems to obtain a reliable estimate of the drowning mortality rate in the study area (Paper II).
- To calculate the economic costs of drowning in Guilan Province, located in the northern part of Iran (Paper III).
- To evaluate the feasibility of an intervention package for drowning prevention in northern Iran (Paper IV).

4 MATERIAL AND METHODS

4.1 STUDY AREA AND POPULATION

Iran is a middle income country, which had a GDP of \$3,920 in 2007/8 (IMF World Economic Outlook Database, 2008). The adult literacy rate is 48%, and 11% of the total labor force is unemployed. The population pyramid has changed due to a rapidly decreasing death rate, generating a younger population age structure as the gap between the number of deaths and births has widened. The country has 30 provinces and 336 districts. Iran currently has a population density of 39 inhabitants per km². Population density in northern Iran (105 inhabitants per km²) is significantly higher than the average for the whole country (SCI, 2010). Near the Caspian Sea, there are two provinces, called Guilan and Mazandran. The population of both provinces was about 4.5 million at the beginning of the study period; about 53% of the people resided in urban areas, and 47% were residents of rural areas (SCI, 2010). The provincial areas around the Caspian Sea are divided into 40 districts. In each district, there is one protected area for swimming with access to rescue services.

In this thesis, we consider a population-based research program for the prevention of drowning deaths among residents and tourists in Guilan and Mazandran provinces from 20 March 2005 through to 20 March 2009 (a period coinciding with Iranian calendar years). The study areas were selected after consultation with the Ministry of Health and Medical Education (MOHME) and provincial health offices in Iran. They recommended that Guilan Province should be involved in the study, because both Guilan (pink area on map) and Mazandran (green area on map) provinces have the highest incidence of drowning in the total population (Figure 3). Studies I, II and IV and the focus group discussions were carried out in both provinces. Study III was conducted only in Guilan Province, at teaching and non-teaching hospitals and using the Red Crescent system.



Figure 3: Map of Iran and the study areas.

4.1.1 Iran's health care delivery system

Today, the largest healthcare delivery network is administered by the Ministry of Health and Medical Education (MOHME) through its health establishments and medical schools in the country. Iran's health care delivery system can be defined at three levels, the first two of which are encompassed by the primary health care (PHC) network (Figure 4).

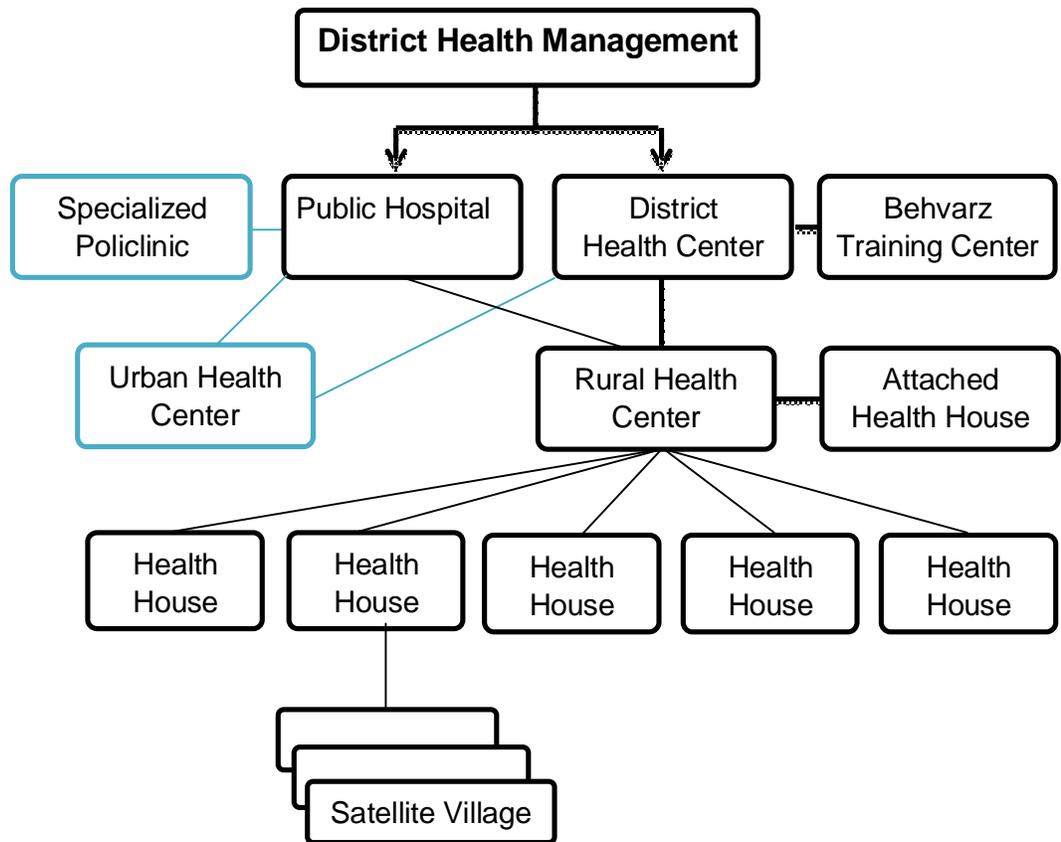


Figure 4: Design of the primary health care network in Iran.

The basic PHC level includes: (1) rural health houses with a catchment population of 1,500, staffed by behvarzes (front-line allied health workers); (2) rural health centers, containing a physician and other health workers (e.g., nurse, midwives, dental technician, environmental health workers), which supervise a number of health houses with a population base of 9,000; (3) urban health posts; and (4) urban health centers. The second level of the system is the district health center, which is responsible for the planning, supervision, and support of the PHC network and district hospitals. The third level of the system consists of the provincial and specialty hospitals. Almost 85% of all births take place in health facilities, and almost 90% percent of babies are delivered by trained health attendants (Tavassoli, 2008).

4.2 RESEARCH DESIGN

A summary of the four papers, including designs and methods, study populations and data collections, is presented in Table 4. Both quantitative and qualitative methods were used. The quantitative studies were performed by using a structured questionnaire and registry-systems data in a cross-sectional study (Paper I), by applying the capture-recapture method to registry data (Paper II), and by using various sources to establish the cost of injury (Paper III). A literature review, focus group discussions (FGDs), brain storming (BS) and interviews with key informants were conducted to collect the qualitative data (Pre-Paper IV).

Table 4: Overview of the study designs, study populations and data collections.

Study	Design and method	Study population	Data collection
Paper I, Victims study, Published	Cross-sectional, registry-based study, household surveys, weekly reports.	Representative samples of fatalities due to drowning among residents and visitors (n = 342).	Structured questionnaire, face-to-face interviews.
Paper II, Registry-systems study, Published	Capture-recapture method.	All deaths due to drowning among residents of northern Iran, identified in the DRS (166) and FMS (129).	Linked database obtained from the DRS and FMS, identification of common data and application of the capture-recapture method.
Paper III, Victims study, Published	Economic burden, cost of injuries.	Representative sample of cases of drowning (137) and near-drowning (104) among residents and visitors in Guilan province, Iran.	Structured questionnaire, face-to-face interviews. Hospital documents obtained for medical costs, and the Red Crescent Society used as a source for lifeguard costing.
Paper IV, Victims study, Submitted	Quasi-experimental method, a controlled before-after design.	Representative sample of cases of drowning among residents and tourists of Guilan and Mazandran provinces in northern Iran.	All records of the DRS and FMS, and weekly reports. Information from the Red Crescent Society

Using the qualitative and quantitative data, and in light of the literature review, the measures relevant to an intervention package were formulated. The measures included: establishment of multisectoral collaboration, integration of public health messages into local television, additional rescue stations and lifeguards, hazard-environment fencing, increasing adult supervision, greater support for promoting swimming ability among children.

From March to July 2006, the intervention package was implemented on a small scale in both study areas (in Anzali County) for five months to gauge community feedback. FGDs and brainstorming were used to assess the initial community response to the intervention package. On the basis of this initial response, the community intervention package was finalized. The local Provincial Government, the Lifeguard Service, the Guilan University of Medical Science and the Red Crescent Society jointly agreed to accept responsibility for the program. In order to gain support within the organizations involved, advocacy meetings were held with them. To evaluate the feasibility of the drowning intervention package in both study areas, a quasi-experimental community-based trial was performed. It included (1) pre- and post-intervention observations in an intervention and a comparison community in a water-recreation area by the Caspian Sea in northern Iran, and (2) pre- and post-intervention observations without a comparison community near the Caspian Sea coastline. Cross-sectional data were

collected at pre-intervention and post-intervention in these areas (Paper IV). See figures 5 and 6.

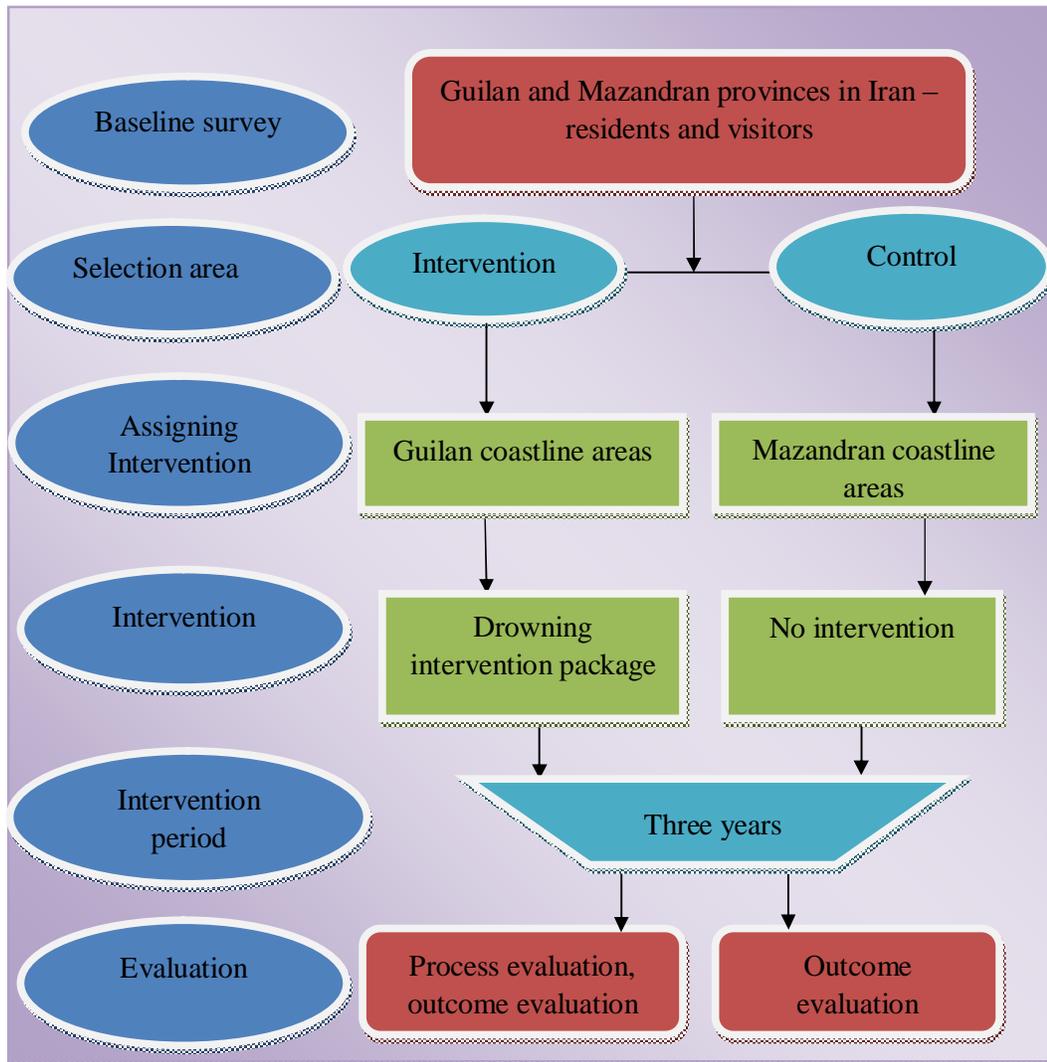


Figure 5: A model for understanding the implementation of a drowning prevention program in the resident and visitor populations of Guilan and Mazandran provinces in northern Iran, using a quasi-experimental study design.

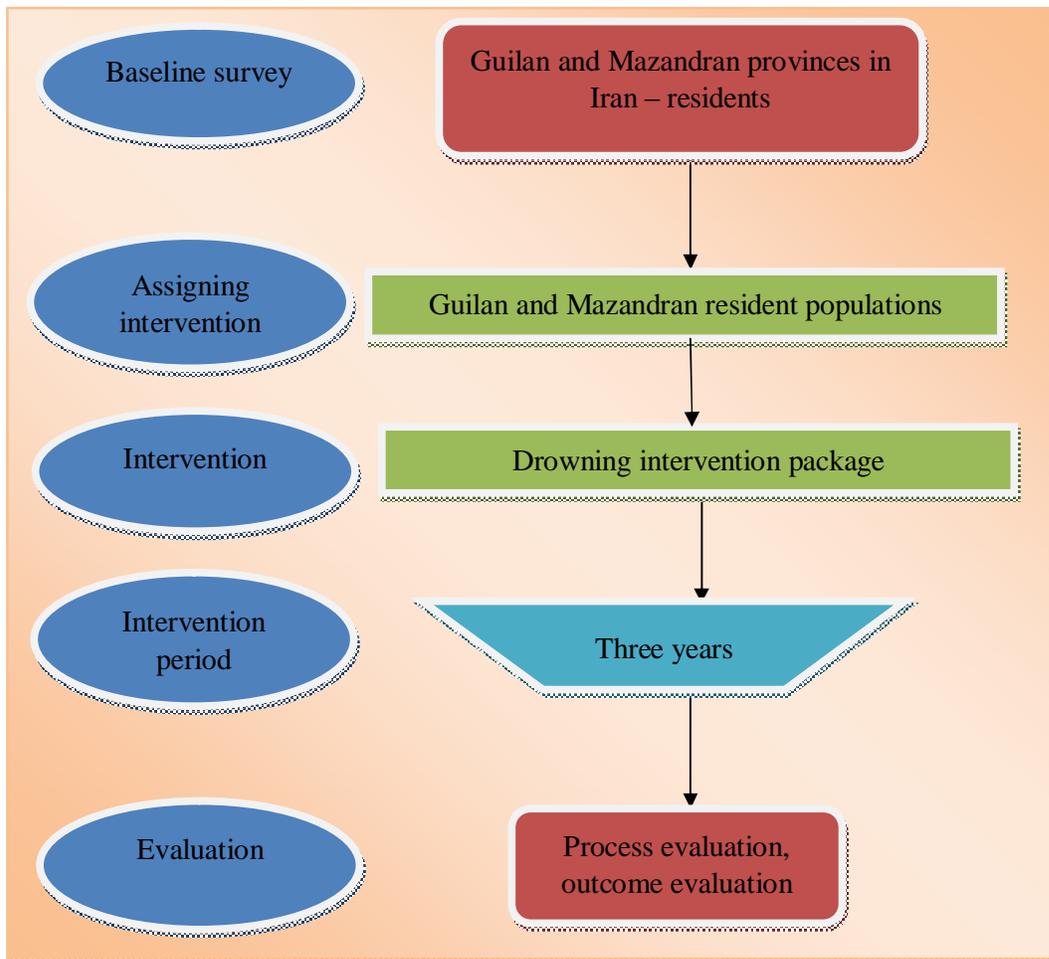


Figure 6: A model for understanding implementation of a drowning prevention program in the resident population of Guilan and Mazandran provinces population in northern Iran, using a before-after study design.

4.2.1 The drowning prevention package

The intervention, with the drowning prevention package, was based on concepts in the field of safety promotion, and was aimed at all age groups, in a variety of physical and socioeconomic environments. The nature of package implementation was adapted to the Iranian health care framework and infrastructure. Implementation was anchored in local community networks, and thereby involved a cross-sectional group for coordinating the drowning prevention program in situ.

4.2.1.1 Process

The baseline drowning prevention package was applied from March 2005 to March 2006 in order to identify epidemiological aspects of drowning throughout both the

provinces in northern Iran. Using the findings from focus group discussions FGDs and a literature review, and the data gathered from a cross-sectional survey at baseline, applicable drowning-prevention measures were formulated.

During March to July 2006, the intervention package was implemented on a small scale in both study areas (in Anzali County) for five months to gauge community feedback. The local provincial government, the Lifeguard Service, the Guilan University of Medical Science and the Red Crescent Society jointly agreed to accept responsibility for the program. FGDs and brainstorming were used to assess the initial community response to the intervention package. The main program was initiated in July 2006, with the aim of reducing drowning incidents and increasing public awareness in the study area.

4.2.1.2 Implementation

The implementation phase evolved from a collaborative effort between the focus group and brainstorming committees, with objectives derived from experiences from the baseline cross-sectional study. This introductory phase of the program was launched in June 2006 in the seaside region of Guilan Province, and completed in March 2009, with application in a comparison community in Mazandran Province. The implementation phase in the residents population was effected simultaneously in both provinces by the Caspian Sea coastline. Public health and safety issues were addressed in accordance with the intervention during the years 2006 to 2009.

Interventions

1) The intervention package in the Caspian seaside region included:

- Extension of lifeguard services throughout the beach regions of the Caspian Sea (one lifeguard for every 1,500 meters of beach, equivalent to 180 lifeguards, compared with 15 lifeguards before the intervention).
- Expansion of the number and scale of rescue service stations in the beach areas where the intervention was to be established (one rescue service station for every 4,500 meters of beach, equivalent to 60 rescue service stations, compared with 8 rescue service stations before the intervention).
- Integration of public health messages into local television and radio news, such as the Darya TV program broadcast in Guilan Province during the summer season (two hours per day over the three-month summer season).
- Increasing the availability of life vests (also known as personal flotation devices, PFDs, or life jackets) at water sites.

2) Elements of the plan in the intervention package in rural settings by the Caspian Sea coastline included:

- Modification of environmental change through, for example, the elimination of certain water reservoirs.
- Information programs for health care workers, the Behvarz, who were employed to educate clients about drowning risk factors, with a specific emphasis on training high-risk populations in basic resuscitation techniques.

In both study areas, intervention programs designed to effect recreational behavior changes were implemented through public health educational campaigns, utilizing posters, pamphlets, and notices at the sites of previous drowning. Their purpose was to

inform the local community about circumstances related to drowning incidents in the country, to educate people about various means of preventing drowning, and to gather data to facilitate the determination of causes of drowning. In both study areas, active interventions were implemented during 2006.

4.2.1.3 Outcome

Analysis of the outcome of the intervention (2009) was performed using information from the cross-sectional baseline study (2005).

4.3 DATA COLLECTION

4.3.1 Paper I

Data were gathered on the unintentional drowning deaths (n = 342) of residents and tourists in northern Iran over a one-year period (2005-2006) using multiple sources (the DRS, the FMS, weekly reports, and a questionnaire survey). Relevant factors included: age, sex, place of death, external cause, date of death, date of examination of the deceased, and underlying causes of death. The activities of children prior to drowning, and also the activities of their mothers at the time of drowning, were collected by questionnaire in a household survey to enable assessment of related causes.

4.3.2 Paper II

Data from records of drowning deaths in two injury-registry systems were gathered to obtain a more reliable estimate of drowning mortality. We used data from the Death Registry System (DRS) and Forensic Medicine System (FMS) for 20 March 2005 through to 20 March 2006. Drowning cases were captured using the FMS, and then re-captured using the DRS. After sorting the drowning data, they were merged into a single file. Duplicated data were determined and cleared. In the first evaluation, six variables were used for matching drowning data: name, age, gender, date of death, place of residence (rural, urban), and residential region. Identification of drowning location was made on the basis of four variables: sea, river, canal, and other natural body of water. A two sample capture-recapture analysis was performed to estimate the extent of "undercounting" in the two registry systems. Estimates of the number of drowning fatalities (N), the variances and 95% confidence intervals (CIs) were calculated using the following formulas:

Estimate of $N = [(S1+1) \times (S2+1) / (C+1)] - 1$ (Wittes and Sidel, 1968; McCarthy et al., 1993; Smail et al., 2000),

where:

S1 represents the number of records in the DRS, and S2 the number of records in the FMS. The overlap between these samples (C) represents the cases in both sources (see Table 5).

Variance in $N = [(S1+1)(S2+1)(S1-C)(S2-C) / (C+1)^2 (C+2)]$

$$95\% \text{ CI} = n \pm 1.96 \sqrt{\text{var}(n)}$$

Table 5: Overlap of cases in the DRS and the FMS.

Case found in the DRS?				
Case found in the FMS?		YES	NO	TOTAL
	YES	C	S2	
	NO	S1	O	
	TOTAL			N

C is equal to the number of cases common to both the DRS and the FMS; S1 represents the number of records in the DRS, and S2 the number of records in the FMS; O stands for unreported cases; and N is equal to the total population of drowning cases.

This method relies on the degree of overlap (common cases) between incomplete and independent data sources (see Figure 7).

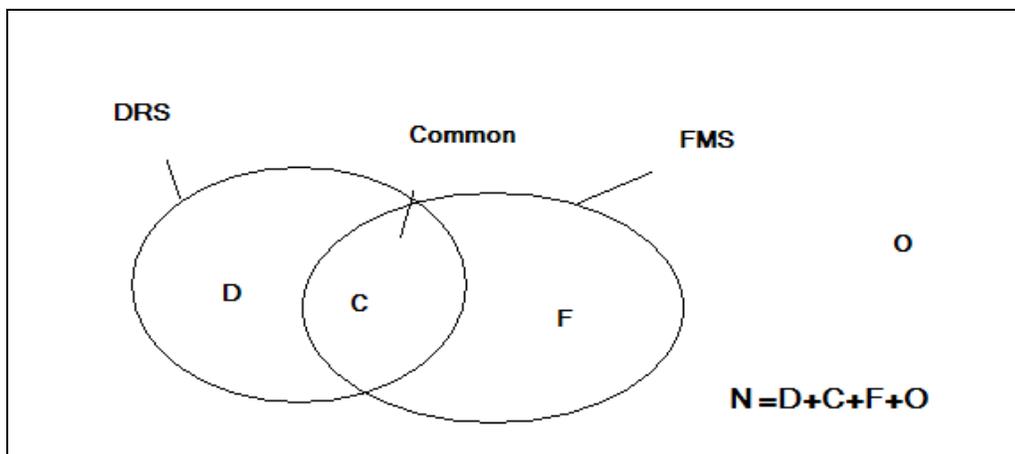


Figure 7: Capture-recapture in the study area with two data sources.

4.3.3 Paper III

During the financial year March 2007 to 2008, the following cost-related aspects of drowning episodes were evaluated (with income adjustment of main cost elements by family and years): medical costs, productivity loss costs, and death costs. In this study, both a top-down and bottom-up approach were adopted to processing the information from the registries; questionnaires and other relevant data sources pertain to drowning incidences. To estimate the incidence of drowning and near-drowning, several data sources were used. For computing unit indirect costs, the study included estimates of the productivity loss costs and death costs of drowning among victims in the age range 20-60 years who were residents of Guilan Province. These figures were determined by interviewing victims (in cases of near-drowning) or their family members. An incidence approach was adopted (Conference report, 2001), and the study method is a mix of top-down and bottom-up approaches.

Productivity losses and death costs were estimated by methods previously used in the Income adjusted by family and years, Deprivation costs, Death costs, Other costs (IDDO) model (Dalal and Jansson, 2007). Our model uses national estimates based on the age at which a person first comes into the workforce, at age 20, and the age at which he or she retires, at age 60. A measure of the economic impact on the victims' families was used to calculate production losses. The costs of productivity losses were Income Adjusted by Family and Years (IAFY):

$$IAFY = [\sum_t (Y_i / Y_{mi}) / N] \times \{Y_i \times (1 + r)^j\} \times E,$$

where:

N = the number of working years of the person effectively earning for the family, starting with the victim's first income year (e.g. if the person started working for the family at the age of 20, and if the incident took place at the age of 25, then $N = 25 - 20 = 5$);

I = is the year of incidence, and Y_i = victim's annual income at year I;

Y_{mi} = family's mean annual income at year I;

r = existing rate of interest in the economy;

j = actual years left for working for the family from year of the incident (e.g. if the average last year of productivity in the person's field of work is 60 and the incident took place at age 25, then $j = 60 - 25 = 35$);

E = the number of days affected by the incident as a proportion of the 365 days of the year.

Through the IAFY calculation, we considered the productivity costs of the injured person for one day, and then over the specific study period.

Death costs were estimated as the Income Impact on the Family (IIF):

$$IIF = \{1 - Y_i / (Y_i + Y_t)\} \times IAFY,$$

where:

$Y_t = j \times Y_i$ (i.e., the years left in the person's working life multiplied by his or her income in their last year);

E = the number of days affected by the incident in proportion to the 365 days of the year (e.g. if the victim died from the injury, then $E = 1 (0 < E < 1)$).

4.3.4 Paper IV

A drowning prevention program was established in March 2005 in order to improve public awareness of measures that had previously been shown to be effective in the prevention of drowning. Program strategies were designed to effect a reduction in drowning events in multiple settings. Evaluation of the intervention package was performed in the form of a quasi-experimental study, involving: (1) pre- and post-intervention observations in an intervention and a comparison community in a water-recreation area by the Caspian Sea in northern Iran; and (2) pre- and post-intervention observations, without a comparison community, in a residential population near the Caspian Sea coastline. Cross-sectional data were collected during the pre-intervention and post-intervention periods on the sites in question. Analysis of outcome measures was based on mortality frequency in the time interval between the drowning event and hospital discharge. Odds ratios were used to compare drowning risks between the intervention and control areas in the beach regions near the Caspian Sea. For individuals injured more than once, only the first episode was included in the data set. Comparative evaluation of outcome measures was performed three years after implementation of the intervention project (March 2006-March 2009) in a residential population near the Caspian Sea coastline. Process evaluation was also performed, and the impact of drowning on the resident population during this period was assessed.

4.3.5 Data sources

In Iran, data on drowning fatalities can be found from a number of different sources, including Iran's Forensic Medicine System (FMS) and Death Registry System (DRS), and information on near-drowning can be obtained from the Red Crescent Society and weekly reports. The DRS is a new system that is currently being expanded to cover the whole of Iran, except Tehran City. It records all deaths by cause, using the International Classification of Diseases, 10th Revision (ICD-10) guidelines. The information gathered includes name, age, sex, date of death, place of death, place of death registration, and residential home address of the deceased. In the DRS, the cause of death is determined by medical certificate or – if not available – by verbal autopsy. Verbal autopsy is an indirect method of ascertaining biomedical causes of death from information on symptoms, signs and circumstances preceding death, obtained from the deceased's caretakers (Soleman et al., 2006). In Figure 8, an overview is presented of the patterns of data sources included in the DRS and the FMS.

Mortality and population data from the DRS were used. Drowning death statistics in this system are collected from rural health houses, health and treatment centers (in both rural and urban settings), hospitals, municipalities, and registry offices. Unintentional drowning cases were identified through report codes based on ICD-10. The study included deaths classified with ICD codes V90-V94, W16, and W67-W74 (WHO, ICD 10, Version 2010). Study variables included gender, age, dates of birth and death, province of death, and factors contributing to death.

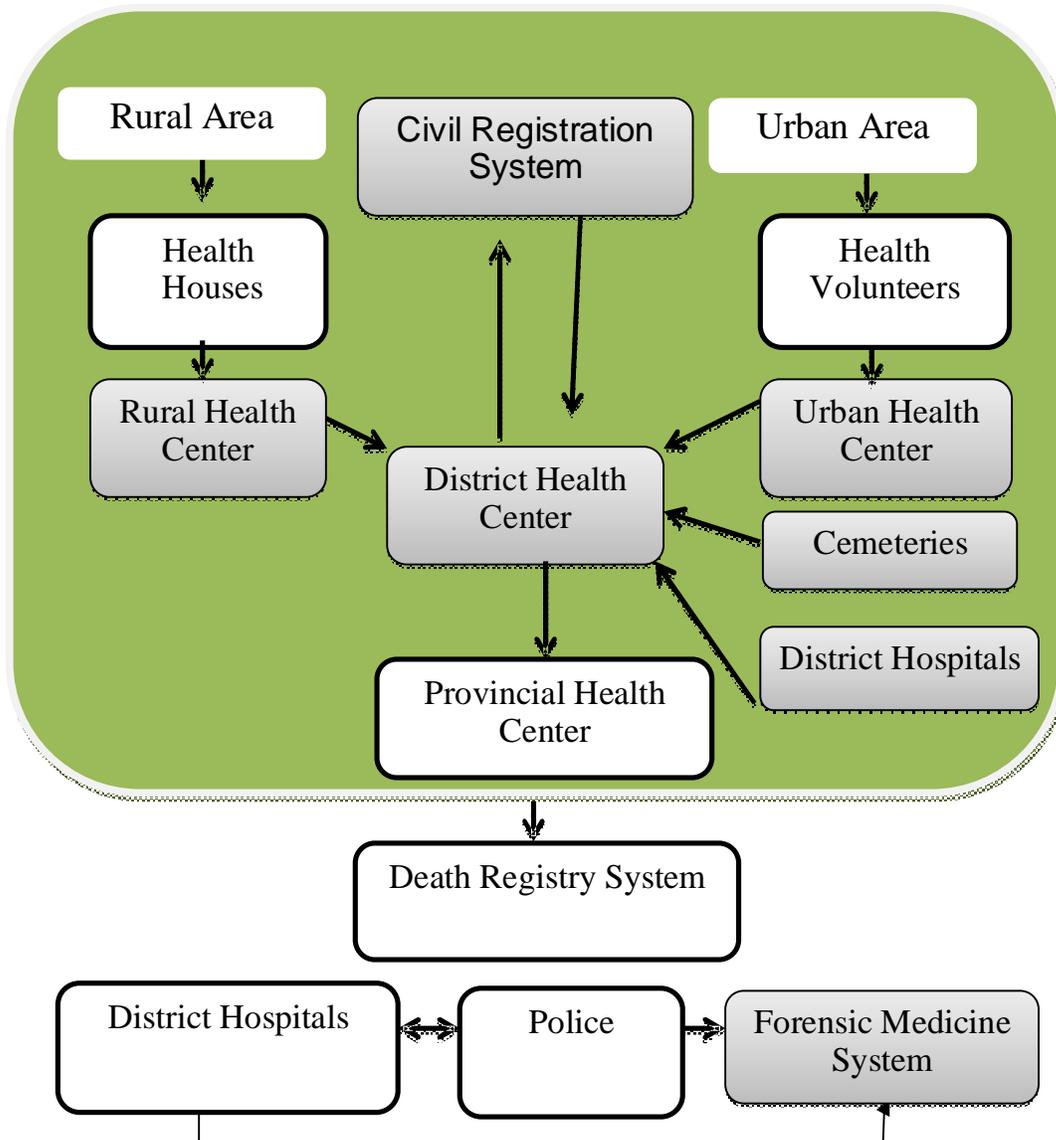


Figure 8: Flow chart indicating data sources for the Death Registry System (DRS) and Forensic Medicine System (FMS) as applicable to northern Iran.

The thesis was augmented by data obtained from weekly reports of drowned victims. The weekly reports were obtained from records sent to the active registry system for drowning in the north of Iran. This registry system obtains case reports from the DRS, and also from ambulances, and thus allows for reports of cases that are not registered in hospitals. Weekly reports were primarily generated during the summer months, when more people are outdoors swimming. These weekly reports also contain information on the victim's usual residence, which allowed us to determine whether death occurred in the victim's home province. Quality control on drowning data gathered in the DRS and through the weekly reports was conducted by trained health officers in each district,

and through standards enforced by the Iranian Ministry of Health and Medical Education at district and national levels, after the data were forwarded from local sources. For this thesis, data were also gathered from the FMS, based on death certificates. The key variables in the three data sources were name, age, sex and place of death, external cause, date of death, date of examination of the deceased, and underlying cause of death. Local sources of cause-of-death information relating to the Caspian Sea beaches of northern Iran for drowning cases include the Red Crescent and the local police. Additional data for this thesis were obtained through household surveys of the family members of unintentional drowning victims whose deaths occurred during the study period, when the victims were residents in the study areas. When a drowning case involving a local resident was identified, a questionnaire was used to collect information related to the death, including time and place of drowning, gender, age, date of birth, and, in the case of children (1-10 years), the activities of the children prior to drowning and the activities of their mothers at the time of drowning were gathered by questionnaire (papers I, III, IV). Moreover, items on socioeconomic, sociocultural, demographic and environmental characteristics of the deceased family were also included in the questionnaire. The socioeconomic and sociocultural variables included were family's income and impact of drowning on the victim's family (Paper III, Pre-Paper IV). In rural Iran, primary adult caretakers of young children are almost always mothers. The demographic variables included mother's age and educational status. Mother's age was divided into three age groups with ten-year intervals: less than 20, 20-30, and above 30). Educational level was divided into four groups, with no education, primary education (from class one to five), high school (classes six to eleven), diploma (class twelve), and higher (Pre-Paper IV). Trained data collectors collected in face-to-face interviews with adult members of the deceased victims' families. Overall, drowning fatality data were extracted from the FMS, the DRS and weekly reports, and near-drowning data solely from weekly reports.

4.4 STATISTICAL ANALYSES

All statistical analyses were performed using SPSS, version 13, 19. The significance level was set at $p = 0.05$. Chi-square tests were conducted to analyze group differences (papers I, IV). For papers II and III, the following methods were used. Outcome implementation of the package was analysed in terms of the incidence of drowning fatalities, in total and by age group, sex, location, date of event, and contributing factors. Two models were adopted.

First, one model compared drowning risks between the two time periods in both the intervention area and the control area by the beaches of the Caspian Sea. For individuals injured more than once, only the first episode was considered. Unconditional logistic regression was used, the interaction parameters for the population odds ratios during different seasons were compared using the Wald test (Newcombe, 1998a). A 5% significance level was used to reject all null hypotheses. The method used to calculate confidence intervals for proportions was the Wilson score method without continuity correction (Newcombe, 1998b). Confidence intervals for the odds ratios were calculated using the methods described by Armitage and Berry (1994). The method used to calculate confidence intervals for differences between two proportions was the Newcombe-Wilson method without continuity correction

(Newcombe, 1998a). The confidence limit for a relative-risk reduction is 1 minus the confidence limit for the relative risk.

Second, to assess any change in outcome in relation to unintentional drowning in the resident population, outcome measures were taken three years after implementation of the intervention package near the Caspian Sea coastline (March 2005/6 – March 2008/9). Population-based rates and relative risks were calculated using the most recent census data for Iran (SCI, 2010). We examined the trend in the unintentional drowning rate in northern Iran over time. Chi-squared tests for trend were used to test for differences over time in unintentional drowning rates between the genders and between places of drowning.

4.5 QUALITATIVE STUDIES

4.5.1 Focus group discussion (FGD)

A focus group discussion (FGD) is essentially a group interview. It is not a problem-solving session, and it does not aim to arrive at a consensus among participants. Rather, it seeks to understand and determine the range of perspectives involved in how people perceive their own situations (Krueger, 1994). FGD is first and foremost a qualitative method that uses group interaction to explore people's experiences and knowledge, in which the focus lies on how the views of participants on a specific topic are formulated and expressed in relation to a certain culture and context with respect to opinions, attitudes, and norm systems (Dahlgren et al., 2004). Further, FGD is a useful tool in the public health field because it does not discriminate against people who cannot read and write. Participation in FGDs has the added advantage of being able to encourage people who are reluctant to be interviewed on their own to share their views (Kitzinger, 1995). The recommended size of a group varies, but the most common is between 6 and 10 participants. Smaller groups may be preferred, depending on the sensitivity or depth of the topic (Dahlgren et al., 2004). In this thesis, focus group discussions were used to explore resident and visitor populations' perceptions of drowning events. Data were drawn from five FGDs. Two were conducted with members of the navy, two with lifeguards, and one within the visitor population. In rural settings, two FGDs were conducted with elected representatives, school teachers and religious leaders. The experts on injury prevention within the framework of health services in both provinces were skilled in conducting FGD-moderated discussions. The number of respondents in the groups ranged from 8 to 12. Each FGD lasted 80-120 minutes, although sometimes the rounding-off of a discussion took longer. As the primary data gathered in the FGDs, the researcher participated in all the discussion sessions.

4.5.2 Brainstorming (BS)

Brainstorming is a group problem-solving technique that involves the spontaneous contributions of ideas from all members of a group. It is a popular way for groups to identify known solutions and invent new ones; brainstorming is used when groups are seeking creative solutions (Osborn, 1963).

The discussions enabled the data collectors to find out the views of stakeholders, working within a health care framework, on the majority of drowning cases. To ensure a high level of individual participation, experts in injury prevention, and also experts in

non-injury prevention, were invited to participate. There were two groups. Each of the groups consisted of 8-12 participants, and a moderator was appointed for each group, whose function was to maintain a positive attitude to the brainstorming process.

The moderated brainstorming sessions were held in the conference rooms of the Guilan Province Health Center. One person in each group was appointed secretary to record all the ideas generated by the group. After the brainstorming portion of the meeting was completed, the researcher categorized all the ideas generated for the purpose of evaluation. Sometimes, after the conclusion of a meeting, participants were sent a copy of the idea list to enable them to retain thoughts and ideas, and transfer them from one session to the next. On some occasions, the author asked members to report back later on ideas they considered worthy of action, and to offer any additional ideas they might come up with about implementation.

4.6 ETHICAL CONSIDERATIONS

The study was approved by the Ethical Committee of the Guilan University of Medical Science in Iran. In all the studies, the interviewees were informed about the purpose and design of the studies, and told that their participation was confidential, anonymous, and voluntary. For studies I, III and IV, informed consent was obtained from the family members of the victims of drowning. Information explaining the aim of the study was provided orally and in writing. The interviewees were also informed that they could withdraw from the sessions at any time. Informed consent was also sought to allow publication of data, from both victims' families and regional authorities. All records and questionnaires were finalized without using any personal information about the subjects, and all information was kept in secure files.

5 RESULTS

Overall, there were 1,294 drowning deaths among the resident and visitor populations of northern Iran between March 2005 and March 2009. During the four-year time period covered by this study, Guilan Province averaged 124 drowning death annually, ranging from a low of 91 cases in March 2008-March 2009 to a high of 193 cases in March 2007 -March 2008, while deaths in Mazandran Province ranged from a low of 176 cases in March 2007-March 2008 to a high of 232 cases in March 2005-March 2006. The combined fatal drowning rate for the resident population in both provinces ranged from 4.5 per 100,000 resident population in March 2007-March 2008 to 3.5 per 100,000 resident population in March 2008-March 2009. Drowning rates for tourists could not be computed since denominator data were incomplete (SCI, 2010).

5.1 PAPER I

The results of the first study were as follows: 342 unintentional drowning deaths occurred in the study area; 44% of all drowning deaths were among the tourist population; and, the combined fatal drowning rate for the resident populations in both provinces was 4.24 per 100,000 residents. For all age groups, the largest proportion of drowning deaths, about 70%, occurred during the summer season. Almost all drowning events (98%) occurred during daytime, between 06:00 and 18:00 hours. Most drowning events involved males (296 victims, 86%); the greatest number of drowning victims was among persons 20-29 years of age (34%). Sixty-seven percent of drowning incidents occurred in unprotected areas by the Caspian Sea coast (n = 229), followed by rivers (n = 85).

5.2 PAPER II

The number of drowning cases in the study population is estimated to be much higher than that suggested by the official figures – ranging from 5.26 to 8.25 per 100,000 residents, which compares with the national figure of 4.5 per 100,000. In percent, in comparison with our estimates, the accuracy of records in the Death Registry System was 70%, and the accuracy of records in the Forensic Medicine System 54.4%.

5.3 PAPER III

A total of 137 drowning fatalities and 104 near-drowning events were recorded during the study period. The estimated medical costs of drowning were \$58,645 in total, with an average cost of \$428 per person; for cases of near-drowning, the estimated costs were \$60,547, with an average cost of \$582 per person. The total costs of drowning and near-drowning among residential victims in the 20-60 years age group came to \$320 per victim for medical costs, \$31,647 per victim for production losses, and \$35,664 per victim for death costs. In sum, the total cost per victim amounted to \$67,631 for the resident population of Guilan Province during the financial year 2007/2008. The study indicates that medical costs are a relatively small component of the total economic burden imposed on families and society by drowning. The drowning cost per person was over 17 times that of the country's gross domestic product (GDP) per capita. This

supports the view that attention should be paid to the costs of drowning at household level.

5.4 PRE-PAPER IV – FOCUS GROUP DISCUSSIONS AND BRAINSTORMING

Although all FGD groups were aware that drowning is a much-neglected health problem, the majority of the groups focused their discussions on drowning incidents among victims in the age range 20-29 years. In most of the FGDs, it was noted that the risk of drowning in the male population is higher than among females. The participants claimed that unprotected areas by the Caspian Sea beaches and the rivers are common sites of drowning. Many participants mentioned that lack of supervision by parents was responsible for the majority of the drowning cases among children that occurred during daylight hours.

Initial responses of the community to the prevention program were that: a) male children should be trained in basic swimming skills; b) additional rescue stations and lifeguards are needed along the Caspian Sea coastline (one lifeguard for every 500 meters); c) integration of public health messages into local radio television, such as into the Darya program, is needed; d) lake fencing and canal/waterway fencing may help to prevent drowning events in rural settings. The majority of the participants expected that some measures, especially the fencing-off of rivers and canals/waterways should be carried out by governmental organizations.

Brainstorming was carried out on three axes: management, the local community, and access to public health resources. Some of the main issues on the management axis were: (1) the multiplicity of organizations involved in decision-making, (2) poor cooperation between organizations, (3) insufficient involvement of managers in organizational procedures, (4) delays in implementing sea-safety programs in areas close to the Caspian Sea, and (5) poor custodial supervision.

On the resource axis, inadequate budgets, insufficient numbers of ambulances and motorboats and limited implementation of sea-safety programs in surrounding areas were the most significant factors. However, inadequate swimming skills, poor awareness of the risk of drowning in high-risk areas, and inattention on the part of lifeguards on duty were decisive at community level. The lack of lifeguard reinforcements and a shortage in the total number of lifeguards played an important role in drowning outcomes.

5.5 PRE-PAPER IV – SOCIOECONOMIC AND CULTURAL STATUS

In this thesis, we determined the socioeconomic status of the victim's family whenever a child (1-10 years) was involved (on either site), using household survey data during the study period. Overall, 148 cases were identified. 130 cases of drowning among children under the age of ten years were considered in the study; in the remaining cases, we had no access to family information (see Table 6).

Table 6: Drowning deaths among children 1-10 years in northern Iran by socioeconomic status of the family, 2005-2009.

Independent variable	No. of cases
Maternal education	130
No education	20
Primary	70
High school	12
Diploma or higher	28
Mother's age (years)	130
Less than 20 years	3
20-30 years	31
More than 30 years	96
Family's income	130
Less than \$200	87
\$200-\$700	32
More than \$700	11

To investigate the role of sociocultural status in explaining post-traumatic stress symptoms among victims' families when children (1-10 years) were involved during the study period (on both sites), the researcher performed an interview and telephone survey of the victims' mothers (130 cases). Although most had experienced strong feelings, such as fear, sadness, guilt and anger, it was still possible, after the event, for them to recall what was emotionally memorable, particularly as the drowned person was a child; they helped us to understand how and why it had happened. This was expressed by one mother as follows:

“Drowning is more painful than any normal death. A normal death is acceptable, but drowning is torment”

We found that most of the women (120) recovered on their own, and got back to their normal life with the support of family and friends, and without professional assistance. However, in cases where people do not recover on their own, professional help may be needed.

5.6 PAPER IV

Interviews with key individuals showed that the program effectively increased the rate of implementation of prevention strategies, and also optimized participation by other organizations engaged in promoting safety activities. The knowledge and practice of drowning prevention in the resident population increased marginally between the two household surveys (a 22% increase in transferring knowledge into practice at baseline, compared with 35% at endline). The risk factors associated with drowning incidents implying that there was a decrease in the control areas too. Overall, 756 unintentional cases of drowning fatality, and 711 of near-drowning, were identified during the study period in the beach areas of the Caspian Sea in the resident and tourist populations. Guilan Province showed a slightly faster decreasing tendency in the risk of drowning, from 1.81 (CI: 1.14 – 2.89) to 0.25 (CI: 0.17 – 0.36), and the probability of a case of death decreased from 64% to 20%. Mazandran Province showed a decrease in the probability of drowning from 62% to 51%, and an odds ratio decrease from 1.58 (CI: 1.17 – 2.12) to 1.04 (CI: 0.83 – 1.31). Comparing odds ratios in Guilan Province and

Mazandran Province showed a significant decrease over time, from 1.15 (CI: 0.66 – 2.01) at the beginning of the study to 0.24 (CI: 0.15 – 0.37) at the end.

During this four-year period (2005/6 to 2008/9), 709 cases of unintentional drowning occurred in the resident population in the study area. The incident rate fell from 4.24 per 100,000 residents at baseline to 3.16 per 100,000 at endline, although no consistent trend was detectable.

The male-to-female ratio was highest in 2008/9, with numbers fluctuating annually. This is reflected in a 3.5 to 11.3 significantly higher annual relative risk for males, compared with females. A chi-squared test for trend between the genders found that the decline was significantly greater ($p = 0.001$) in females when looking at the age groups; the highest rate was observed among 10-19 year-olds, with an annual rate of between 2.1 and 6.12 per 100,000 resident population during the period (2005-2009).

6 DISCUSSION

6.1 DROWNING EPIDEMIOLOGY AND RISK FACTORS (PAPERS I, II, IV)

Papers I-II are the first detailed studies of drowning incidence in Iran. Paper I is a community-based but cross-sectional study, based on registry data. Therefore, causal relationships (Gordis, 2000) between the variables cannot be addressed. The key findings from studies I, II and IV show that males have higher fatality rates than females at all ages, which is comparable with the global pattern of drowning (Sibert et al., 2003; Dowd et al., 2002; Edmond et al., 2001; Peden, 2002). The gender imbalance correlates with Tan's (2004) findings. Also, a similar proportion, of 4.16, has been reported in the USA by Wintemute et al. (1991). Similar results have been reported in Denmark by Kringsholm and Filshov (1991), and in the USA (Minneapolis) by Hedberg et al., (1990).

The gender difference depends on males being less likely to use protective devices in water-related activities and having a higher exposure, e.g. during boating and fishing. Shallow-water diving shows the highest drowning incidence rate near the Caspian Sea coast, followed by activities in rivers and lakes, as demonstrated by Riley et al. (1996) and Yu (2000). On the other hand, near the Caspian Sea Coast, men drowned more frequently than women, probably due to cultural norms related to gender roles, which may have been expected on the basis of Iranian culture. Males are exposed to drowning even during the nights, whereas females are exposed to drowning only during the days. Further, females are less likely to develop swimming skills and more likely to engage in recreational activities in shallow water in or near their home.

Residents are more likely to get involved in drowning incidents (55%) than visitors. In northern Iran, there are numerous rivers and lakes around the villages and cities, which are used for boating, swimming, and washing purposes throughout the year. These environments are common hazard locations for the resident population. The situation is not consistent with that found in an earlier study from the Netherlands, which shows a three-fold greater risk of residents' dying from accidental drowning (Verweij and Bierens, 2002). But it does correlate with the findings of studies in Bangladesh and China (Rahman et al., 2006; Ya et al., 2007).

The risk of dying from drowning was found to be higher among children of older rather than younger mothers. The main reason for this is probably that the older mothers usually have more children, and mothers in households with many children may pay less attention to the safety of their children than those in households with fewer children. One earlier study has found that households with more children are more likely to be involved in drowning (Baqui et al., 1998). When looking at the unintentional drowning rate in the resident population by age group, the highest annual rates were found in the 10-19 age group, which ranged from 6.12 per 100,000 at baseline to 2.1 per 100,000 at endline. A large number of studies have shown that more than half of all drowning deaths occur among children below the age of 15 years (McGee, Krug, Peden, 2002); one reason for this is that older children (between 10 and 19 years-old) overestimate their physical capacity. However, younger children (under 10 years of age) are at risk due to undeveloped skills in swimming and a lack of

parental supervision. Among all the age groups identified within the study period, a consistently decreasing rate of drowning fatalities is observed, except for the 20-65 age group where the rate fluctuates.

Analysis of the age groups associated with drowning among visitors showed that the 20-29 years group accounted for the largest number of drowning fatalities. However, the drowning rate for the population of visitors could not be computed since denominator data were lacking. With regard to location of drowning, this research shows that unprotected areas near the Caspian Sea, and also rivers and lakes, are the most common water-hazard environments, and thus the places where most drowning incidents take place. This should be seen in contrast to the situation in developed countries where deaths due to drowning in swimming pools constitute 22-44.5%, and in bathtubs 7%, of all cases. The main reason for the observed difference is that the use of bathtubs and swimming pools is much less common in Iran (Naghavi, 2004). Unfortunately, there are very few evidence-based studies regarding the locations of drowning incidents that have been reported to the World Health Organization, so a comparison on this factor cannot be made at global level.

The majority of drowning deaths take place during the rainy season, when water levels in the ponds, lakes, rivers and wells are high, whereas in the summer season, the majority of deaths take place when recreational swimming is popular during the warmer months of the year. The presence of strong undertow, rip currents (Figure 9) and occasional high wave action in the Caspian Sea creates hazardous environments, even for skilled swimmers. But we still found, on average, that a proportion (3%) of drowning incidents in each year of the study period was related to fishing and boating. This was considered in the intervention program, in the message to make the presence of PFDs in boats compulsory.

The literature review confirmed that many drowning victims have alcohol in their blood. However, no information about alcohol use among victims was collected.



Figure 9: Rip currents in the Caspian Sea.

6.2 THE DROWNING-REGISTRY SYSTEMS (PAPER II)

The problem of drowning is considerably underestimated, as shown in Study II. The main types of biases that affect the validity of a study concern selection and misclassification. Selection bias may be a validity issue in our studies, since we included only unintentional drowning victims in our research; motor-vehicle-related cases of drowning were coded as transport incidents, and suicide- or homicide-related cases were not included. A study in Iran has reported that 3.6 of cases of drowning might be coded as suicidal, and 0.3% as homicidal (Anary, 2010).

In our studies, misclassification of causes of death may have resulted from some of the deceased being treated by private health care workers. In fact, the DRS does not record this type of case, or the case where a victim is admitted to hospital due to the delayed effects of submersion, e.g. for the evaluation of possible neurological effects. Nor does the DRS include cases where victims have a hospital stay longer than 30 days before death occurs, even when the event would have been recorded as a death with a neurological cause, rather than drowning.

Under-reporting is also likely to occur, particularly in rural areas, if a victim's burial takes place before the authorities are notified. In Paper II it is estimated that about 13.5% of all drowning cases are not reported, which is comparable with the situation in the USA, Australia and China (Passmore et al., 2007, Ya et al., 2007). A total of 237 (CI 95%: 219 - 255) drowning cases are reported in Paper II, corresponding to a mortality rate of 5.26 per 100,000 population. This estimate suggests that the DRS may actually ascertain only 70% of the estimated total number of drowning cases, and that the FMS only uncovers 54%.

6.3 A COST OF INJURY MODEL FOR DROWNING PREVENTION (PAPER III)

Our third paper introduced some significant concepts concerned with the cost elements that affect the futures of families in developing countries, where most family members depend on one person's earnings. The concepts of Income Adjusted by Family and Years, Income Impact on the Family, and Death Costs are new to the costing of drowning. Our model shows that the economic impact of drowning on families is much higher than that indicated when only the victim's income is considered, or when only traditional medical and employment costs are included.

A mixed study design, adopting both a top-down and a bottom-up approach, was employed; the top-down study is based on registry data, while the bottom-up evaluation was conducted as a population-based study. One of the shortcomings of the top-down approach is that a number of costs in low and middle income countries like Iran may remain undetected, potentially leading to an underestimation of costs. Since bottom-up studies are population-based, they provide information from previously undiagnosed cases. Then, inter-observational and inter-individual biases are avoided. No comparable data are available on the costs of drowning in low and middle income countries. However, the results on direct costs, based on country income, are comparable (Mathers and Penm, 1999; Moller, 1999). The model, in its present form, cannot predict the economic burden at country level. For such estimation, we need large-scale national studies.

6.4 SOCIOECONOMIC AND CULTURAL BACKGROUND TO DROWNING (PRE-PAPER IV)

The risk of dying from drowning was found to be higher among the children of older rather than younger mothers. Baqui et al. (1998) have reported a similar finding. This may be because older mothers usually have more children, and mothers and other caregivers in households with many children may pay less attention to the safety of their children than households with fewer children. This thesis also shows that the children of families with less educated mothers and lower economic status are more vulnerable to drowning, because those mothers are less experienced in closely supervising their children. This finding is consistent with those of previous studies (Barss et al, 1998), See Table 6.

That there was a major impact of drowning on victims' mothers, when the child victims were under ten years of age, was an important finding from interviews with mothers; the issue has received only limited attention in previous studies. Unfortunately, many of the mothers have experienced high levels of depression and anxiety, suffered from posttraumatic stress disorder, and have had difficulties in relationships, work and daily life. On the other hand, greater behavioral control within the family unit and the enhancement of social support tend to reduce the burden felt by caregivers (Söndergaard et al., 2003; Lindencrona et al., 2008).

6.5 INTERVENTION ON DROWNING IN NORTHERN IRAN (PAPER IV)

The principal finding of our fourth study was that there was a greater reduction in fatal drowning in the intervention than in the control area. It was difficult to measure the effectiveness of the individual intervention components separately. Therefore, the evaluation only considered the overall effect of the whole package.

Some important features need to be considered when interpreting the results. First, the baseline drowning fatality rate in the intervention community was found to be similar to that reported from other low and middle income countries. A randomized community cluster analysis (Macaulay et al., 1999) was not logically feasible, so a quasi-experimental design was employed. It may be questioned whether this design can distinguish the program effect in the intervention area from general trends in drowning rates. However, applying a quasi-experimental design is the only practical way of assessing the efficacy of countermeasures or of preventive interventions (Bangdiwala, 2001; Larsson et al., 2006). As a consequence, multiple prevention measures were implemented, in conjunction with each other, to develop an intervention package that consisted of both "passive" environmental or engineering solutions and "active" behavioral solutions. Paper IV shows that drowning prevention is feasible if it is supported by the processes and outcomes generated by the program implemented near the Caspian Sea coastline.

The first factor involved was the focus on encouraging communities to deliver a water-safety program, on the basis of a "community champion" model. The second factor was the presence of lifeguards and lifesavers. A lifesaver initiates rescues without

equipment, whereas a lifeguard is a rescue professional (Stallman, 2004). An interesting question arises regarding the role of the lifeguards who were evidently involved in cases of drowning. How quickly did these lifeguards respond, and were their responses appropriate? Early resuscitation efforts are needed at the scene. Our study suggests that lifeguards and health workers (Behvarz), and volunteers from the Red Crescent Society, would benefit from CPR certification.

In addition to the availability of a lifeguard if rescue or resuscitation is needed, the presence of lifeguards may also discourage behaviors, e.g., horseplay, that might put swimmers at risk of drowning. This has been witnessed in comparable studies performed in the USA and Brazil (Branche et al., 2001, Szpilman, 1999). As mentioned above, lifeguard monitoring has three components: a realistic budget, an adequate number of lifeguards per swimmer, and quality lifeguard services. The first component has a budget restriction; lifeguard services cannot provide adequate protection if, like this research, they only cover the summer season. The second component consists in the ratio of lifeguards to swimmers, which depends on the number of swimmers, and may increase or decrease due to unexpected fluctuations in the level of tourism; for example, visitors were much more active on the Caspian Sea coast in 2007 than in other years during the study period. In many countries, like Greece and Brazil (King Decree, 1973; Decree Law, 2000), the number of lifeguards in relation to number of swimmers is stipulated by law: in Greece one lifeguard per 600 m. of beach, in Brazil two lifeguards per 500 m. of beach (Szpilman, 1999), but in Iran no such legislation has been passed. In this thesis, the researcher considered one lifeguard per 1,500 m. of beach on the Caspian Sea coast. However, he suggests that one lifeguard per 500 m. of beach is preferable around the Caspian Sea, where each 500 m. of beach comprises one risk hazard area. The third component of lifeguard monitoring is quality of lifeguard services. On the Caspian Sea coast, the hours of operation of lifeguard services are 8 am to 8 pm, but we found that men are likely to engage in water-recreation activities at any time during the day or night.

Our FGD participants' perceptions of male predominance, places of drowning, seasonality and lack of adult supervision corroborate the findings of our first paper. In terms of knowledge, the participants appeared to be well aware of drowning prevention measures, but the FGDs revealed that parents and caregivers rarely take any measures to protect their children from drowning. The community expressed specific ideas on what they thought could be done to reduce the burden of drowning mortality, and the focus on maternal vigilance is promising. Children need to be regarded as community assets, and vigilance needs to be extended beyond the mother to all family members, and possibly outside the home. Physical proximity is the only form of supervisory behavior (compared with visual or auditory supervision) that is protective for children. The gap between knowledge and behavior may be due to the prevailing culture and the practice of accepting drowning events as natural and inevitable, which results in a lack of effort at both individual and community levels. The majority of the participants expected that some measures, especially the fencing-off of rivers and canals/waterways should be taken by governmental organizations. In the developed world, pool fencing, alongside some legislation, has proved to be an effective means of drowning prevention. Finally, due to the relatively short duration of the intervention, the restricted number of first responders prevented the demonstration of any significant effect with regard to reducing fatal drowning. If the intervention period had been prolonged, the number of first responders would have increased, and some changes might have been observable.

The evaluation had a number of limitations, since inadequate budgets limited evaluation designs and activities. The most significant limitation lies in a lack of comparison data, which constrains the drawing of conclusions about the associations between the program and observed changes on impact and outcome measures. Because of defects in the estimates of the tourist population, the rate of drowning was not calculated for this group. Finally, trend analysis was not possible due to the limitation that conclusions could not be drawn from such a restricted number of observations.

6.6 VALIDITY

6.6.1 Internal validity

Three main types of biases might have threatened validity in the study: selection bias, misclassification, and confounding. To minimize selection bias, we included only unintentional drowning victims in our findings. Thus, the main potential sources of bias in our studies are likely to be data misclassification and confounding. We demonstrated some shortfalls in the reporting of drowning events, owing to the fact that information on drowning deaths in a number of cases was incomplete, or lacking, perhaps at least partially due to misclassification of the cause of death. Under-reporting may also have influenced reliability, despite the fact that data were gathered from multiple reporting systems. Additional studies involving the capture-recapture of data may prompt improvements in injury registry systems for similar study populations. Overall, bias in selection effects refers to differences between intervention and comparison groups in before-after studies. Any two communities labeled as similar in our research are unlikely to be identical in all the respects that might have affected the impact of the intervention. The choice to conduct a before-after study is usually determined by whether resources for carrying out that study are an issue, and might involve confounding factors that are difficult to control for, whereas the use of quasi-experimental designs, which are easier to interpret, can facilitate the determination of at least a few potential confounding factors.

To overcome problems of internal validity, the researcher used multiple triangulation (Kimchi et al., 1991). The researcher and his supervisor were familiar with the study area and its health framework (Mohammadi et al., 2005). We effected secondary triangulation by using multiple data sources (the DRS, the FMS, interviews, and weekly reports). In terms of tertiary triangulation, the thesis used household surveys, focus group discussions, brainstorming, a literature review, the cross-sectional survey method, the capture-recapture technique (Kiakalayeh et al., 2011a), an analysis of the economic burden (Kiakalayeh et al., 2011b), and a quasi-experimental study, each of which targeted specific research problems. A fourth triangulation was achieved by adopting more than one strategy for statistical analysis of the data, including regression, the computation of odds ratios and chi-square, and t-tests. There was also a qualitative analysis.

6.6.2 External validity

Since the results presented in this thesis are largely based on registry systems that essentially comprise all the regions of Iran, our results are likely to be applicable to the whole population. Also, the data collected for this thesis were used within a health system framework in a rural setting similar to those existing in more developed countries.

The main strength of the thesis lies in the high response rate of the family members interviewed, combined with the accuracy of the data generated by careful data management, by the participation of trained health care workers, and through active follow-up. Also, the capture-recapture method is effective with regard to cost. With regard to Paper III, for which costs were calculated from different data sources, it was possible to generate rich data related to drowning prevention from the perspectives of different stakeholders.

7 CONCLUSIONS

This thesis presents studies showing that a prevention program to counteract drowning is feasible when high-quality local drowning data are employed to target and model community-based injury prevention.

Application of capture-recapture methodology may provide better accuracy in measuring drowning events, and also help in the estimation of incidence rates and in comparisons between different populations.

The results of our studies show that drowning continues to have a significant impact on the northern Iranian community and its health care system. In addition to reducing the injured-person costs identified in the studies, effective prevention programs were found to lead to cost savings in other areas related to drowning events, such as damage to property. Further, local communities and health care workers should be taught basic life-saving techniques and pre-hospital care.

The thesis shows that drowning prevention is possible by raising community awareness, in partnership with relevant organizations. The qualitative studies show that the intervention program was well received in the community. Since the program was designed to involve the community, it was expected to be feasible and accepted by that community. To determine the effectiveness of the intervention package, we need to increase efforts to develop its evidence base, e.g. by expanding the time intervals of analysis to evaluate long term-impacts and to consider seasonal variation. Further work needs to be undertaken to implement programs of this kind in a more strategic manner, especially in similar sociocultural, economic and geographic settings. Such strategies need to take account of behavioral and ecological change.

8 RECOMMENDATIONS

This thesis shows that our drowning prevention program constituted a feasible intervention package in Guilan Province in northern Iran. The results of our studies provide material for policy-makers to extend the prevention program to similar areas, particularly to Mazandran Province, which was the control area in our research. The program can also be used as a model for other safety promotion activities in similar settings. Therefore, the program should be continued and improved, so as to understand its success, and also the challenges that might arise from scaling-up. In order to overcome these challenges, further research is necessary.

To have a truly effective national drowning-prevention strategy, at-risk populations, particularly children, should be trained in basic swimming and rescue skills, and many more rescue stations are needed in areas where swimming take place. Necessary changes include having buoys and markers to delimit swimming areas, and making available lifesaving devices, consisting of life jugs, ring buoys and lines, and poles and prominent signs.

The lifeguard service provided by trained professionals (lifeguards) and community volunteers (lifesavers) in implementing the prevention program was a vital tool in drowning prevention in a coastal area of the Caspian Sea. And Iran's health care delivery system is ideally positioned to provide support for complementary drowning prevention strategies, employing education as an essential element in rural settings around the Caspian Sea .

Personal flotation devices (PFDs) can be provided, on a loan basis, in popular swimming areas along the Caspian Sea coastline; there is experience of successful implementation of such provision in Sweden over many years.

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