DOCTORAL THESIS

CHILD BURN INJURY PREVENTION IN MONGOLIA

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2023

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LIST OF ABBREVIATION

Abbreviation	Definition
ARIMA	Autoregressive Integrated Moving Average
CV	Contingent Valuation Method
WTP	Willingness to Pay
DBDC	Double Bounded Dichotomous Choice
ITS	Interrupted Time Series Analysis
LMICs	Low and Middle-Income Countries
HICs	High-Income Countries
CV	Coefficient Variance

GLOSSARY

Words	Definitions
Thermal burns	Thermal burns are skin damage caused by exposure to hot temperatures, such as hot surfaces, hot liquids, steam, or flame.
Radiation burns	Injuries are produced by prolonged sun exposure or other electromagnetic radiation forms, such as x-rays.
Chemical burns	Injuries are produced by contact with acids, alkaline solutions, cleansers, or chemicals.
Electrical burns	It means burn injuries caused by direct electric current.
TBSA	Total body surface area affected. It is calculated using pre-specified and age-adjusted charts.
Minor burns	Burns cover less than 10% of TBSA and less than 2% of full-thickness burns in children.
Moderate burn	5-10% TBSA, 2-5% full-thickness burn, any electric burns, possible inhalational burns, circumferential burns, and other health conditions.
Moderate burn	More than 10% of TBSA burns in young children and more than 5% of full-thickness burns, electric burns, inhalation burns, and any burns to the face, eyes, ears, genitalia, or joints, are accompanied by other injuries.

ABSTRACT

The author of this dissertation aimed to find a better approach to preventing child burn injuries in Mongolia. In Chapter I, the author reviewed the trends, causes, and countermeasures of child burn injuries in Mongolia and the fundamentals of injury prevention strategies. The burden of burn injuries is substantial among Mongolian children. The author's previous study, including 906 children hospitalized for burn injuries, revealed that children under the age of five years who live in gers with no separate kitchen area were vulnerable to scald injuries. Moreover, electric cooking appliances were responsible for two-thirds of major scalds among hospitalized children. In the past, community-based educational campaigns were implemented to prevent child burn injuries from electric cooking appliances, though the effectiveness of the campaigns has not been evaluated.

In Chapter II, the author therefore examined the effectiveness of two community-based educational campaigns conducted from June 2014 to May 2015 and from January to February 2017 to prevent child burn injuries from electric cooking appliances, using an interrupted time series analysis based on the hospital injury surveillance data. During the 10-year study period from 2009 to 2018, 18,433 children under the age of five years sought medical care for scald injuries, with 6,920 (38%) cases being severe. Before the first campaign, the monthly incidence rate of scald injuries increased by 0.5%. After the first campaign, the rate decreased by 3% per month. However, the rate increased again after the second campaign by 3.7% per month. These changes in the trend were observed in both sexes. However, there was no significant change in the trend of severe scald injuries throughout the study period in either sex. The author concluded that alternative interventions should be considered

to prevent severe scald injuries from electric cooking appliances by using an environmental approach given the limited effectiveness of an educational approach.

In Chapter III, the author examined parental acceptance and willingness to pay for a newly designed kitchen rack as an environmental approach to prevent pediatric scald injuries from electric cooking appliances in a particular type of housing in Mongolia. The kitchen rack was designed to make electric cooking appliances inaccessible to children. The author used the contingent valuation method with a double-bounded dichotomous choice technique to elicit their willingness to pay for the kitchen rack. The participants were fifty households with children aged under four years, and the kitchen rack was well-accepted by the parents. The median willingness to pay was US$37. The median willingness to pay appeared to be higher for the households with higher income, child burn experiences, and more children under five years.

In Chapter IV, the author discussed the study findings and policy implications for preventing pediatric scald injuries in Mongolia. The current pediatric burn prevention efforts should be reconsidered since educational campaigns were ineffective in reducing severe scalds. As a measure to prevent severe scalds, the proposed kitchen rack is potentially accepted among the target household with children. Presumably, once the effectiveness of the kitchen rack is confirmed, their willingness to pay for the rack will increase, given their familiarity with pediatric scalds due to electric cooking appliances, which makes marketing of the rack more realistic. Moreover, the government might be motivated to provide subsidies to those households with children to purchase the proposed kitchen rack because public expenditures for burn treatment, which is free for children, can be reduced by reducing the incidence of burn injuries. Burn prevention efforts in Mongolia should employ an environmental approach in addition to an educational approach for better outcomes.

CHAPTER I. INTRODUCTION

1.1 Backgrounds

The burden of pediatric burn and scald injuries is a significant public health concern. Globally, burn injuries cause more than 265,000 fatalities, around 95% of which occur in low and middle-income countries (LMICs)[1–3]. In 2013, the mortality rate of burn injuries among children one to 14 years of age was 2.5 per 100,000, ranging from 0 to 9.5. The burden was most noticeable in Mongolia and some African countries (**Fig. 1–1**)[3]. Additionally, 11 million non-fatal burn injuries occur annually, many of them resulting in prolonged hospitalization and disability[4]. About 18 million disability-adjusted life years (DALYs) are lost annually, approximately 94% of which occur in LMICs[1]. Those with permanent disabilities and disfigurements from burn injuries in LMICs are often among the poorest and the most vulnerable people who have difficulties coping with devastating health and economic consequences[4,5].

According to data from the burn registry, globally, over 50% of burn injuries occur among children under the age of 18 years, particularly among young children [4,6,7]. Many sustain severe injuries that need surgical treatment or end in death or permanent disability (48% of them undergo surgical procedures)[7]. Pediatric burn injuries frequently occur at home[8,9]. Crowded living environments with open fires and cooking spaces with particular cooking appliances contribute to the high risk of child burn injuries in many LMICs[10–16]. The type of burn injuries varies between countries depending on their living environment. In Africa, severe pediatric burns from open fires are common in households where open fires are used for cooking and heating[4]. In Asian countries, including Mongolia, pediatric scalds are common, particularly in housings with mutual living and cooking space.

Comprehensive burn care improves survival and minimizes the long-term consequences[17]. However, resources for such care are less available in LMICs[6,7,18]. Reports from Ghana, Nepal, Mexico, India, and Vietnam suggest that a lack of emergency and critical care capabilities and human resources is a common barrier to achieving desirable results[16,19,20]. According to the research of 2506 patients from three LMICs, patients were waiting 4-6 years for contracture release, resulting in an adverse prognosis 12.7 times higher than in high-income countries[21].

Treatment of burn injuries is costly[22], which is more expensive when the injuries are more severe[23,24]. The financial burden on the healthcare system is significant. For example, in the United States of America, the direct cost of caring for children with burn injuries was US$ 211 million in 2000. An estimated US$26 million is spent yearly in South Africa to treat burn injuries caused by kerosene (paraffin) cook-stoves[5]. Besides the high burn treatment cost, indirect expenses such as unemployment of caregivers and prolonged care for physical and psychological distress are burdensome[25]. Furthermore, studies demonstrated that burn patients and their caregivers experience elevated anxiety, traumatic stress, and higher long-term psychological distress[26,27]. These economic and psychological burdens might affect their subsequent therapy and daily life. In conclusion, the burden of child burn injury is prominent in developing countries where comprehensive treatments are less available.

1.2 Overview of child burn injuries in Mongolia

Burn injuries are the third leading cause of morbidity among children aged under five years in Mongolia[28]. A previous community-based survey of 900 caregivers showed that 27% of children had a history of burn injury, and 70% lived in ger areas[29]. Sh. Nansalmaa identified that the cause of the death of burn injuries among children aged under five years shifted from flames to scalds after 2004 in Ulaanbaatar. From 2004 to 2014, the mortality rate of burn injuries increased from 3 to 26 per 10,000 children (**Fig. 1–2)**[30].

According to hospital-based injury surveillance, pediatric burn injuries showed an increasing trend among children under the age of five years between 2006 and 2020 (**Fig. 1–3)**. The incidence rate of burn injuries requiring outpatient care was 162 per 10,000 in 2006, but it reached 259 in 2020. During the same period, the incidence rate of burn injuries requiring inpatient care increased from 49 to 61 per 10,000[31].

1.2.1 Factors associated with childhood burns from the previous study

Understanding the causes of burn injuries is essential for developing prevention strategies[32]. Therefore, a previous study by the author aimed to examine the circumstances of burn injuries among hospitalized children at the NTORC between August 2015 and July 2016[15]. A survey of 906 child inpatients in the National Trauma Orthopedic Research Center (NTORC) found that infants and toddlers were at an elevated risk of burns and scalds if they lived in a ger or detached houses with no designated cooking space[15]. Of the child inpatients, 83% were children aged under four years. Two-thirds of them had injuries while cooking activity in those houses. The most common cause of burn injuries was contact with hot liquids in electric pots and kettles (93%). Two-thirds (66%) of the inpatients were severely injured, and 52% were inflicted by the electric pot (**Fig. 1-4)**. Additionally, the electric pots caused more severe injuries than any other hot liquid container. While children frequently fell into electric pots, they often pulled the electric kettles over themselves. Since 2000, these electric cooking appliances have widely become available for convenience. These results suggested that in other to lower the incidence of pediatric burns, preventive measures are needed to rethink the cooking area in a ger, which lacks a designated cooking space.

1.2.2 Burn preventive actions in Mongolia

The government of Mongolia approved the "National Injury Prevention Program" and implemented it in 2009[33]. This national program aimed to reduce the high rate of deaths and burn injuries by coordinating inter-sectorial activities, improving the participation of citizens and communities in creating a safe living environment, and improving emergency services and critical care management. This program aimed to decrease the incidence rate of child burns from 80 to 66 per 100,000 by 2022.

As part of the injury prevention program, a local NGO launched educational campaigns to raise public awareness about child burns from 2014 to 2015. These campaigns primarily aimed to draw public attention to scald hazards such as electric pots and kettles, which cause excessive scald-related deaths. In addition, the government conducted educational campaigns calling for "Child burn-parental responsibility" in 2017. Evaluating these efforts is critical to moving from unreliable prevention practices to evidence-based ones.

Injuries are not accidents but are avoidable if preventative measures are appropriately designed and implemented. Over four to five decades, burn rates have significantly decreased in high-income countries by implementing various preventive strategies addressing the common risk factors[17]. These strategies have made a difference in HIC through engineering regulations such as installing smoke detectors, controlling bathtub water temperatures, and adopting electrical and other residential construction standards[34–36]. Unfortunately, many of these strategies are not necessarily adoptable in most low- and middle-income settings where injury hazards and living environments differ. Therefore, pediatric burn prevention actions should be issue-focused and country-specific.

1.3 Conceptual framework of injury prevention

The five E's (Epidemiology, Engineering, Enforcement, Education, and Evaluation) are key components in the framework of injury prevention (**Fig. 1-5**)[37]. First, finding epidemiological characteristics such as patients' demographics, injury hazards, and circumstances surrounding injuries is essential to plan and implementing injury prevention strategies. In this regard, the model has been proposed from the early years. In 1949, John Gordon[38] established the model that injuries occur due to destructive relationships between the host, the vector, and the environment. In 1968, William Haddon adopted it and developed the conceptual framework called the "phase-factor" model or "Haddon matrix" for identifying injury risks and planning prevention strategies[39–41]. The model describes that injuries result from an interaction of factors, namely a host, agent, and physical and social environments. Burn injuries result from an uncontrolled transfer of thermal, electric, or chemical energy to the human body (host) to the extent that a body cannot tolerate it. These injury-producing energies (agents) are transferred to the host in certain circumstances (environment). The second dimension of the model is the injury event phases: pre-event, event, and post-event. Understanding the time phase of injury events is helpful in planning interventions at each phase, i.e., blocking risk factors for an injury, reducing the possibility of an injury being severe, and alleviating the consequences of an injury. These are referred to as primary, secondary, and tertiary prevention.

Once the epidemiology of injuries is clarified in terms of the type of risk factors and even phases, injury prevention strategies can be planned. There are two main approaches to injury prevention. One is an educational approach that aims to convince people to adopt preventive measures to make an injury less likely to happen. This approach, referred to as active intervention, is often necessary but not necessarily sufficient for behavior change. The other is an environmental approach or passive intervention which aims to modify physical and social environments by preventing the release of hazards, placing barriers between hazards and people, and changing the nature of hazards. This approach requires engineering and enforcement through regulation and law (**Fig. 1-6**)[34].

Finally, the evaluation of injury prevention strategies is indispensable to identify the extent of success or reasons for the failure of the strategies. In this regard, Carol Runyan made a unique proposal to apply the third dimension to the Haddon matrix, which is the decision criteria of prioritizing and implementing prevention strategies such as effectiveness, cost, freedom, equity, stigmatization, preferences, feasibility, and other identified criteria of the prevention strategies[42] (**Fig. 1-7**). In this proposed model, the problem is defined, potential solutions are conceived, and the values of each solution are weighted against alternative solutions in terms of the decision criteria. For example, the cost of a child safety product may be compared to its potential effectiveness in preventing injuries when the safety product is selected. These criteria may help us find realistic strategies.

. [37].

1.4 Literature reviews for child burn prevention in LMICs

In this section, the author reviewed studies related to the intervention to prevent pediatric burn and scald injuries in LMICs. The databases, including MEDLINE, EMBASE, Cochrane Library, and Web of Science, were used to search the literatures, using the following keywords: (("child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields] OR "child s"[All Fields] OR "children s"[All Fields] OR "childrens"[All Fields] OR "childs"[All Fields]) AND ("burns"[MeSH Terms] OR "burns"[All Fields] OR ("burn"[All Fields] AND "injury"[All Fields]) OR "burn injury"[All Fields]) AND ("prevent"[All Fields] OR "preventability"[All Fields] OR "preventable"[All Fields] OR "preventative"[All Fields] OR "preventatively"[All Fields] OR "preventatives"[All Fields] OR "prevented"[All Fields] OR "preventing"[All Fields] OR "prevention and control"[MeSH Subheading] OR ("prevention"[All Fields] AND "control"[All Fields]) OR "prevention and control"[All Fields] OR "prevention"[All Fields] OR "prevention s"[All Fields] OR "preventions"[All Fields] OR "preventive"[All Fields] OR "preventively"[All Fields] OR "preventives"[All Fields] OR "prevents"[All Fields]) AND "lmic"[All Fields]) AND (fft[Filter]). Additionally, the author identified the studies or reports on injury prevention programs in LMICs from the references cited in the searched literature. In the search process, the author found two systematic reviews on burn prevention in LMICs between 1983 and 2020[43,44].

The first systematic review by Rybarczyk et al. included research articles published between 1983 and 2015 on preventing burn injuries in LMICs[43]. The study covered a total of 11 articles on educational approaches targeting the family, school, and community to reduce potentially hazardous behaviors or increase the knowledge of potential causes of burn injuries. Most of these articles concluded that educational programs increased knowledge and reduced risky behaviors. The reviewers suggested that the effectiveness of these educational interventions for burn prevention should be evaluated using burn morbidity or mortality as an outcome. Moreover, environmental interventions should be implemented alongside educational interventions to reduce the physical hazards of burn injuries.

Following the systematic review by Rybarczyk et al., Price et al. updated the review by searching for publications released between 2015 and 2020[44]. This systematic review included a total of 24 articles. Sixteen articles were related to an educational approach, four employed a mixed approach (a combination of educational and environmental approaches), and the other four focused on an environmental approach. Some articles on an educational approach evaluated the effectiveness of the interventions in terms of a change in knowledge on burn prevention. However, none of them used the burn incidence as an outcome of the interventions empirically. Moreover, only one of the four studies measured the change in knowledge but not in the burn incidences[45].

The four articles on an environmental approach evaluated the interventions with the burn incidence as an outcome. In Rwanda, Kirby et al. implemented the intervention to improve cook stoves to reduce acute respiratory disease among children[46]. They evaluated the intervention with the incidence of burn injuries as a secondary outcome and reported that the burn incidence dropped from 3.6% to 1.8% among the intervention's target population. However, the other two studies in Ethiopia and Malawi that replicated the study by Kirby et al. did not find a significant reduction in burn incidence[47,48]. In India, Chamania et al. evaluated the intervention of replacing traditional kerosene lamps with LED or solar lights[49]. They found no lamp-related burn injuries in the subsequent 6-month follow-up.

Although not covered in those two systematic reviews, the author found four studies on child burn prevention using an environmental approach conducted in Madagascar, Guatemala, China, and South Africa. A study in Madagascar identified a significant reduction in burn injuries from ethanol after improved wood stoves were introduced[50]. In Guatemala, the effort was made to replace open flames with enclosed stoves for several decades. Twenty years after the enclosed stove was introduced, the incidence rate of fire-related burn injuries halved[51].

According to a study in northern China, children had a higher risk of sustaining severe burn injuries in certain types of dwellings where a wood-burning stove for cooking and heating is attached to a bed without barriers between a stove and a bed[10]. In order to prevent child burns from the bedside stove, a barrier was distributed and installed in the targeted houses. Consequently, a decline in child burn injuries was observed. From 1996 to 2001, a total of 5,212 pediatric scald burns occurred, of which 2,213 cases (43%) were due to bedside stoves. However, between 2002 and 2010, 2,876 pediatric burns due to bedside stoves occurred, accounting for 27% of a total of 10,604 scalds.

The study in South Africa reported that over 60% of children scalded by electric kettles needed skin grafting surgery, and over 20% of the households live in informal houses with communal spaces such as cooking areas. To prevent scalds in that setting, a simple, cost-effective method was developed for preventing scalds with electric kettles by restricting the kettle's movement with a strap. One year after distributing the strap to the target population, the study concluded that the Kettle Strap was an appropriate, simple, and affordable solution for preventing pediatric scalds with electric kettles, though the effects of using the strap on the scald incidence were not investigated[52].

In conclusion, burn prevention efforts in LMICs have been evaluated mainly in improving knowledge of burn prevention. Only a few studies used burn incidence as an outcome of the interventions. Moreover, an environmental approach has been less likely employed in burn prevention efforts despite its importance in injury prevention.

1.5 Objectives

This thesis aimed to design a better preventive approach for burns and scald injuries among Mongolian children who live in traditional housing, such as gers and detached houses, where severe burn injuries frequently occur from electric cooking appliances. The following objectives have been set to achieve this goal.

1. Using an interrupted time series analysis, the author examined the effectiveness of community-based educational campaigns to prevent child burn injuries from electric cooking appliances.
2. The author examined parental perception, acceptance, and willingness-to-pay for the newly designed kitchen rack, steal furniture accommodating electric cooking appliances in the top section of the furniture, making these appliances inaccessible to children to prevent child burn injuries.

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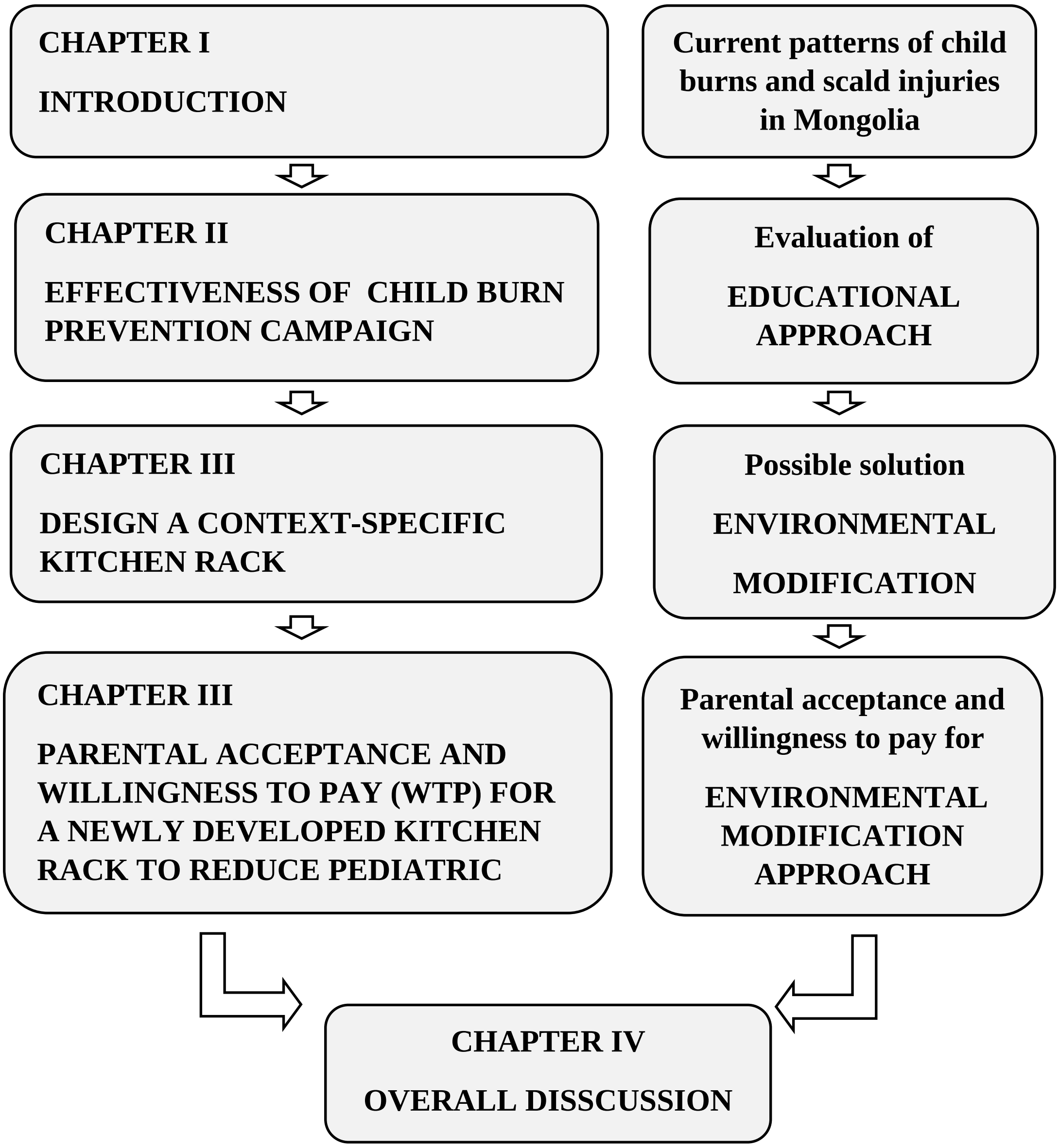
1.6 Framework of the thesis



CHAPTER II. EFFECTIVENESS OF CHILD BURN PREVENTION CAMPAIGNS ACROSS MONGOLIA

2.1 Introduction

The educational approach is the direct approach to burn injuries prevention practice[43,44]. Most burn prevention campaigns focus on raising public awareness and motivating the public, with the goal of modifying behavior to reduce incidence. In particular, educational campaigns like those in the study in Waikato, New Zealand, successfully reduced the incidence of burn injuries. Herd and his colleague gave approximately 200 lectures to target groups in the Waikato region in New Zealand to reduce burn injuries. Between 1981 and 1983, hospitalization for burn injuries in Waikato declined by 55% for children under the age of three years and 39% for children under the age of five. The author assumed that persistent efforts and the longer duration of these campaigns could explain the positive results[43]. Therefore, with little exception, educational campaigns assess interventions' effectiveness by measuring pre- and post-score in knowledge change[44]. In other words. many of the positive results of educational campaigns illustrated the increased knowledge in individuals or groups, not a change in behavioral differences.

There was a lack of evidence on whether community-based educational campaigns effectively reduce the mortality and morbidity of burn injuries[53]. Only one systematic review of community-based interventions for reducing burn and scald injuries in children was found[54]. The review included 39 studies, but only four evaluated the effectiveness of community-based educational campaigns using burn incidence data. Two of those four reported a significant decrease in burn injuries in the intervention group compared with the control groups[55,56]. Peleg and his team identified that hospitalization rates for children under the age of 5 years with burn injuries significantly dropped by 25% in the intervention group, falling from 1.39 to 1.05 per 1000. At the same time, the rate in control communities stayed the same at 1.26 per 1000 before and after the intervention[55]. In the Harstad Injury Prevention Study, Ytterstad demonstrated that in the seventh and tenth years after the interventions, burn injury rates decreased by 52.9% (from 52.4 to 24.7 per 10,000 person-years) in the intervention community. While the six cities nearby experienced a reduction of 14.1%, Trondheim, which is 1000 km away from the intervention community, experienced an increase of 9.9%[56].

A relevant example is the Boston Project Burn Prevention study[57]. This community-based study aimed to increase awareness about burn hazards and decrease the incidence of burn injuries. The project included a mass media campaign, a school-based program, and a community outreach plan. Burn incidence and severity of injury by mode among the patients were estimated during the four years before implementation of the program, during the program, and 12 months immediately after the campaign. Both school-based and mass media campaigns were ineffective. However, community outreach programs had a moderate, temporary impact on the reduction in the rate of burn injuries. This community-based study aimed to increase awareness about burn hazards and decrease the incidence of burn injuries. This project includes a mass media campaign, a school-based program, and a community outreach plan. Then it estimated burn incidence and severity of injury by mode among the patients during the four years before implementation of the program, during the program, and 12 months immediately after the campaign. Both school-based and mass media campaigns were ineffective. However, community outreach programs had a moderate, temporary impact on the reduction in the rate of burn injuries.

Evaluation of public health intervention is essential to determine whether it reduces the severity of injuries in the target population and to identify any limitations to effectiveness. However, there is no data on the effectiveness of community-based educational campaigns in reducing burns and scalds among children in LMICs. It may be difficult to show such effects in cases where the intervention's target population is small, or incidence is low in the target population. In this respect, the availability of systematic surveillance data and a high incidence of child burns provide a unique chance to assess Mongolia's burn injury prevention efforts and analyze their effectiveness. The findings of this study will help optimize the success of the intervention, or if the intervention is not practical, it will help avoid wasting resources and repeating it elsewhere. Therefore, the current study aimed to assess whether community-based educational campaigns effectively reduced child scald injuries.

2.1.1 Description of educational interventions

The government of Mongolia and a local NGO implemented consecutive nationwide campaigns to tackle child burn injuries. The NGO implemented the first program in Mongolia from June 20, 2014, to May 30, 2015. The primary goal of this campaign was to raise public awareness about the risks of domestic cooking appliances causing severe scald injuries among young children[58]. The government initiated the second campaign between January 15 and February 28, 2017, aiming to increase the responsibility and knowledge of parents and caregivers[59].

The primary intervention of the campaign was four short videos disseminated on television with the following messages[60–63].

1. Mostly, infants and toddlers are killed or severely injured from scalds.

2. Electric pots, kettles, pressure cookers, rice cookers, flasks, and stoves cause scalds.
3. These hazards should be inaccessible to children.
4. Do’s and don’ts of first aid.

These videos were also shared through social media, and posters were put up in hospitals, schools, and daycare centers nationwide. Public TV broadcasters voluntarily disseminated the videos and reported real-life tragic stories of child burns. Furthermore, community initiatives involving various government bodies, non-government groups, commercial enterprises, and even individuals raised funds for strengthening burn care facilities [64,65]. One of those fundraising events initiated by public TV-25 involved launching a one-week fundraising campaign in October 2015 to purchase essential surgical equipment for burn care[66]. These actions increase public awareness of child burn injuries throughout the country.

The second campaign’s primary message was to protect children by strengthening parental supervision. Educational material was delivered in person and through social media. However, unlike the first campaign, which lasted 12 months, this campaign lasted for just a month[67]. The motto of this campaign was ‘child burn injury—parental responsibility,’ and the campaign's target audiences were parents, day-care staff, and health center staff. Campaign posters were shared through social media and posted on the websites of governmental agencies, hospitals, and child protection organizations.

2.2 Study objectives

This study aimed to evaluate the effectiveness of community-based educational campaigns to prevent child burn injuries from electric cooking appliances, using an interrupted time series analysis.

2.3. Study methods

2.3.1 Study settings

Mongolia is located in the center of Asia, between Russia and China (**Fig. 2-1)**. The country has a small population of around 3.4 million people. The capital, Ulaanbaatar, has a population of 1.5 million, accounting for 47% of the population (**Fig. 2-2)**. In other words, half of the population resides in less than 1% of the country's territory, and the rest is sparsely distributed throughout the country[68]. In addition, Mongolia has a long, cold season, from September to May, during which individuals rely on household heating and spend more time inside their homes to stay warm. As a result, hot meals and drinks are an essential part of their daily routine. Ulaanbaatar is divided into nine districts (**Appendix 1**). According to Population and Housing Census statistics, 44% (171,700/391,700) of households reside in apartments with water and heater supply[69]. Meanwhile, 56% (220,000/391,700) of households live in the ger area[68]. Households in the ger area reside in detached houses and traditional tent-like housing called a 'ger.' The central electricity system is connected to 99.1% of residences in the capital[70].

2.3.2 Burn care delivery across Mongolia

Mongolia's health administration system is divided into capital and rural areas. Ulaanbaatar's health delivery system is divided into nine districts, which subdivide into 153 sub-districts[33]. The rural area consists of 21 provinces. Additionally, each province is divided into *soums* (sub-provinces), and then the soum is divided into *bags* (communes). Therefore, there are two referral systems in rural areas: primary care and secondary care (**Fig. 2-3**). Secondary care centers include 21 provincial hospitals and five regional diagnostic and treatment centers (RDTC). At the same time, 329 *soums* have a primary healthcare center and 1,613 communes (**Fig. 2-3**).

In Ulaanbaatar, where nearly half of the population lives, there are 153 primary healthcare providers, nine secondary healthcare providers, and 11 specialist centers or tertiary-level care providers[71]. Primary healthcare centers (PHCs) are run by family physicians and offer a wide range of outpatient services, including maternal and child care, public health services, and compulsory vaccination. Secondary care centers provide outpatient, inpatient, and emergency health services to neighboring residents for 24 hours. At the same time, all the tertiary-level hospitals and national centers offer specialized health services and educational programs. The NTORC provides trauma care, including burns, in Ulaanbaatar.

2.3.3 Study design: Interrupted time series design

There are three main methods to evaluate interventions and health programs: non-experimental, experimental, and quasi-experimental. Because random assignments often have logistical or ethical challenges, experimental designs are rarely used in public health studies. Non-experimental methods include case studies that observe an outcome before and after intervention but do not include a comparison group and static group comparisons that do not have prior observations. Non-experimental designs can usually be used with limited resources, but they are difficult to interpret because they need to account for potential confounding. These studies examine outcomes for the same subgroup of patients at a specific time point before and after receiving an intervention without referring to a control group. Unlike interrupted time series studies, which compare changes in outcomes for successive groups of patients before and after receiving an intervention, these studies compare differences in outcomes for the same group of patients before and after receiving an intervention[72].

Quasi-experimental designs are widely applied to assess the effectiveness of community-based interventions. The primary considerations for planning a quasi-experimental design are the precise time point of intervention, feasibility, and availability of data on injury outcomes. The quasi-experimental design applied in this study is a single time series design, ITS analysis. It examines trends in burn incidence for young children by comparing outcomes at multiple time points before and after an educational intervention is implemented to see whether an intervention has an effect that is statistically significant than the underlying trend[73–75]. The causal hypothesis states that after the intervention, observations will have a different level or slope than before the intervention[76]. According to a recommendation for methodology issues, ITS studies should include enough data sets and data points pre and post-intervention[77]. However, the quantity of data should be sufficient to estimate the specified model. A comprehensive analysis considering seasonality and autocorrelation requires at least 50 data observations for each time point[78,79].

ITS analysis classifies data as either looking back or forward[80]. T The analysis is then divided into two types according to whether it used just one group or if a control group was included. Concurrent events during the study may be mitigated by including a control group that is not affected by the intervention. According to a single ITS research, if the intervention is not discontinued, the immediate change in the level and trend of a particular outcome measure in the intervention group will stay unchanged **(Fig. 2-4)**[80]**.** The controlled ITS approach's counterfactual assumption is that the intervention group's level and trend will alter in about the same direction as that of the control group **(Fig. 2-5)**. The ITS method also has the benefit of being graphically appealing to the audience. The baseline levels and trends and the impact of an intervention on the graph are all clearly understood by readers[80].

2.3.4 Study participants

The study participants were children under the age of five years from the Ulaanbaatar area who were seeking burn care at the emergency department of NTORC between January 1, 2009, and December 31, 2018. The target population is likely to seek free medical care since the injury frequently occurs in disadvantaged households[15,81]. The center provides burn care free of charge for children.

Data were stratified by the demographic characteristics of children (age, sex, and residential area). The International Classification of Diseases and Health-Related Problems, 10th revision, was used to code medical records at the center. Each patient was classified by the mode of burns (scald, contact, flame, electric, chemical, or other) and the severity of their injuries. Injury severity was determined as minor, moderate, or severe depending on whether the degree of burn injury was first-degree, second-degree, third-degree, or unspecified and involved multiple body regions respectively. Population data were obtained from the National Statistical Office.

Considering physical accessibility to the NTORC, participants were restricted to patients living in Ulaanbaatar. First, accessibility and availability of burn care are unequal across the country. A recent survey assessing trauma care in Mongolia reported that Ulaanbaatar has an excellent trauma care system. However, the rest of the nation struggles with a deficiency of essential resources, including professional staff and medical equipment, to provide comprehensive treatment to severely injured patients[82]. The NTORC is the only hospital in the country that provides that service and has a nationwide surveillance system on mortality and morbidity in child burns[83]. Moreover, since the NTORC is in Ulaanbaatar, children from Ulaanbaatar mainly present to the NTORC for burn care. Although private hospitals started providing outpatient services for burn patients in recent years, data show that most trauma patients (97%) in Ulaanbaatar seek care in NTORC (**Appendix 2**). Finally, the location of the NTORC makes a significant difference in the geographical distance between rural and urban children accessing burn care.

2.3.5 Statistical analyses

To evaluate the campaign's effectiveness, we calculated the monthly rate of scald injuries per 10,000 children under the age of five living in Ulaanbaatar because the campaign was focused on child scald prevention. Further, the rate was stratified by sex and injury severity (severe, moderate, or minor).

Then, ITS analysis was performed to determine whether the rate had changed following the campaign. The regressing was applied the rate on the number of months following January 2009, the start of the study period (predictor: month), after June 2014, when the first nationwide campaign began (predictor: slope change at 66th month), and after January 2017, when the second facility-based campaign began (predictor: slope change at 97th month). After the first campaign started in June 2014 and the second in January 2017, the predictor allowed an elbow at the 66th and 97th months, respectively, for the anticipated injury rate. This analysis was further stratified by injury severity, excluding minor injuries, because the number was too small to be analyzed.

ITS analysis uses different statistical techniques to assess the effectiveness of interventions. The autoregressive integrated moving average (ARIMA) model was used in this study. A wide variety of effects may be observed when the ARIMA model is used to evaluate the intervention. We focus on two main types of effects: level change and slope change. Change in level describes an abrupt change in which the time series suddenly moves up or down by a specific amount just after the intervention. In contrast, a change in slope means a sustained change in the time series after the intervention. The variable takes a value of zero before the intervention and increases by one after the intervention starts. The educational intervention has a gradual effect, while mandatory legislation might immediately impact the outcome. Considering the nature of the intervention, the change in slope variable in the model for both interventions was included. The ARIMA predicts the dependent variable without intervention in ITS analysis and determines how the observed differs from the predicted. Unlike segmented regression, the ARIMA model does not require the inclusion of time or seasonal dummy variables. If estimating the pre-and post-intervention slope is preferred, time as a covariate and parameters of the ARIMA model address the issue of autocorrelation.

Time series data can be presented in three ways: autoregressive (AR), moving average (MA), or a combination of the two (ARMA or ARIMA). AR means the values of previous time points predict the value of the current time points. For example, the current month's incidence rate is built based on the previous month's incidence rate. AR predicts using one or multiple lagged values of the dependent variable. The MA model assumes that the value of the current time point results from previous unexpected events. Therefore, MA is predicted by one or multiple lagged values of the error. Differencing (integration) in the ARIMA model leads to stationarity. The fundamental expression of a non-seasonal ARIMA model is given by *p, d*, and *q*, which are positive integers, with *p* indicating the order of the AR term, *d* indicating the order of difference, and *q* indicating the order of the MA term. For example, a stationary (white noise) model is denoted by ARIMA (0,0,0), and an AR model with *p* lags is written as ARIMA (p,0,0), while an MA model with *q* lags is expressed as ARIMA (0,0, q).

The steps for fitting the ARIMA model are model identification and selection, parameter estimation, and model-checking.

The first step in time series analysis is identifying if the data follow the stationary data assumption. As per this assumption, data should have a constant mean and constant variance. The fundamental assumption of linear regression is that the residuals are independent and not correlated. On plotting the current data, an inconstant variance was detected. The log() function is used for stabilizing the variance. Log transformation can only be applied to time series with positive values. By taking a log, the values are reduced until they equal zero. The shrinking is large for larger values and lower for those close to one, reducing variation.

For model selection, the autocorrelation function (ACF) and partial autocorrelation function (PACF) are plotted to identify potential AR and MA parameters and the best-fitting ARIMA model. The ARIMA function in the forecast R package was used to determine the parameters of the ARIMA model based on the corrected Akaike information criterion. The values of time series observations are frequently associated with values from past time points; this feature is called autocorrelation. Consequently, a correlation between the current value and values at previous time points should always be evaluated using the ACF and PACF plots. ACF values are used to measure the correlation of values between the current month and the past month, but the incidence rate of the current month is also correlated to the value two months prior. Therefore, the analysis must remove the influence of the prior months to measure the actual correlation between the current and the previous time point. PACF helps measure the correlation by eliminating other time points' influence. Consequently, in practice, PACF evaluates the time series analysis in error terms.

For model checking, the ARIMA's residual normality was examined using Ljung-Box test statistics. All statistical analyses were conducted with R version 3.5.2[84]

After fitting the models and verifying the residual plots, a sensitivity analysis was conducted using joinpoint regression analysis based on the same monthly rate of scald injuries to identify the month in the research period when the trend in the rate shifted. Joinpoint regression has been used in many such situations, including cancer mortality rates, traffic accident mortalities, and mortality risk, to assess changes in time series data. In this case, join point regression was employed to identify structural changes in the time series of child scald injuries and to understand when it occurs. In summary, this method identifies the month when a trend change is observed and calculates the annual percentage change (APC) in rates between trend-change points, using incidence rates as the dependent variable. When there are joinpoints, the entire period is divided into segments by the points where the trend changes. The analysis calculates the yearly percent change in the trend's rate. It evaluates if the difference differs from zero at the 5% level of significance[85]. In the regression, three joinpoints were identified from January 2009 to August 2014, August 2014 to June 2016, and June 2016 to December 2018 with APC equal to 0.54, –3.02, and 0.42, respectively, and segments equal to 69, 22, and 29 months (about two and a half years), respectively. The downward trend change was noticed two months (August 2014) after the first campaign, which was launched in June 2014, whereas the upward trend change began six months before (June 2016) the second intervention, which was implemented in January 2017. Unlike in the interrupted time-series analysis (where change points were fixed at the start of the campaigns), change points in this analysis were determined as the trend data fit.

Finally, here is a little explanation about the interpretation of the model's coefficient: since the dependent variable was log-transformed, the coefficients should be interpreted as a percentage change in the outcome because it is constant for the time. For example, after taking the exponent of the coefficient and subtracting one from it, it is multiplied by one hundred. Following the above steps, when the coefficient is 0.0051, we obtain (exp (0.0051)-1) *100=0.51. It means that for every one-unit change in the independent variable, the dependent variable increases by 0.51%. The estimated change at one-year post-intervention (the time point is the 78th month, or June 2015) was calculated using the model coefficients.

2.4 Ethical approval

The Research Ethics Committee of the Faculty of Medicine at the University of Tsukuba approved (approval no. 1620) the proposal for this research.

2.5 Results

During the ten-year study period, 23,459 children under the age of five years residing in Ulaanbaatar were treated at the NTORC's emergency department for burn injuries; of these, 66% were males, and 84% were under the age of three years. As regards the cause of injury, 18,433 (79%) of the burn injuries were caused by scalding, followed by contact (19%) and flame (1%). **Table 2-1** shows the distribution of age, sex, affected body area, and injury incidence by year among children who had scald injuries (who are the subject of the following analysis) and the severity of the injuries**.**

Before the campaign, an increasing trend was observed; the monthly rate increased by 0.51% (95% CI: 0.32, 0.71). However, after the first nationwide campaign, the rate decreased by 3.13% (95% CI: −3.64, −2.62). After the second campaign started, the rate increased by 3.13% (95% CI: 2.66, 4.69). Such significant trend change was observed in both sexes. However, there was no significant change in the trend of severe scald injuries throughout the study period in either sex **(Table 2-2)**. The observed and predicted monthly rates of scald injuries are shown with grey circles and a solid line, respectively. The author regressed the log-transformed scald injury rate in the months after January 2009 (when the study period started) and after June 2014 (when the first nationwide campaign started). Then after January 2017 (when the second facility-based campaign started), where the generalized least square autoregressive moving average (1, 2) structure was applied to the residuals of the model (**Fig. 2-6**).

Joinpoint regression analysis revealed an upward trend before the first campaign with a significant annual percent change of 0.54. From August 2014, approximately two months after the first campaign began, a downward trend was observed, with a significant annual percent change of –3.16. Then, there was an upward trend from September 2016 to the start of the second campaign, with a non-significant annual percent change of 0.55. No such trend was observed in the rate of severe scald injuries **(Fig. 2-7)**.

2.6 Discussion

Between June 2014 and May 2015, a local NGO in Mongolia conducted a nationwide burn prevention campaign, and following the campaign, there was a substantial reduction in scald injuries among children under the age of five years. One year after the intervention, the relative change in the incidence of scald injuries was –32%. However, no such reduction was observed after the second campaign between January and February 2017. Additionally, severe scald injuries have remained constant over the years.

With scald-focused messages and a longer campaign duration, the first nationwide public awareness program successfully reduced non-severe scald injuries. The campaign received considerable media coverage and support from various stakeholders and individuals[86–89]. Additionally, local media channels frequently disseminated advice, guidance, and interviews with burn patients' physicians and parents[90–94]. Volunteer organizations, local businesses, and individuals initiated fundraising activities to raise resources for burn care[65,66].

However, a reduction in scald injuries was not sustained. The rate of scald injuries began to increase before the beginning of the second campaign, and this rising trend continued until the conclusion of the second campaign. Regardless of the second campaign, the benefits of the first campaign may have faded over time. It is reasonable to infer that the initial effort effectively decreased pediatric scald injuries, as it was the first time the topic was raised, and many people must have taken measures. As a result, those who failed to take preventative measures may have been pointed out during the second campaign.

There was an increasing trend in the rate of scald injuries after the second campaign, which seems to have triggered the increase. However, this is less likely, because the sensitivity analysis (join point regression analysis) suggested that the increasing trend started before the second campaign and continued thereafter. The second campaign was ineffective in reducing scald injuries for the reasons mentioned above.

Notably, major scald injuries did not decrease during the study period. The author's previous study demonstrated that severe scalds among children tended to occur with electric pots and kettles in a traditional tent-like dwelling or ger, where there is no separate kitchen. Moreover, it is common to place these electric appliances on the floor or low table in a living space while cooking[15]. In such a living environment, scalds caused by these electric appliances are unlikely to be prevented solely through education; product or environmental modifications are also needed. Electric pots and kettles, for example, can be used safely if a barrier is present or if they have been modified in some way to make them child-resistant. Manufacturers should contribute to such enhancements, and such measures may be regulated by law.

To this end, the following section discusses designing and testing a context-specific kitchen rack that makes electric appliances inaccessible to children.

2.7 Conclusion

A nationwide burn prevention program successfully reduced the rate of non-severe burn injuries in young children. Given that the campaign's primary objective was to raise public awareness about the risks of child burn injuries, additional interventions involving passive measures to prevent severe burn injuries should be considered.

CHAPTER III. PARENTAL ACCEPTANCE AND WILLINGNESS TO PAY (WTP) FOR A NEWLY DEVELOPED KITCHEN RACK TO REDUCE PEDIATRIC BURNS

3.1 Introduction

In injury prevention, removing hazards or restricting access by modifying the physical environment are considered promising solutions[41]. There are good practices for burn prevention in HICs, such as installing smoke alarms and making sleepwear flame-resistant clothing and child-resistant lighters. However, enforcement through measures such as banning electric cooking appliances and creating separate cooking spaces in a ger could be impractical. Therefore, the study designed and tested a possible solution, an environmental modification approach, to make those electric cooking appliances in their respective housings inaccessible to children. This solution is designed to reduce the risks of scalds from electric cooking appliances by arranging the cooking area using a context-specific kitchen rack.

The current study started with designing a context-specific rack to make children inaccessible to electric cooking appliances in a ger dwelling. Then, the study estimated parental acceptance and willingness to pay for a newly designed kitchen rack as a prevention tool. How much do parents value the kitchen rack? By estimating parental willingness to pay value, actual intervention can be suggested at prices the target communities can afford, resulting in the child's well-being. Therefore, evaluating the health-related and non-health-related benefits of the proposed intervention is essential for planning and implementing preventive programs.

In healthcare, economic valuation using stated preference techniques is applied to estimate an individual’s perception of non-market goods and services. The method is used for eliciting individual money valuations of benefits and costs.

Whenever a person receives a benefit, they are willing to give up something they value. How large the benefits are measured by how much an individual is willing to pay to get the benefits. Willingness to pay has the theoretical underpinnings of welfare economics to support the economic evaluation of publicly funded healthcare decision-making. Individuals judge the products' value based on how well it meets their needs and expectations[42].

This method assigns a monetary value to non-marketed goods and services where the monetary value has a particular and precise meaning. This evaluation estimates the change in individuals' well-being from product provision. People's preference determines their well-being. Hence the willingness to pay logically follows from preferences. Willingness to pay (WTP) is a measure of the utility of choice, thus, a measure of well-being.

3.1.1 Designing a context-specific kitchen rack to reduce child burn injury in Mongolia

Fig. 3–1 shows how people in a ger housing use electric pots for daily cooking. As research findings by the author suggested, severe childhood scalds occur in homes, especially those homes without a separate cooking area, when cooking with electric pots and kettles. The living environment shown in **Fig. 3-1** should be modified to reduce child burn injuries. In this regard, a context-specific kitchen rack is designed to prevent child scalds. Ideas of a possible solution were discussed with the Japanese furniture company Nitori, which designed the rack prototypes. Local mothers' opinions were considered during the rack designing process, and the rack was updated accordingly, as shown in **Appendix 3.** Prototype-2 was employed in the current study.

The kitchen rack size is 60, 55, and 75 cm (width, depth, height). The weight is 20 kilograms, and it is simple to assemble and disassemble. The top part of the rack is designed like a box accommodating electric pots and kettles (**Fig. 3-2**).

The assumption is that if parents value the rack of child burn prevention, the outcome of prevention efforts could be more effective than sole educational campaigns. Thus, the author aimed to demonstrate how parents value and accept this preventive approach (modifying the cooking environment) against child burn injuries from electric pots and kettles.

3.1.2 Parental perception

It is typically assumed that individuals have comprehensive, stable, and coherent economic preferences. An individual can establish accurate preference comparisons between the costs or benefits under consideration and the standard measurement of money. Even when employing different elicitation techniques, their preferences remain the same, making it less likely that they will vary over time. Coherent refers to the requirement that the preferences elicited by any individual be internally consistent, theoretically. WTP expressed in contingent valuation surveys is behavioral intentions from a psychological standpoint. Fishbein and Ajzen's attitude behavioral models investigated the relationship between people's attitudes and intended behavior, as revealed by surveys and subsequent actual behavior; it is called the 'theory of reasoned action'[95]. Applying the model to the current study, a particular behavior, for example, actual payment for the kitchen rack, is determined by an individual's behavioral intention, such as the hypothetical willingness to pay. This behavioral intention is the function of personal attitudes and perceptions about what behavioral belief produces individuals (and others) think. Attitude is a parental disposition to act in a certain way. Because some mothers use a similar rack to avoid child burn injuries, they may decide not to use this context-specific rack. At the same time, normative belief refers to when people close to parents agree or disagree about their behavior. For example, a mother may have positive WTP for the rack if she considers having the rack will help to protect children from scalds and perceives that others think it is a crucial thing to do so. Subjective norms are the parental perception of social norms or their peers' beliefs about the behavior. A mother may say that because the people vital to her care about her actions, she wants to protect her children. Behavioral belief produces in an individual a favorable or unfavorable attitude toward behavior. Parents of infants and toddlers are deciding on using the kitchen rack. Evaluation of behavioral belief is the values attached to the outcome or behavior or parents' positive or negative judgment—for example, an evaluation on whether to use the rack. Motivation to comply means agreeing with what friends, parents, and family think is the proper behavior, and using the rack can protect children. Then, they may be willing to use the rack. Finally, other factors such as demographic variables, attitudes toward targets, personality traits, and other individual differences may influence parental intention to behave.

3.2 Study objectives

This research aims to identify if this context-specific approach to prevention is acceptable and whether parents are willing to pay for a product to reduce burn injuries. Additionally, the study considers how the observed differences are explained by factors that influence WTP, including household income, past burn experience, number of children at home, parental perceptions of burn injury severity, susceptibility, barriers, benefits, and cues to action.

3.3 Study methods

3.3.1 Contingent valuation in health care

Klose (1998) discussed the considerable discrepancies in CVM research design regarding methodological and conceptual factors in healthcare. In particular, the elicitation methods used to determine monetary values revealed substantial differences, implying that contingent valuation, as applied in healthcare, is a set of various methodologies. Therefore, he discussed the advantages and disadvantages of four types (open-ended, bidding game, referendum, and payment card) of eliciting methods. These differences may affect the validity of CVM results obtained in the studies. In this study, a referendum with follow-up questions was applied. In this type of CVM, bids might ignore potential bids. To avoid the likelihood of ignoring, the author pre-tested the determined bids with a broad range. Additionally, in a double-bounded dichotomous choice format (DBDC), respondents are presented with two sequential bids (possible prices of the goods or services) and are asked to answer whether they are willing to pay the presented bid. Therefore, this study follows the DBDC to estimate parental perception.

Yeung and Smith (2010) addressed the key points related to CV research before explaining other technical policies and priorities and suggesting guidelines for such research. They used a systematic review of the CV literature in health to describe critical issues about the conduct of CV studies before commenting on the approach's remaining policy and research objectives and offering a guideline for such investigations. His team mentioned that CV applications have failed to deliver on the theoretical benefit of the approach, which partially reflects the lack of agreed-upon norms in health economics for conducting CV research. As a result, there is a method-policy gap, with the methodology having a minor impact on decision-making processes. The checklist for CV study in healthcare has been included in this review. Both reviews addressed that respondents' understanding of the evaluation method and the valuation task is essential to all contingent valuation studies.

The study suggested the following guidelines for designing the CV study: NOAA (National Oceanic and Atmospheric Administration) developed methodological and practical recommendations for credible CVM studies in 1993 for environmental value studies[59]. This panel study recommends face-to-face interviews and conducting the referendum in a binary style. A response rate of at least 70% is considered satisfactory. Considering these guidelines, in this study, the author used the actual product to avoid hypothetical bias and the in-person interview method to give a clear understanding of the proposed product. Moreover, the pre-tested bids are assigned randomly to each participant to avoid anchoring bias.

In summary, this study is a referendum with follow-up questions or DBDC format to elicit respondents' WTP. Therefore, respondents were given two consecutive predetermined bids and asked to indicate their willingness to pay the presented bid. DBDC enables rapid response and a high response rate, increasing statistical efficiency[60,61]. In-person interviews with trained interviewers may provide the most promising alternative for detailed questions and responses when performing a survey. In-person interviews, utilizing DBDC to elicit WTP, are increasingly used to overcome the disadvantages of other techniques, such as non-response and outliers.

3.3.2 Study settings

This research was conducted in Ulaanbaatar, Mongolia. The selected district, Songinokhairkhan, is one of the largest one among the nine districts of Ulaanbaatar, with a population of 373,000 (**Appendix 1**). In addition, 73% of households reside in the ger area within this district, which is 20% higher than in Ulaanbaatar, as shown in **Fig. 3-3,** which compares the housing types between Ulaanbaatar and the selected district, Songinokhairkhan. In this respect, the district households were invited to participate in the study. Pictures of common housing types are shown in **Appendix 5**. According to health data, this district in Ulaanbaatar has the highest rate of pediatric burn injuries. Furthermore, local authorities approved the implementation of this study within this district.

3.3.3 Study participants and data collection

The participants were from families living in a ger with children under the age of four years and using electric pots for their daily cooking. This age group accounts for 75% of children hospitalized in the Burn Unit of NTORC, according to a previous study[15]. Five sub-districts with a large ger area were purposefully chosen from this selected district. The head offices of the selected sub-districts provided a list of households living in ger housings with children under the age of four years. Ten households from each sub-district were randomly selected and contacted by phone. Each household was approached three times before being replaced with another household on the list. Research assistants could not reach around 30% of the households. In cases where a household either did not answer or their phone was not in service, a research assistant attempted to get in touch three times. Fourteen households were excluded after being contacted because they did not use an electric pot. Households that could not be contacted or did not have an electric pot were replaced randomly with new households from the lists. Questions on the cooking practice at home were asked separately. Fifty households living in gers were given kitchen racks to safely store electric pots and electric kettles while cooking to reduce scald injuries in children. Note that the author obtained information on children under the age of five years in the study questionnaires. Since young children are in the same house, they are likely to play together, potentially increasing their susceptibility to burn injury. Moreover, the history of burn injuries in those young children is essential to design the prevention approach. With this respect, though the household selection was restricted to children under four years, the questionnaires of the current study included information related to children under the age of five years.

This study was conducted from May through June 2020. At first, researchers visited with district officials to obtain permission to conduct research and collect household data on children under the age of four years living in a ger. Trained enumerators described the study's objectives, product safety provisions, installation procedures, and the follow-up survey to the participants. After scheduling appointments, two teams visited each household separately to install the rack, instruct them, and conduct in-person interviews with the mothers using questionnaires.

3.3.4 Survey instruments

Eliciting method for WTP

To employ this technique, four bids were determined for the kitchen rack (MNT 30,000, 50,000, 70,000, and 90,000) based on a pre-test with a subset of eligible households not included in the current study. The average monthly income in ger regions is expected to be between MNT 500,000 and 700,000 (MNT 100,000, around US$35). This average is much less than the national average of MNT 1,390,000. The participants were then presented with one of four randomly selected bids, say MNT 50,000, and inquired whether they were willing to pay that amount for the proposed kitchen rack. If they said yes to the first bid, they moved to a higher bid twice the first bid (i.e., MNT 100,000) for the next round. If they said no, they received a lower bid, which is half the first bid (i.e., MNT 25,000). Therefore, the minimum and maximum bids presented to the respondents were MNT 15,000 (half of the minimum first bid) and MNT 180,000 (double the maximum first bid), respectively (**Appendices 7 and 8**).

Other questionnaires

In addition to parental WTP, the survey asked about the household's demographic and socioeconomic characteristics (age, marital status, family structure, family members, and monthly income of the parents), daily cooking practices with electric cook appliances, prior experience with burn injuries, parental perceptions of burn severity and susceptibility, perceived barriers to and benefits of child burn prevention, and first aid. Respondents were asked to rate their perceived susceptibility and severity of child burn injuries and their perceived barriers and benefits of child burn prevention on a five-point scale ranging from 'strongly agree' to 'strongly disagree.' Two statements were used for each attribute. For example: 'children are at a higher risk of burn' (susceptibility), 'burn treatment can lead to a financial burden' (severity), 'removing home hazards helps prevent child burns' (benefits), and 'it is hard to pay attention to children all the time' (barriers) (**Appendix 6**).

3.3.5 Statistical analysis

The author conducted the following statistical analyses using the R statistical program, version 3.4.2. Firstly, the participating households' characteristics and experiences with children burns were described. Then, logistic regression and contingent valuation data were used to estimate a median WTP for the proposed kitchen rack. The dependent variable in the model was binary (yes or no to paying the offered bid), whereas the independent variable was the amount of the presented offer. The first bid was chosen randomly from four prepared bids ranging from MNT 30,000 to 90,000, and the second bid depended on the answer to the first bid, which ranged from MNT 15,000 to 180,000. At the aggregate level, the dependent variable shows the likelihood of paying for the offered bid, which is proportional to the bid amount.

The higher the proposed bid, the less likely it will be accepted. The author calculated the bid at which 50% of respondents were willing to pay based on this pattern of WTP. This was the median WTP for the proposed rack.

The median WTP was estimated based on household monthly income levels that are low (MNT 500,000 or less), middle (MNT 500,001–900,000), and high (MNT 900,001 or above); the level of treatment received by those who had suffered a child burn injury (no experience, at home, outpatient, and inpatient); and the number of children under the age of five in the household (one, two, and three or more). It is assumed that these variables influence the WTP for the kitchen rack. Households with several burn incidents were classified based on the highest level of care obtained. Other potential contributing factors, such as parental perceptions of child burn injury, were not included in the analyses because all respondents had equivalent perceptions. The recruitment of participating households restricted the child's age.

Based on the theoretical consideration of the DBDC method, the following dependent and independent variables were defined. Dependent variables are the answers to the first and second bids, which are binary choice variables measuring the WTP for the rack. The variables take the value 1 for a ‘yes’ answer to respective bid offers and 0 otherwise. Independent variables (first bid and second bid) are the bid amount for both the initial bid and the follow-up bid. The variables, number of children under the age of five years in a household, level of treatment for a past pediatric burn injury, and household income, were categorized. The author calculated the median WTP by controlling for the abovementioned three variables. It means the median WTP was calculated using household income level while the other two variables remained constant. This estimate was generated using the DCchoice package from the Comprehensive R Archive Network. The bootstrap approach was employed in the DCchoice package to calculate the 95% confidence interval for the median WTP based on one thousand re-samplings. (**Appendix 9**).

3.4 Ethical approval

The Research Ethics Committees of the Ministry of Health in Mongolia and the Faculty of Medicine at the University of Tsukuba in Japan examined and approved all study protocols, including the techniques for recruiting participants and collecting data. The district office also authorized us to conduct this research in Songinokhairkhan District.

3.5 Results

Characteristics of the fifty households are described in **Table 3-1.** Thirty-four participants had two or three children under the age of 5. The fifty households had 89 children under the age of 5. Around half of them were male, and approximately 90% were between 0 and 3 years old. The average age of fathers was 32 years old (SD: 5.4), while mothers' age was 30 years old (SD: 5.5). The median number of family members in the household was 5, ranging from 3 to 10, which matched national statistics. Mothers headed eight households. 33 households with income per month less than MNT 900,000 (about US$315). Seven households were with income per month of less than MNT 500,000 (approximately US$175).

Most households used an electric pot regularly, and when cooking, the pot was often put on a low wooden table, chair, or floor. Additionally, an electric kettle was used in 41 houses. Like the electric pot, the electric kettle was frequently put on the floor, a table, or a stool. Parental perceptions of the susceptibility and severity of child burn injury and the barriers and benefits of child burn prevention were consistent; the statements on each of these attributes were agreed upon or highly agreed upon by 48 of the 50 participants.

Table 3-2 summarizes the burn history since the birth of 89 children under the age of five years living in fifty households. There were 59 reported burns and scald injuries, with 30, 16, and 13 burn injuries treated at home, outpatient, and inpatient departments, respectively. Of the 50 households, 24 (48%), 13 (26%), and 11 (22%) had at least one child aged under five years treated for burn injuries at home, outpatient, and inpatient departments, respectively. There were 40 (80%) households with at least one child who had a burn injury, including 22 (44%) households with at least one child treated in the hospital. Indeed, numerous households were afflicted with several child burns and scalds. Burn injuries treated in medical facilities often occurred during a child's first year and were frequently caused by electric pots or kettles. In contrast, burns and scald injuries treated at home were primarily caused by furnaces or flasks at various ages.

The median WTP for the proposed kitchen rack is shown in **Table 3-3** by the level of treatment provided for child burns and scald injuries and the number of children under the age of five in the household. MNT 106,000 was the median WTP (about US$37). The lowest median WTP was MNT 87,000 (about US$31) for low-income households, while the highest median WTP was MNT 129,000 (approximately US$46) for households with three or more children under the age of five years. Parents with a higher income, more severe child burn experiences, and a larger family size tended to have a higher WTP.

The relationship between the proposed kitchen rack price and the proportion of people willing to pay is shown in **Fig. 3-4**. The median WTP is the price to be paid for the proposed rack by half the study participants.

3.6 Discussion

To reduce pediatric burns and scalds from electric pots, our research team developed a kitchen rack that accommodated traditional housing and assessed its acceptance in households with infants or toddlers. As shown by a median WTP of MNT 106,000 (about US$37), parents expressed interest in using the proposed rack, which corresponds to half of the households willing to pay for it at that price. This amount represents about 10% to 20% of the monthly income of households in the ger area. These findings indicate a significant demand for the kitchen rack.

The author used an actual product instead of a hypothetical scenario, as is frequently done in CV studies. Moreover, a trained researcher distributed the rack, installed it, and gave instructions to each household. The provision of the product justified the prevention of specific health outcomes, reduction of future burn care costs, and other health and economic benefits. After installing the kitchen rack, parents of young children in a ger expressed willingness to pay. It is more practical and convenient to use than proposals given in hypothetical situations. This technique enables parents to comprehend the product’s quality, fittings in a ger, and feasibility. There is a potential bias in investigating this hypothetical technique since participants may not fully comprehend the item's qualities or the perception of the products may differ among respondents. In the current study, such a risk of bias was averted.

Additionally, the logistic regression calculated in this investigation was compatible with theoretical expectations. The bid variable was significant, showing that when the price of the kitchen rack increases, demand for it decreases. Additionally, the predicted WTP was greater in households with a higher income, more severe child burn occurrences, and a higher proportion of children under the age of five years, validating our research participants' responses. In the future, we should determine if the rack will be used over time, especially during the winter, since seasonal variations in rack use may occur. In the winter, households heat their homes with a furnace. Finally, the effectiveness of the kitchen rack in reducing child burns should be evaluated using a sufficiently large sample size.

These study outcomes indicate that we should reduce the rack's cost. Half the participants expect to pay US$37 or 20% of their typical monthly income. However, this amount is less than the cost of production. Cost reductions may be achieved through mass manufacturing and local manufacturing. The primary function of this product is to ensure safety. However, there is uncertainty regarding how to produce the rack using locally available resources. The effectiveness of the kitchen rack in preventing child burn injuries must be evaluated. In 2013, the government began enforcing the use of car seats for children under ten years of age. That action was promoted by government subsidy. As a result, if the author can demonstrate the rack's effectiveness in reducing child burn injuries, the government may support this intervention.

Demonstrating the effectiveness of the kitchen rack in reducing child burn injuries is a strategic goal. The author has already started planning an assessment study to evaluate the effectiveness of the proposed rack in reducing pediatric scalds and burn injuries. There are significant barriers to obtaining funding for a main trial. Indeed, an effective primary preventive strategy is essential in burn care if the feasibility is tested. Thus, it is critical to determine whether the method decreases pediatric incidence and saves further healthcare costs at individual and healthcare system levels. This evidence-based data may influence the government to consider subsidizing the widespread adoption of a burn injury prevention device.

The study had a sample size of fifty participants. However, the author conducted a random sampling of the community. Due to the limited sample size, the estimated WTP had larger confidence intervals. Additionally, parents may ignore financial limits when offering WTP because many have substantially experienced the burden of child burns.

Additionally, parental perceptions of child burn injury susceptibility and severity and the barriers to and benefits of child burn prevention appeared consistent, with minor variations in perspectives. These factors may have a beneficial effect on their purpose. The estimated WTP was higher among households that had experienced severe burns. However, the estimated WTP (MNT 106,000) seems reasonable given the market prices for an electric pot (about MNT 40,000–70,000) and an electric kettle (around MNT 8,000–25,000) at the time of the research. The WTP was determined using the fixed price of four initial offers within a specific range. This range may be limiting the WTP that respondents offer. To avoid this bias, a pre-test was done to determine the likelihood of ignoring a broad range of offers.

The author used the guidelines to establish the offers. Additionally, the initial bid was randomly assigned to the first bid to minimize anchoring bias. In-person interviews and utilizing DBDC to elicit WTP are increasingly used to overcome the disadvantages of other techniques, such as non-responsiveness and outliers.

3.7. Conclusion

To conclude, the kitchen rack it developed to prevent child burns was accepted by Mongolian households with infants and toddlers who live in traditional tent-like dwellings. The willingness to pay for the kitchen rack was greater among households with a higher income, a history of severe child burns, and a larger child number. The rack's efficiency in preventing child burn injuries is the next step.

CHAPTER IV. OVERALL DISCUSSION

Burn prevention efforts in Mongolia were primarily directed at public awareness through educational interventions like in other LMICs. Educational interventions aim to convince people to change their behaviors to prevent burn injuries by increasing their awareness of the risk of burn injuries. However, there has been a lack of evidence regarding the relationship between increased awareness and the reduction of burn injuries. In Chapter II, the author demonstrated that educational campaigns for child burn prevention in Mongolia, with specific messages targeting a high-risk group and emphasizing home hazards, reduced the incidence of non-severe scalds. However, the campaigns had no impact on reducing severe scald injuries. Educational interventions might be effective if they are carefully planned and sustainably implemented, focusing on a specific burn type, not all burns[96,97].

Child burn prevention will be possible only if risk factors are recognized and these risk factors are readily changeable. In the study of Chapter III, all parents accepted the kitchen rack as a means of protecting children from scalds, perhaps because parents recognized home hazards that increase the risk of scalds and perceived that the kitchen rack would increase the safety of the cooking area, reducing the risk of scalds. Indeed, there was an apparent demand for the kitchen rack.

The demand curve for the kitchen rack generated in this study illustrated that 50% of households with children were willing to pay MNT 106,000. In other words, if the rack costs MNT 106,000 in the market, about half of the households might purchase it. If the rack price is MNT 150,000, almost 20% of the households might purchase it. If the rack price drops to MNT 50,000, over 80% of the households might purchase it. Using the demand curve, we can estimate how the rack price would affect the demand for the rack. This information helps facilitate the diffusion of the rack.

The author expects the following scenario. Once the effectiveness of the kitchen rack is confirmed, the willingness to pay for the rack among the target households with children will increase, given their familiarity and experience with pediatric scalds due to electric cooking appliances, which makes marketing of the rack more realistic. Moreover, the government might be motivated to provide subsidies to those households with children to purchase the kitchen rack because public expenditures for burn treatment, which is free for children, can be reduced by reducing the incidence of burn injuries. The kitchen rack might be rapidly diffused to targeted households in this case.

Pediatric burn prevention requires complex, multi-faceted efforts[56]. As discussed earlier, there are two distinct injury prevention approaches: educational and environmental. Considering human errors, an environmental approach is preferable. In the case of the present study, the kitchen rack blocks the causal pathways of scald injuries between children and electric cooking appliances. However, an educational approach is still needed to inform people of the usefulness of the kitchen rack and convince them to use it all the time. In other words, these two approaches are not mutually exclusive, and both are required to achieve the prevention goals.

Mongolia's current pediatric burn prevention efforts should be reconsidered, and better preventive measures are urgently called for. Since it is known that electric pots and kettles are the main products causing severe burn injuries, the author proposed the kitchen rack as a means of preventing burn injuries due to these electric appliances. Alternatively, if electric pots and kettles are somehow modified to be childproofed, they can be safely used at home though it is uncertain whether such modifications are feasible. In any case, the burn prevention efforts in Mongolia should employ an environmental approach in addition to an educational approach for better outcomes of the efforts, and regular epidemiological evaluation is indispensable to determine the trend of burn injuries and improve the prevention efforts.

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TABLES

Table 2-1. Characteristics of children who were treated for scald injuries at the Emergency Department of the NTORC from 2009 to 2018, shown by the injury severity

	Severe (n=6920)		Moderate (n=10390)		Minor (n=1123)	
	n	%	n	%	n	%
Sex						
Male	3021	43.7	4618	44.4	498	44.3
Female	3899	56.3	5772	55.6	625	55.7
Age						
0	1268	18.3	2194	21.1	250	22.3
1	3158	45.6	4692	45.2	527	46.9
2	1317	19.0	1787	17.2	161	14.3
3	689	10.0	1066	10.3	126	11.2
4	488	7.1	651	6.3	59	5.3
Affected body region						
Multiple body regions	2483	35.9	618	5.9	0	0
Hip and lower limb	1444	20.9	2248	21.6	162	14.4
Wrist and hand	905	13.1	2356	22.7	322	28.7
Shoulder and upper limb	832	12.0	2057	19.8	280	24.9
Trunk	621	9.0	1590	15.3	124	11.0
Ankle and foot	346	5.0	996	9.6	107	9.5
Head and neck	244	3.5	523	5.0	100	8.9
Others/Unspecified	45	0.7	2	0.0	28	2.5
Years						
2009	466	6.7	745	7.2	70	6.2
2010	565	8.2	931	9.0	109	9.7
2011	619	8.9	1261	12.1	101	9.0
2012	539	7.8	1230	11.8	109	9.7
2013	740	10.7	1602	15.4	97	8.6
2014	732	10.6	1703	16.4	153	13.6
2015	780	11.3	1054	10.1	143	12.7
2016	835	12.1	640	6.2	112	10.0
2017	790	11.4	558	5.4	103	9.2
2018	854	12.3	666	6.4	126	11.2

Table 2-2. Effect of burn prevention campaigns on scald injuries among children under the age of five years in Ulaanbaatar, Mongolia

	Both						Males						Females					
	% change		95% CI				% change		95% CI				% change		95% CI			
All scalds																		
Time (baseline trend)	0.51	%	0.32	%	0.71	%	0.55	%	0.31	%	0.79	%	0.50	%	0.26	%	0.74	%
Trend change after the first campaign	−3.22	%	−3.64	%	−2.62	%	−3.22	%	−3.85	%	−2.59	%	−3.05	%	−4.04	%	−2.64	%
Trend change after the second campaign	3.85	%	2.66	%	4.69	%	3.85	%	2.60	%	5.13	%	3.40	%	2.14	%	4.68	%
Severe scalds																		
Time (baseline trend)	0.09	%	−0.15	%	0.33	%	0.35	%	−1.14	%	0.84	%	−0.03	%	−0.32	%	0.26	%
Trend change after the first campaign	−0.34	%	−0.99	%	0.31	%	−0.79	%	−2.07	%	0.51	%	−0.03	%	−0.82	%	0.76	%
Trend change for the second campaign	0.56	%	−0.68	%	1.81	%	0.83	%	−1.51	%	3.22	%	−0.05	%	−1.53	%	1.45	%
Moderate scalds																		
Time (baseline trend)	0.80	%	0.56	%	1.05	%	0.78	%	0.55	%	1.02	%	0.87	%	0.61	%	1.12	%
Trend change after the first campaign	−5.33	%	−5.96	%	−4.7	%	−5.4	%	−5.99	%	−4.79	%	−5.34	%	−5.99	%	−4.69	%
Trend change for the second campaign	6.37	%	5.05	%	7.71	%	6.63	%	5.36	%	7.92	%	6.09	%	4.72	%	7.48	%

Table 3-1. Characteristics of 50 participating households

Characteristics	n	%
Number of children aged <5 years in the household		
1	16	32
2	29	58
3	5	10
Sex of children aged <5 years (n=89)		
Male	46	51
Female	43	49
Age of children aged <5 years (n=89)		
< 1 year	19	22
1 year	24	27
2 years	25	28
3 years	9	9
4 years	12	14
Age of parents, mean (SD, range)		
Father	32 (5.4, 23 to 44)	
Mother	30 (5.5, 18 to 44)	
Number of cohabitants in the household		
3 to 4	20	40
5 to 6	23	46
7+	7	14
Median (range)	5 (3 to 10)	
Single parent (mother-only) household	8	16
Monthly income (in Mongolian Tugrik: MNT)[a]		
500,000 or lower	7	14
500,001-900,000	26	52
900,001-1600,000	16	32
1600,001 or above	1	2
Placement of electric pot		
Floor	27	54
Table	18	36
Stool	3	6
Other	2	4
Placement of electric kettle		
Floor	20	40
Table	17	34
Stool	3	6
Other	1	2
Not using an electric kettle	9	18

[a]MNT 100,000 is equivalent to about USD 35.

Table 3-2. Burn experiences among 89 children aged <5 years in fifty participating households

	Treated at:		
	Home (n=30)	Outpatient (n=16)	Inpatient (n=13)
Number of households[a] (n=40)	24	13	11
Age at burn injury			
<1 year	5	2	2
1 year	9	8	6
2 years	8	2	2
3 years	2	1	1
4 years	6	3	2
Products involved			
Furnace	21	1	1
Flask	6	1	3
Electric pot	1	5	6
Electric kettle	1	5	3
Traditional pot	0	2	0
Pot	1	1	0
Pressure cooker	0	1	0

[a]The number of households with at least one child aged <5 years has ever been treated for burn injury at home, in an inpatient, or an outpatient department. A total of 40 out of fifty households reported having such a child. From the 40 households, a total of 59 burn injuries were reported due to multiple burn experiences in some households

Table 3-3. A median willingness to pay for kitchen rack

Variables	Median (95% confidence interval)
All households	106,000 (84,000 to 130,000)
Monthly income[a]	
Lower	87,000 (46,000 to 131,000)
Middle	102,000 (80,000 to 123,000)
Higher	117,000 (82,000 to 160,000)
Child burn experience[b]	
None	94,000 (63,000 to 132,000)
Treated at home	102,000 (80,000 to 125,000)
Treated at outpatient	110,000 (83,000 to 137,000)
Treated at inpatient	118,000 (73,000 to 161,000)
Number of children	
1	91,000 (57,000 to 126,000)
2	110,000 (88,000 to 136,000)
3	129,000 (78,000 to 190,000)

[a]The monthly income was classified into the lower, middle, and higher levels (MNT 500,000 or below; 500,001 to 900,000; 900,001 or higher). MNT 100,000 is equivalent to about US$35.
[b]Households that had multiple burn experiences treated at various levels were classified under the highest level of treatment they received.

FIGURES

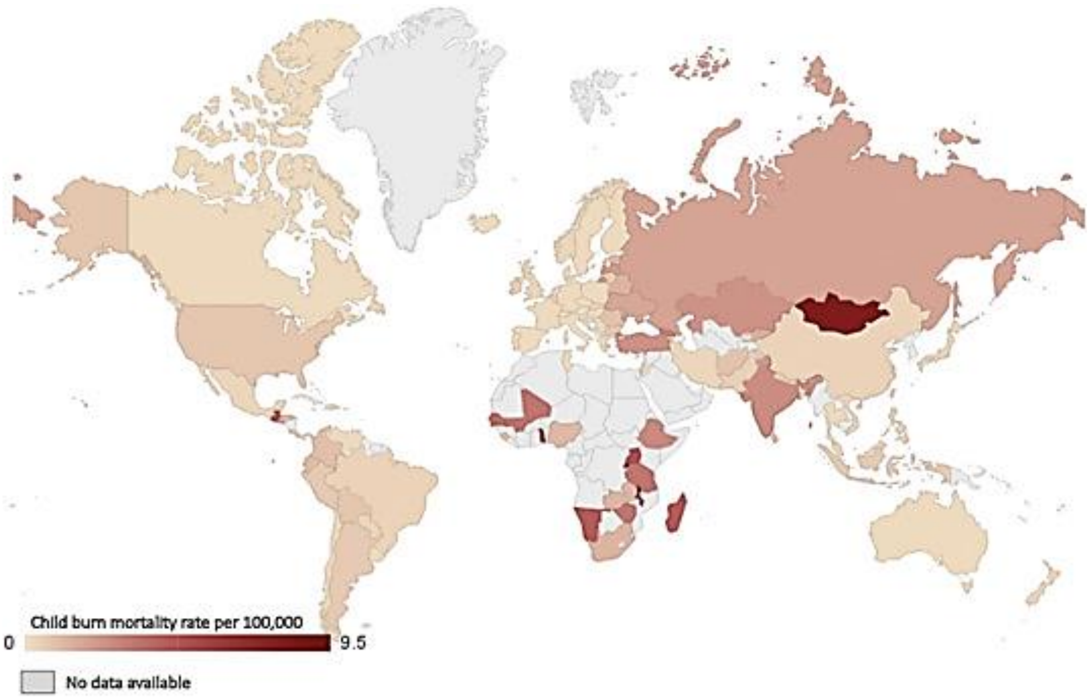
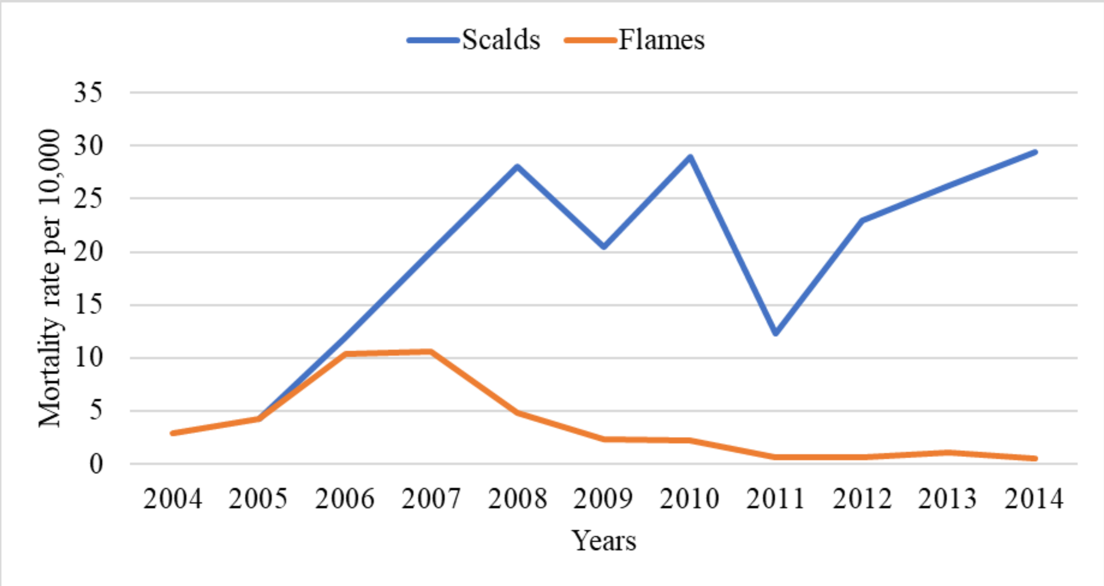


Figure 1-1. Geographical distribution of child burn mortality per 100,000 in 2013[1]

[1] Sengoelge M, El-Khatib Z, Laflamme L. The global burden of child burn injuries in light of country level economic development and income inequality. *Prev Med Rep.* 2017;6:115-120. doi:10.1016/j.pmedr.2017.02.024

Figure 1-2. Mortality rate (per 10,000) of burn injuries by flames and scalds among



children aged under the age of five years in Ulaanbaatar between 2004 and 2014[2]

[2] Nansalmaa S. Distribution of Burn Injuries among Mongolian children under the age of five years, and Some Risk Factors. National Medical University of Mongolia; 2017. Accessed October 19, 2022. http://data.stf.mn/Publication/Thesis/ThesisViewPublic.aspx?id=1286833

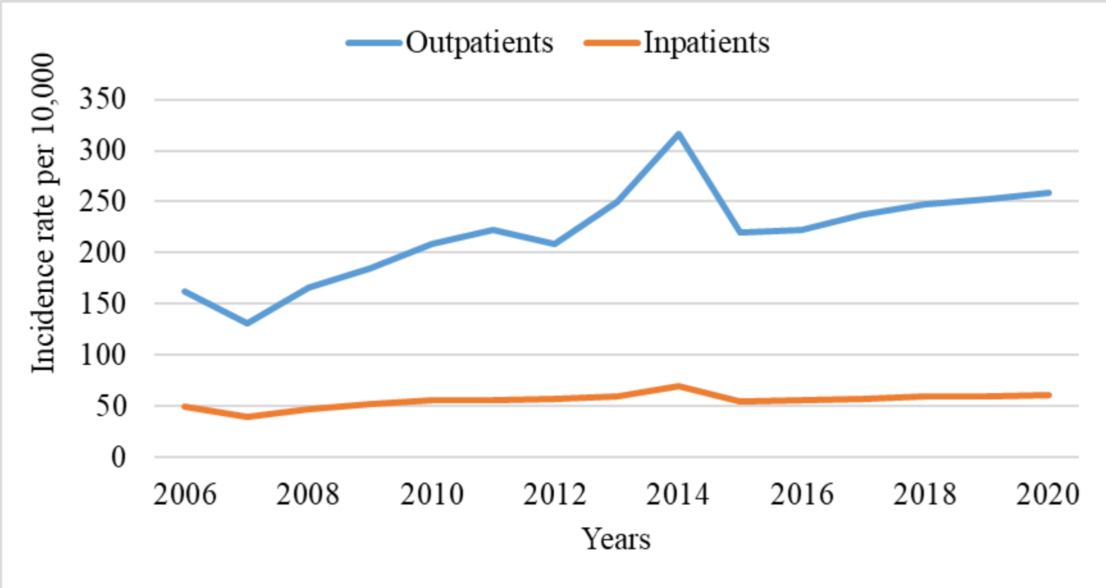


Figure 1-3. Incident rate (per 10,000) of burn injuries requiring outpatient or inpatient care at the National Traumatic Orthopedic Research Center (NTORC) among children aged under five years, 2006-2020[3]

[3] Tumen-Ulzii B. *National Surveillance on Trauma Mortality and Morbidity.* 2020.Accessed October 10, 2021. http://gemtel.mn/uploads/603dbd97-633c-4954-a47c-5d9fd9ae9497-Эргэн-мэдээлэл-2020-он.pdf

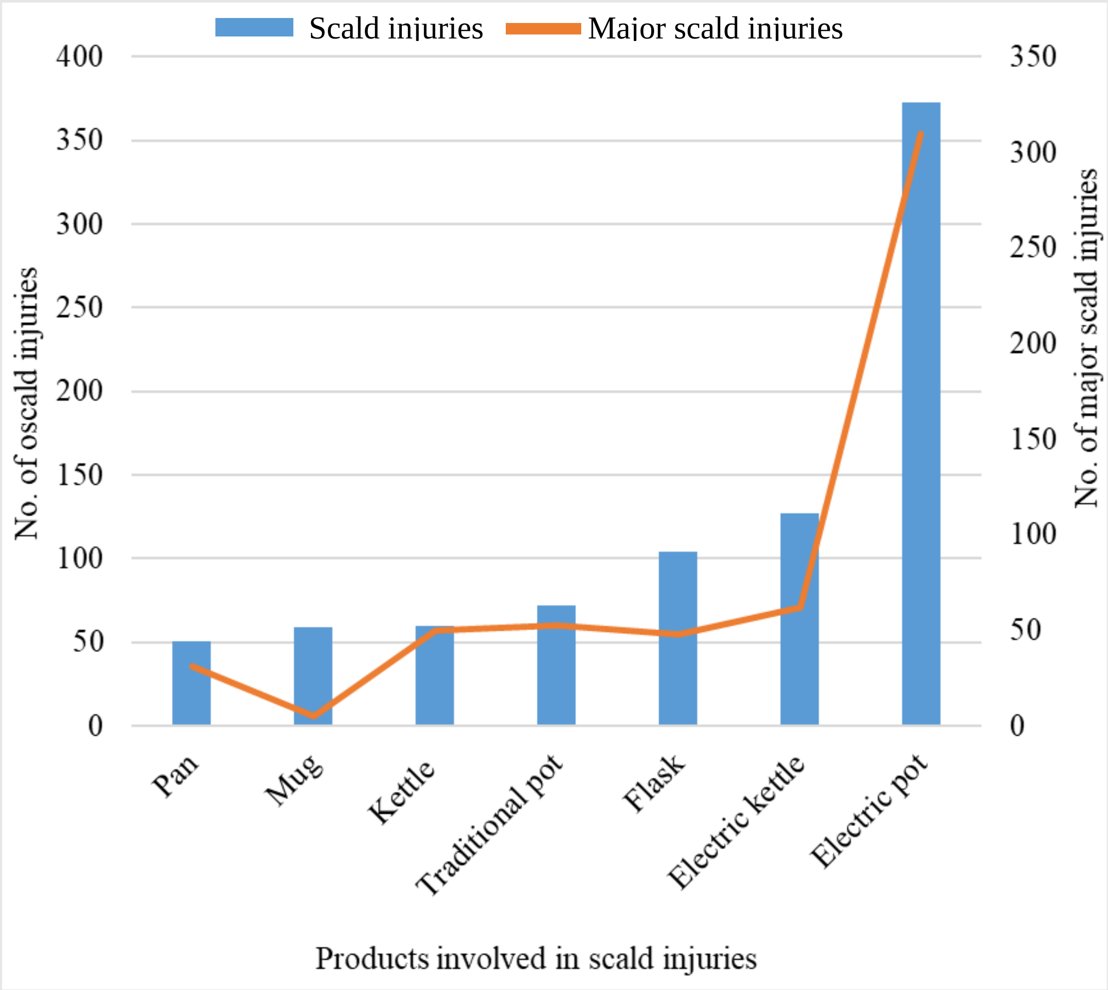


Figure 1-4. The products involved in scalds and major scald injuries[4]

[4] Gerelmaa G, Tumen-Ulzii B, Nakahara S, Ichikawa M. Patterns of burns and scalds in Mongolian children: a hospital-based prospective study. *Trop Med Int Health TM IH*. 2018;23(3):334-340. doi:10.1111/tmi.13034

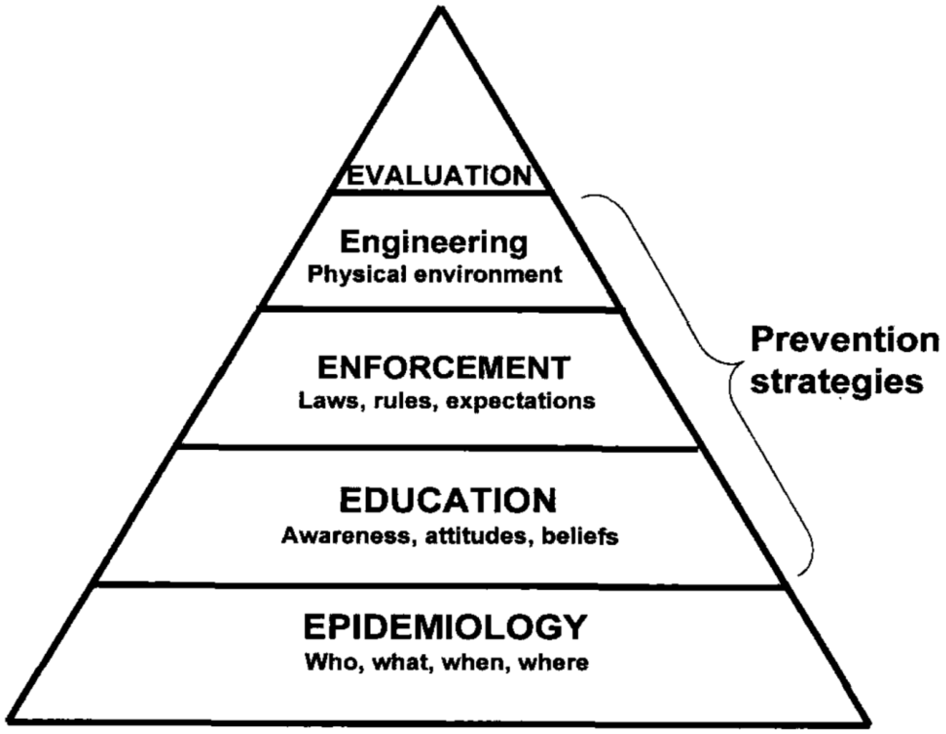


Figure 1-5. The five E's of injury prevention[5]

[5] Judkins DG. Injury prevention. In: Greene HI, ed. *Clinical Medicine.* 2nd ed. St Louis, MO: Mosby; 1996;108-112.

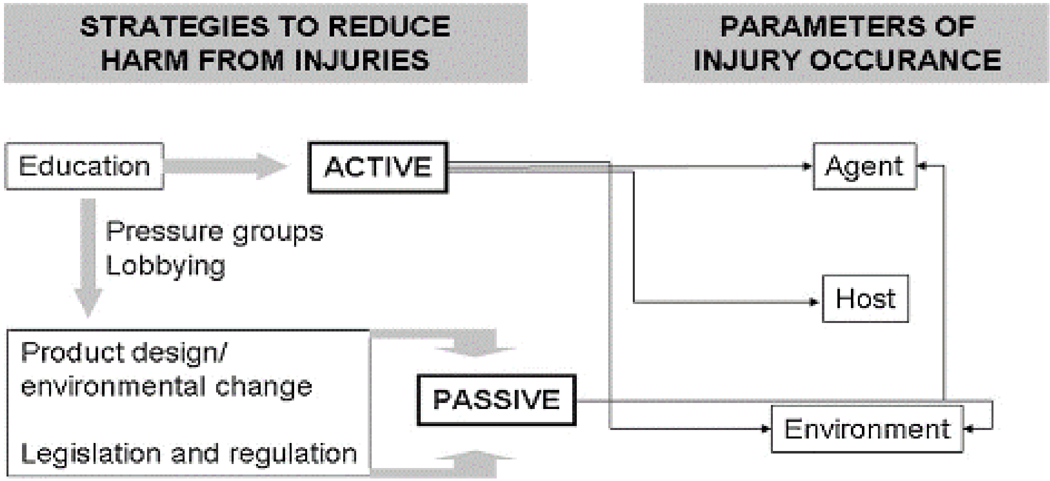


Figure 1-6. Strategies to reduce harm of injury[6]

[6] Atiyeh BS, Costagliola M, Hayek SN. Burn prevention mechanisms and outcomes: pitfalls, failures and successes. *Burns J Int Soc Burn Inj*. 2009;35(2):181-193. doi:10.1016/j.burns.2008.06.002

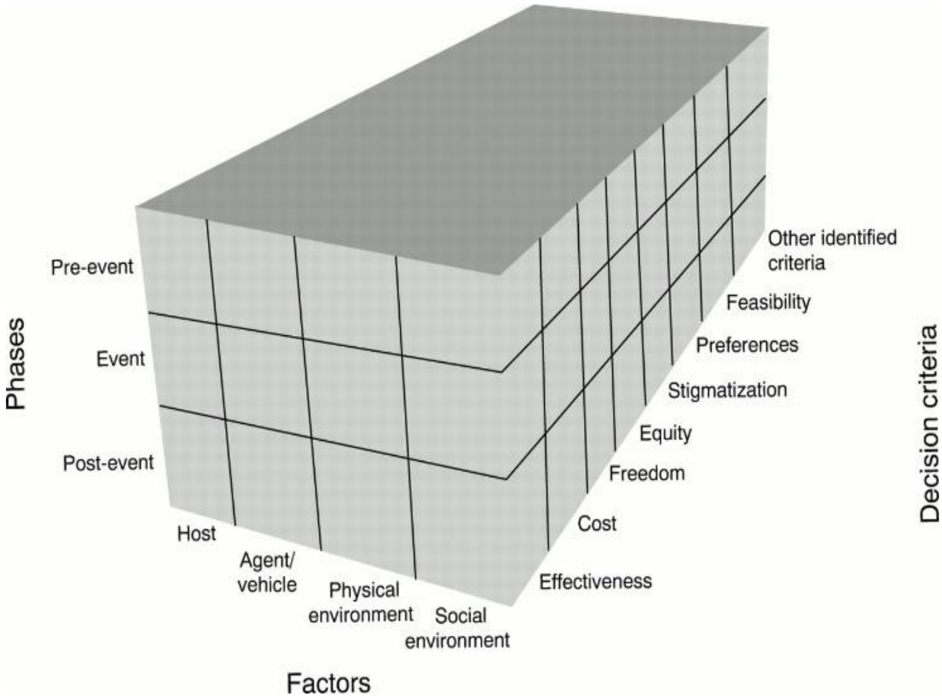


Figure 1-7. Proposed three-dimensional Haddon matrix[7]

[7] Runyan CW. Using the Haddon matrix: introducing the third dimension. *Inj Prev*. 1998;4(4):302-307. doi:10.1136/ip.4.4.302

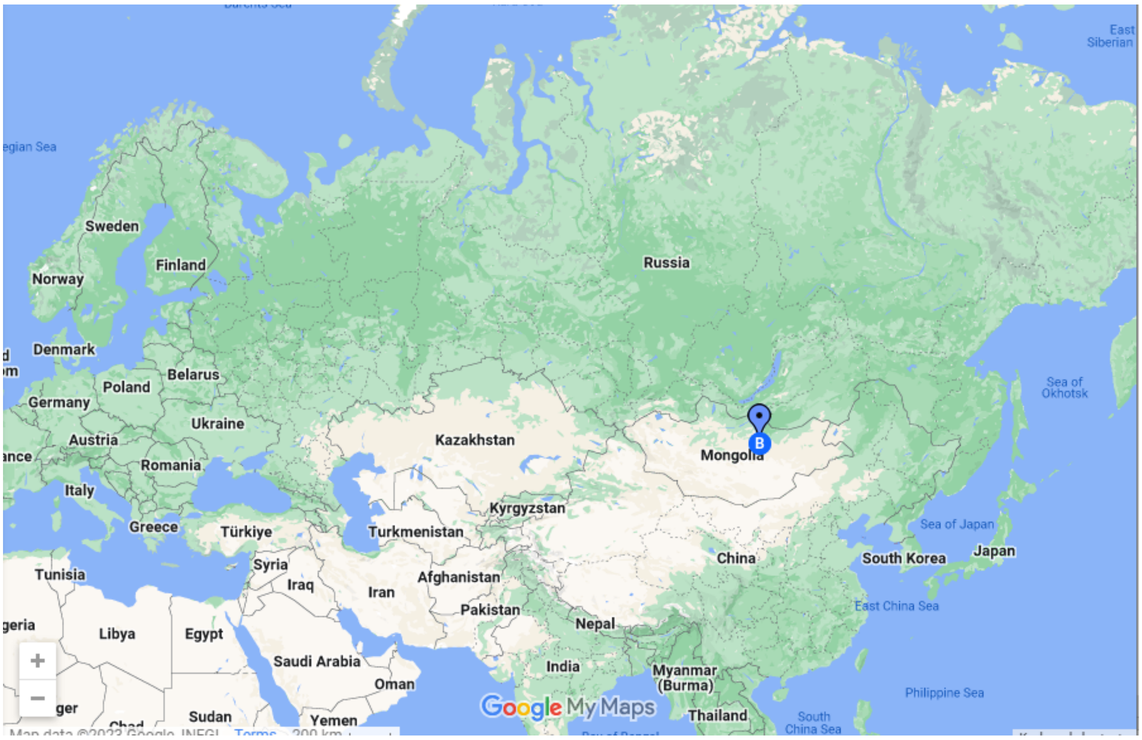


Figure 2-1. Map of Mongolia[8]

[8] Google. Google maps. https://www.google.com/maps/d/viewer?mid=1Wwy-mCkFXLXaIXZfH0XNQRsRogI&hl=en_US&ll=56.22779180689157%2C80.12460918634245&z=3 Accessed February 7, 2023.

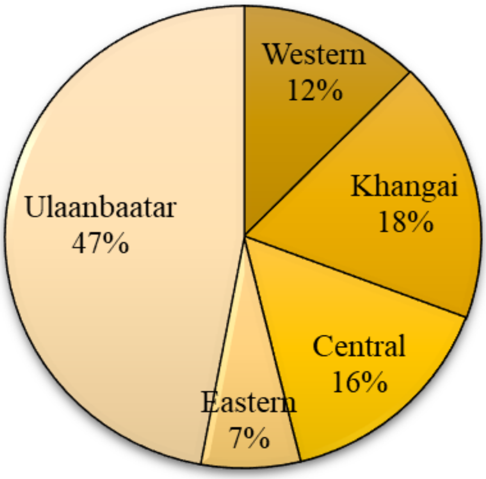


Figure 2-2. Population distribution in Mongolia[9]

[9] National Statistical Office. *Statistical white book*. Ulaanbaatar; September 5,2021. https://www.1212.mn/BookLibraryDownload.ashx?url=Census2020_Mongolia_Eng.pdf&ln=En

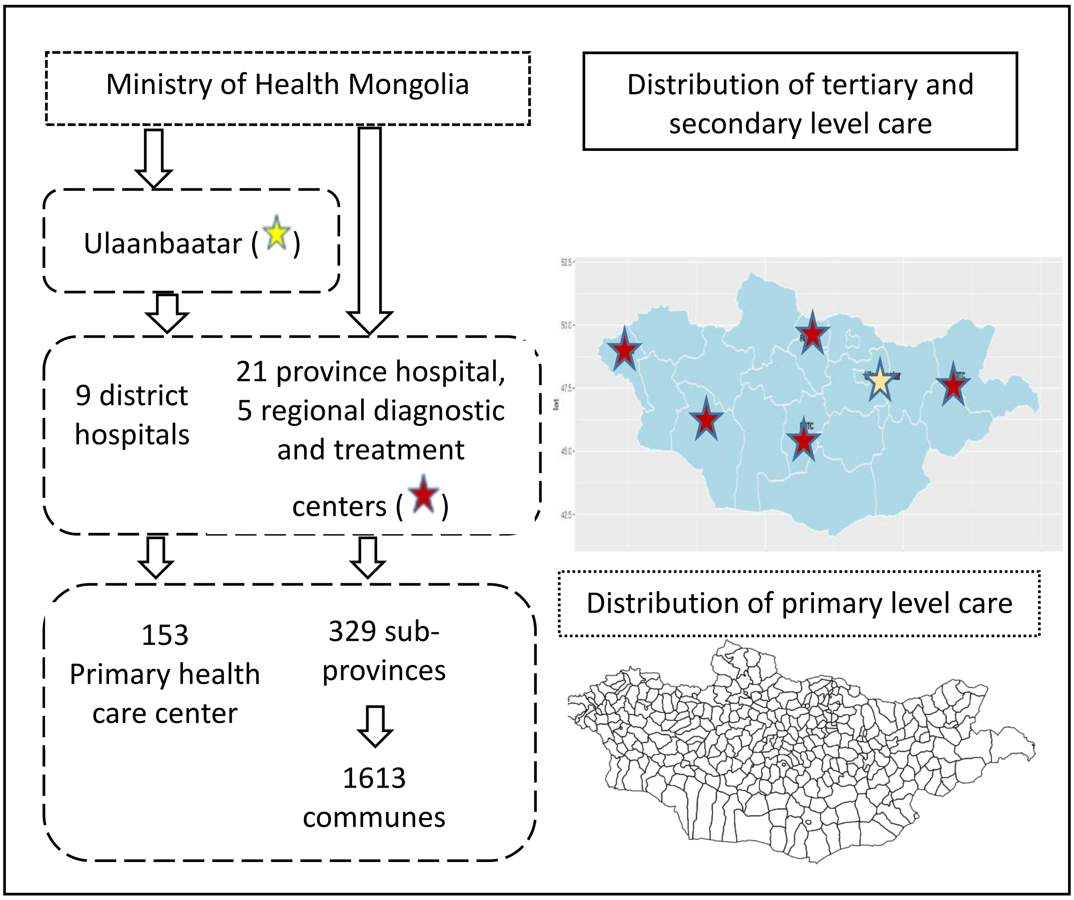


Figure 2-3. Health administrative divisions in Mongolia[10]

[10] Ministry of Mongolia. Health indicators 2014. Five regional diagnostic and treatment centers (RTDC) are located in the eastern, western, northern, and southern areas of the country. http://www.hdc.gov.mn/media/files/2014_AghzAyY.pdf. Accessed February 7, 2023.

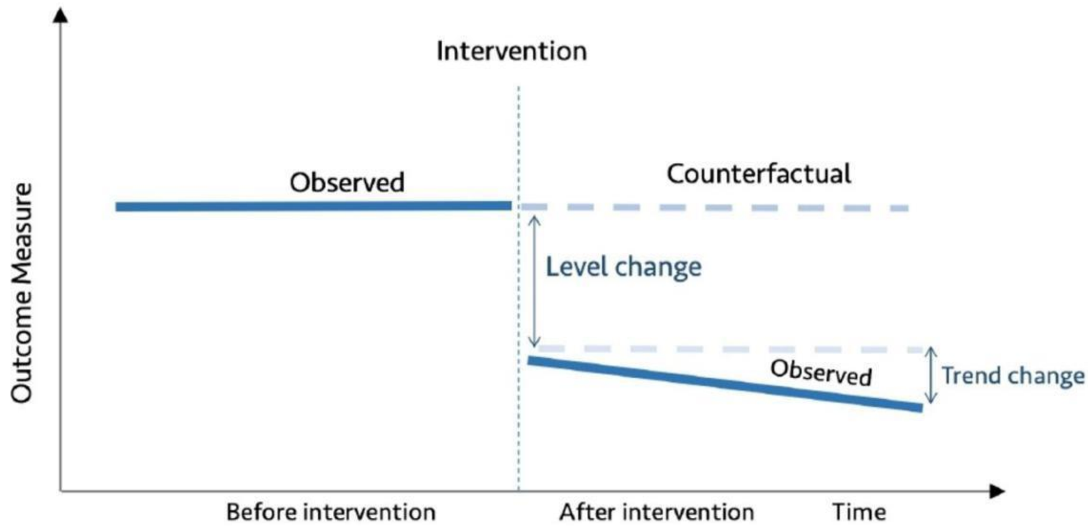


Figure 2-4. Diagrammatic representation of single interrupted time series

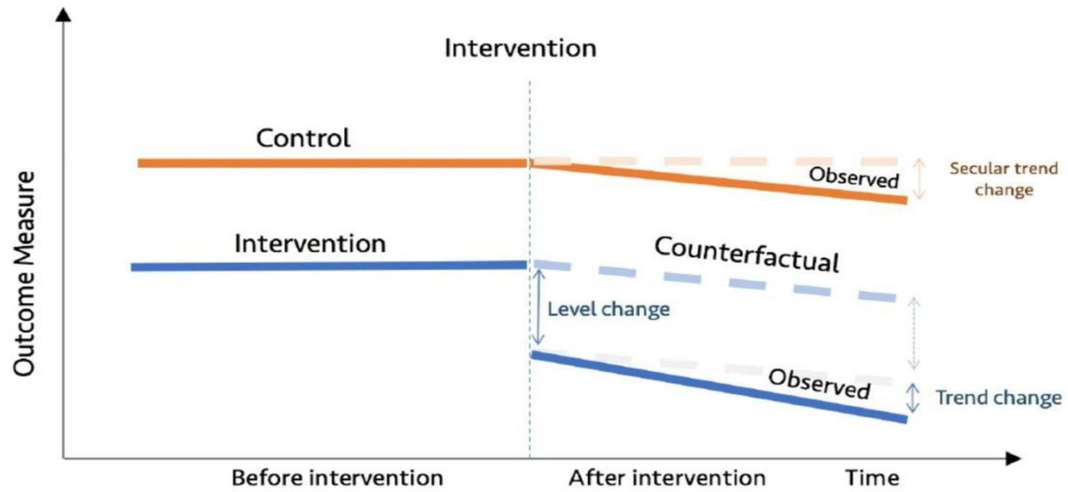


Figure 2-5. Diagrammatic representation of controlled interrupted time series[11]

[11] Hategeka C, Ruton H, Karamouzian M, Lynd LD, Law MR. Use of interrupted time series methods in the evaluation of health system quality improvement interventions: a methodological systematic review. *BMJ Glob Health*. 2020;5(10):e003567. doi:10.1136/bmjgh-2020-003567

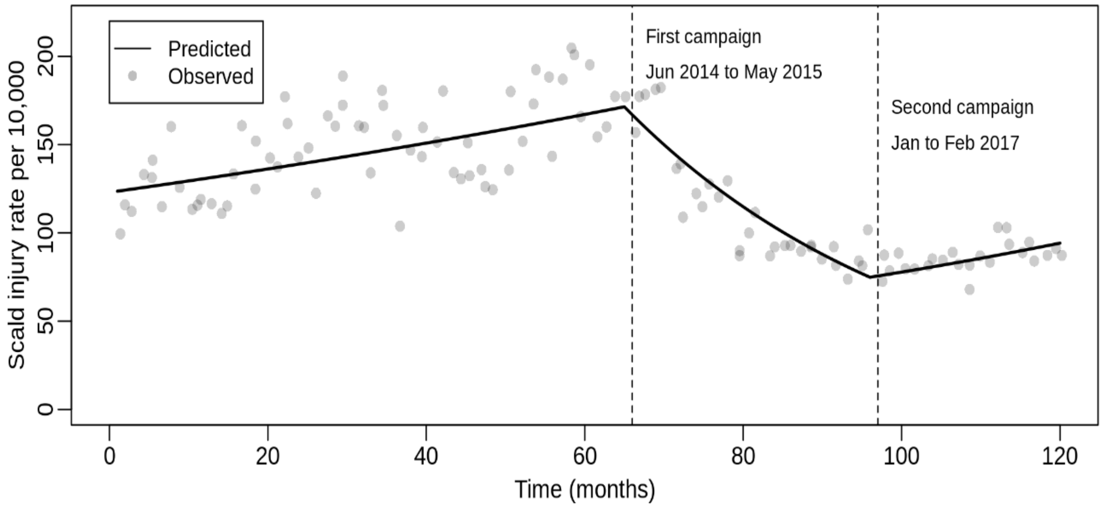


Figure 2-6. Monthly rates of scald injuries per 10,000 children aged under the age of 5 years from 2009 to 2018 in Ulaanbaatar, Mongolia

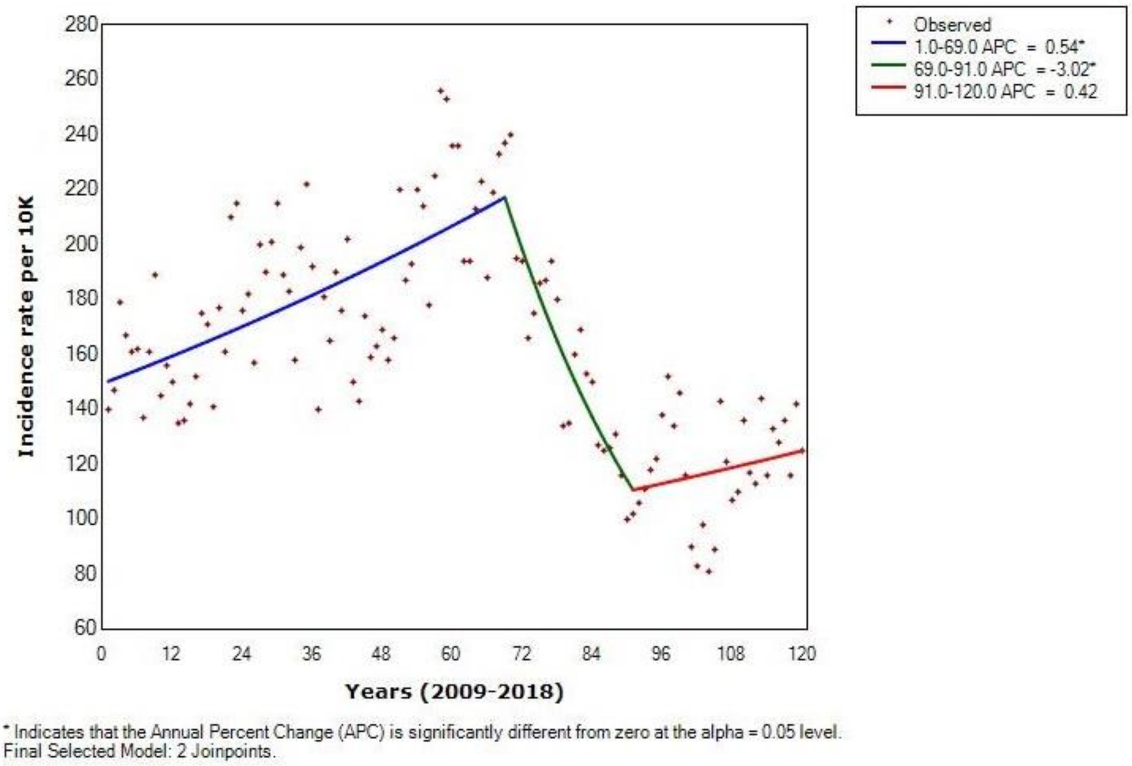


Figure 2-7. Sensitivity analysis using join point regression

Figure 3-1. Cooking practice in a ger with an electric pot in daily life

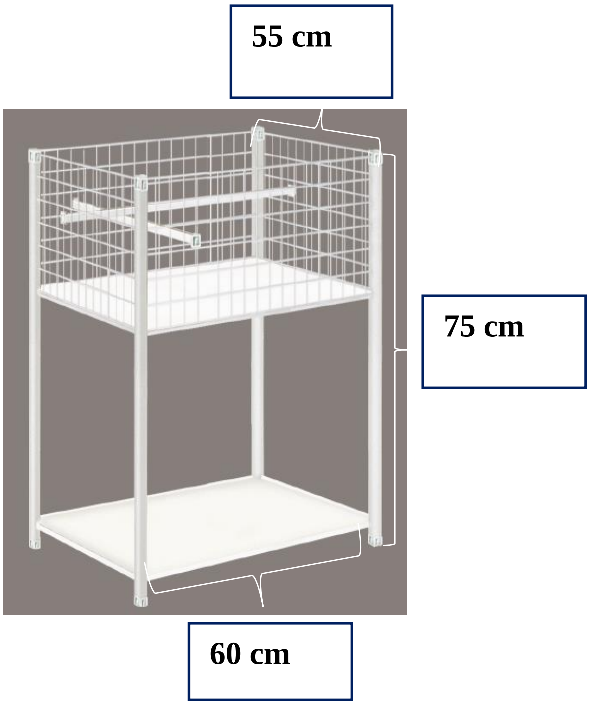
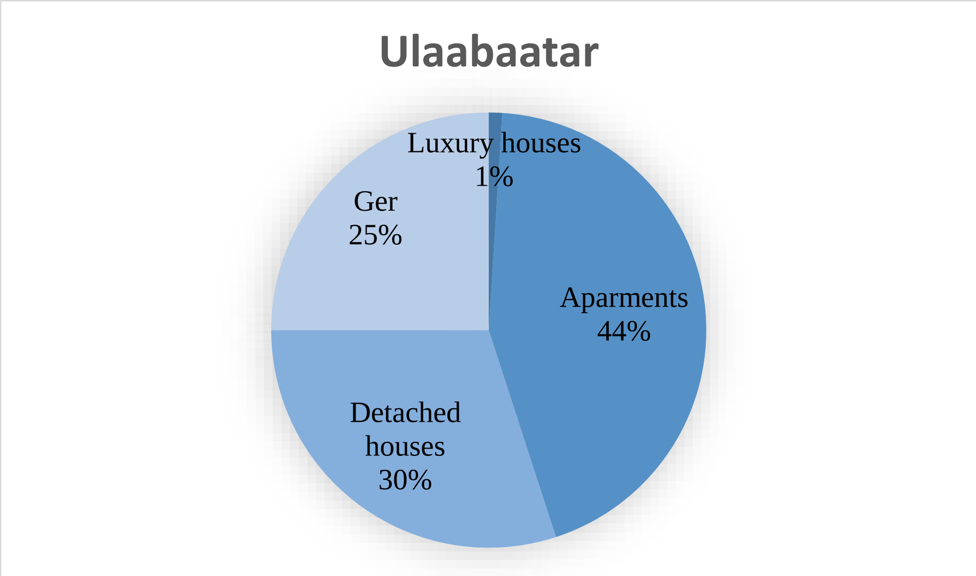


Figure 3-2. Size of a newly designed kitchen



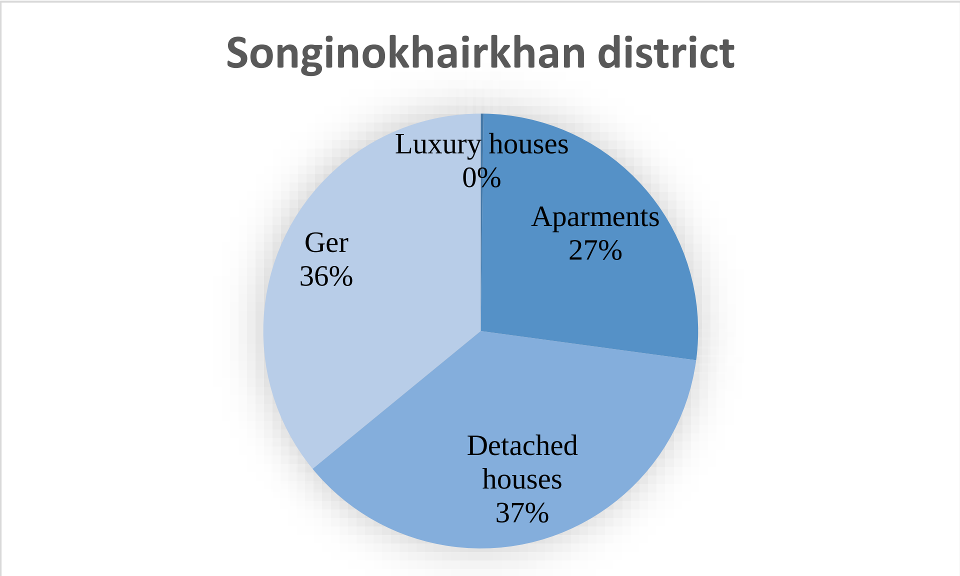


Figure 3-3. Comparison of housing types between Ulaanbaatar and Songinokhairkhan district[12]

[12] National Statistical Office. Housing types by region. National Statistical Office. Accessed October 10, 2021. http://1212.mn/tables.aspx?tbl_id=dt_nso_3500_006v1.

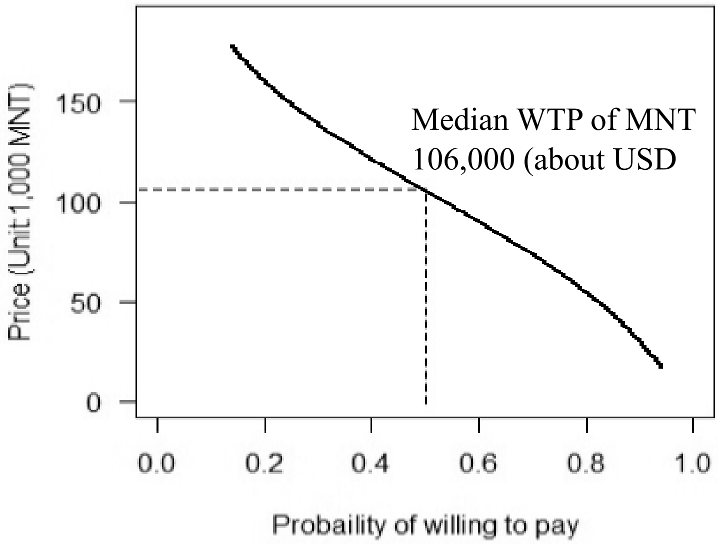
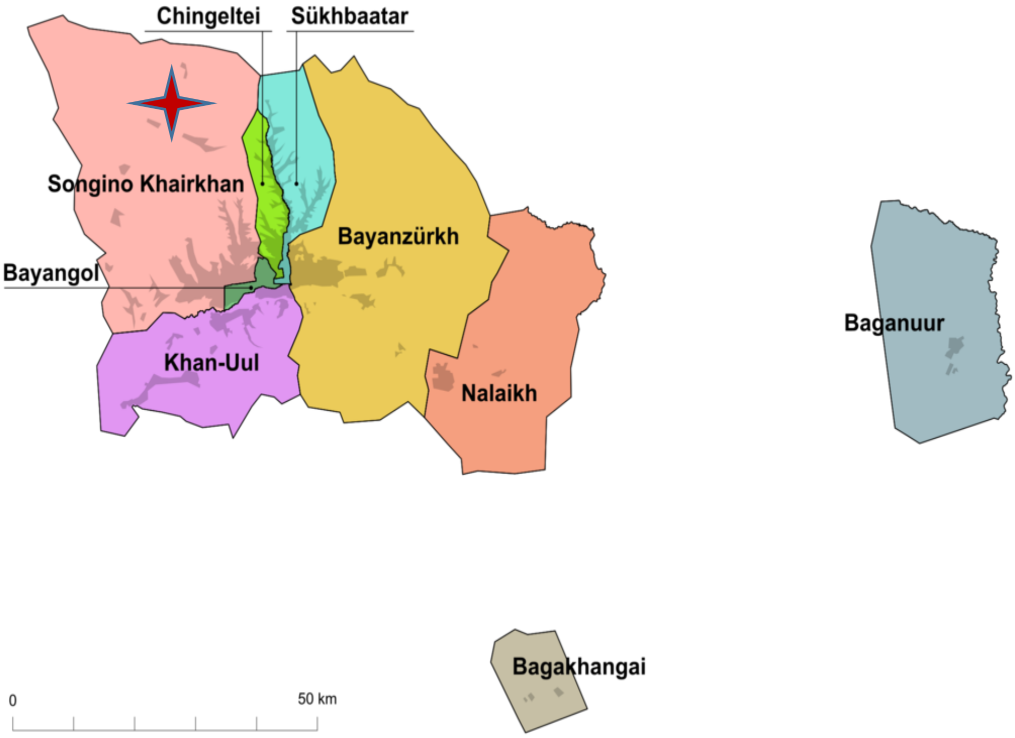


Figure 3-4. Relationship between the price of kitchen rack and the probability of willingness to pay for the price among fifty participating household

APPENDICES

Appendix 1. Districts of Ulaanbaatar[13]



Selected district-

13 https://en.wikipedia.org/wiki/Districts_of_Ulaanbaatar. Accessed January 30, 2013.

Appendix 2. Trauma care distribution within hospitals in Ulaanbaatar

	2016		2017		2018		2019	
	n	%	n	%	n	%	n	%
NTORC	77890	96.63	85356	97.00	111553	97.33	125688	97.30
General Hospital for Civil Servants	652	0.81	524	0.60	816	0.71	920	0.70
National Center for Maternal and Child Health	438	0.54	426	0.48	356	0.31	484	0.45
Military central hospital	429	0.53	489	0.56	386	0.34	465	0.40
Nalaikh	311	0.39	298	0.34	325	0.28	423	0.30
Khan-Uul	213	0.26	189	0.21	259	0.23	259	0.24
State first hospital	89	0.11	126	0.14	201	0.18	232	0.21
Baganuur	112	0.14	98	0.11	189	0.16	201	0.20
Chingeltei	28	0.03	35	0.04	97	0.08	95	0.10
Intermed	76	0.09	84	0.10	82	0.07	92	0.10
Mungun guur	76	0.09	69	0.08	79	0.07	75	0.07
Songinokhairkhan	89	0.11	85	0.10	75	0.07	68	0.10
Bayanzurkh	76	0.09	59	0.07	69	0.06	65	0.06
Sukhbaatar	39	0.05	46	0.05	43	0.04	58	0.05
Railway hospital	29	0.04	35	0.04	21	0.02	35	0.04
State 3rd central hospital	30	0.04	36	0.04	26	0.02	24	0.03
State 2d central hospital	8	0.01	12	0.01	9	0.01	12	0.01
Bagakhangai	11	0.01	8	0.01	11	0.01	12	0.01
Bayangol	9	0.01	11	0.01	8	0.01	7	0.01
National Center for Mental Health	2	0.00	6	0.01	5	0.00	4	0.01

Appendix 3. Prototypes of a newly designed kitchen rack to reduce child burn in Mongolia

Prototype 1

(December 2017)

Prototype 2

(June 2020)

Appendix 4. Principles of estimating sample size in CVM

Mitchell and Carson made recommendations on the sample size and level of accuracy in the CVM research using random sampling. Indeed, to calculate the percentage variation from the true mean or relative error. We first need to calculate the coefficient of variation using the standard deviation of WTP answers and the mean of the population WTP. As a result, the authors created the formula for estimating sample size, which is the mean of estimated WTP bids multiplied by the percentage difference between the actual and estimated WTP answers, divided by the estimated standard deviation of the WTP responses. Z is the reference value. He recommended that a suitable range for the percentage difference should be between 0.05 and 0.3, and the coefficient of variation (CV) should be around 2. Thus, when CV=2 was used, the needed sample size was 1532[98].

Appendix 5. Common housing types in Mongolia

A

B

C

D

A- Apartments

B- Luxury House

C- Detached house

D- Ger (traditional housing)

Appendix 6. Survey questionnaires

Part I. Demographics and household characteristics						
1	Relationship with the child	☐1. Father ☐2. Mother ☐3. Others specify …………				
2	Parent's age	Father______ Mother____ (Please give number)				
3	Members living with you	☐1. Father ☐2. Mother ☐3. Grandfather ☐4. Grandmother ☐5. Children … (Please give number)				
4	Age and sex for children under five years living with	Child 1 (M/F)	Child 2 (M/F)	Child 3 (M/F)	Child 4 (M/F)	Child 5 (M/F)
		Age___ DOB	Age___ DOB	Age___ DOB	Age__ DOB	Age___ DOB
5	Father's education completed	☐1. Less than primary school ☐2. Primary school ☐3. Secondary school or high school ☐4. Technical school or university ☐5. Not applicable				
6	Mother's education completed	☐1. Less than primary school ☒2. Primary school ☐3. Secondary school or high school ☐4. Technical school or university ☐5. Not applicable				
7	Current housing status	☐1 Owned home ☐2 Rented home ☐3 Others (specify)				

8	Work status of father in the past 12 months	☐1. Public sector ☐2. Private sector ☐3. Self-employed (including herders and farmers) ☐4. Non-government ☐5. Student ☐6. Unemployed ☐7. Others specify
9	Work status of the mother in the past 12 months	☐1. Public sector ☐2. Private sector ☐3. Self-employed (including herders and farmers) ☐4. Non-government ☐5. Student ☐6. Unemployed ☐7. Others specify
10	Source of household income in the past 12 months	☐1. Wage______, ☐2. Pension_______, ☐3. Capital income (renting land or property) ☐4. Household business______ ☐5. Social transfer (child money, welfare allowance)_____ ☐6. Other___________
11	Monthly income (total)	☐1. <300,001 ☐2. 300,001–500 000 ☐3. 500,001–700,000 ☐4. 700,001–900,000 ☐5. 900,001–1,100 000 ☐6. 1,100,000–1,600,000 ☐7. 1,600,001–2,100,000 ☐8. <2,100,001
12	Monthly loan or lease payment	☐1. None ☐2. <30,000 ☐3. 30,001–50,000 ☐4. 50,001–100,000 ☐5. >100,001

Part II. Daily cooking practice with electric cooking appliances: the experience of burn injury				
1	Check the cooking appliances that you use within the home	☐1. Electric pot ☐2. Electric kettle ☐3. Flask ☐4. Traditional pot ☐5 Kettle/pot ☐6 Mug/bowl ☐7 Pan ☐8 Other: specify_______________		
2	Frequency of using electric pots	☐1. Every day ☐2. A few days a week ☐3. Once a week ☐4. Less than once a week		
3	Frequency of using electric kettles	☐1. Every day ☐2. A few days a week ☐3. Once a week ☐4. Less than once a week		
4	Places of electric pots while cooking	☐1. On the table ☐2. On the chair ☐3. On the floor ☐4. On the cupboard ☐5 On the freezer ☐6 Other: specify_______________		
5	History of burn injury	Treated at home	Treated in outpatients	Treated at inpatients
	Child 1	What age___ Products involved	What age___ Products involved	What age_ Products involved
	Child 2	What age___ Products involved	What age____ Products involved	What age___ Products involved
	Child 3	What age___	What age____	What age_____

		Products involved	Products involved	Products involved
	Child 4	What age___ Products involved	What age___ Products involved	What age___ Products involved
	Child 5	What age Products involved	What age Products involved	What age Products involved
	Select the product involved in burn injury: A. Electric pot B. Electric kettle C. Flask, D. Traditional pot E. Kettle/pot F. Mug/bowl G. Pan H. Furnace, I. Benzene, J. Ash/open fire K. House fire, L. Gas or gas stove M. Socket, electric cord N. Other: specify____			

Part III. Susceptibility, severity, barriers, and cues to action for burn prevention

		Strongly	Agree	Neutral	Disagree	Strongly
1	Cooking at a lower level increases the risk of child burn.					
2	Children are at a higher risk of burns.					
3	Burn can even cause disability or death.					
4	Burn treatment can lead to a financial burden.					

5	Removing home hazards helps prevent child burn.					
6	Safety equipment helps prevent child burn.					
7	Hard to pay attention to children all the time.					
8	Hard to restrict children from access to the cooking area.					
9	Hard to afford safety equipment to prevent child burns.					
10	Hard to make space to use safety equipment to prevent child burns.					
11	Burn prevention advertisements have an influence on you.					
12	Learning others' real-life stories of child burn have an influence on you.					

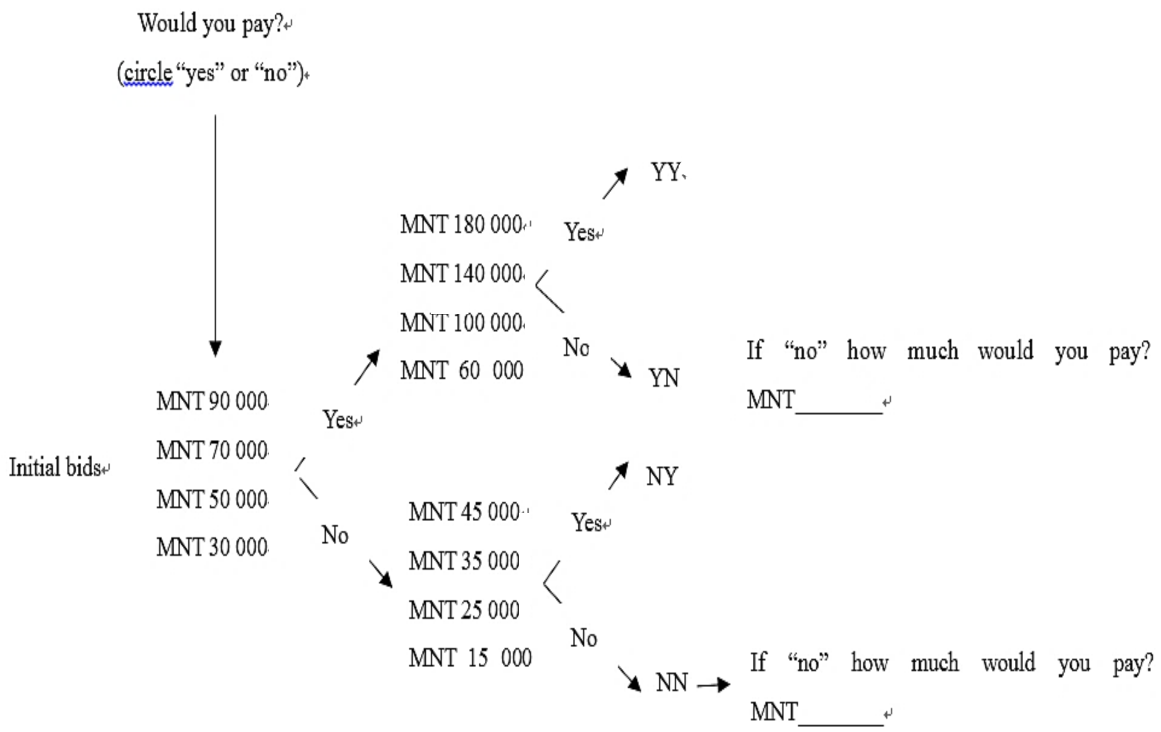
Part IV. Parental practice on first aid for burn injury		
1	What do you do as a first aid if your child gets burnt?	
	☐1. Don't know ☐2. Cold water ☐3. 'Khoromkhon' ☐4. Cream ☐5. Hand soap ☐6. Sugar ☐7. Toothpaste ☐8. Raw meat ☐9. Antibiotics ☐10. Cow dung ☐11. Dog blood ☐12. Ice ☐13. Yellow glue ☐14. Others	
2	If water: How?	☐1. Running water ☐2. Still
	If water: How long?	☐1.__________________

3	What would you cover the burns with?	☐1. Nothing ☐2. Towel ☐3. Plastic film ☐4. Others, specify___________
4	Where did you hear about this first aid?	☐1. TV ☐2.School ☐3. Health worker ☐4. Friends ☐5. Internet ☐6. Other media

Appendix 7. Explaining the provision of a newly designed kitchen rack and asking for acceptance

I will ask you how much it is worth to you in real currency (MNT) to prevent a child from burning from an electric cooking appliance at home. Let me explain the pattern of child burns injuries in Mongolia briefly. Mongolia has the highest child burn mortality rate (8.1 per 100 000 children), which is more than three times as high as the global average. According to the community-based survey, 27% of children experienced burn injuries. The hospital-based survey reported that scalds due to hot liquid accounted for 94% of hospitalized children. Moreover, over half of the severe scald injuries were due to electric pots or kettles used at home. Imagine what would happen if a child fell into electric pots on the floor. It can result in very severe burns with life-long disabilities and scars, which require expensive, repetitive reconstructive surgery. We are therefore proposing the kitchen rack for child burn prevention. If you accommodate an electric pot and kettle in this kitchen rack, children will not fall into the pot and pull the kettle down over themselves. The kitchen rack is made of steel, 60 cm wide, 55 cm deep, and 90 cm high, and weighs 20 kg. It is easy to assemble and disassemble. In this study, you will receive the kitchen rack for free, but if you are supposed to buy it, how much are you willing to pay for it? First, would you pay for it? If yes, would you pay [initial bid]? How about [second bit]? How much would you pay if you do not pay [second bit]?

Appendix 8. Double bounded dichotomous choice for WTP



Appendix 9. R codes for data analysis of CV study

##Packages needed for the analysis

```
library (DCchoice)
library (Ecdat)
library(lmtest)
##add new variables to a dataframe
PS$answer1 <- ifelse(PS$ans == "yy" | PS$ans == "yn", 1, 0)
PS$answer2 <- ifelse(PS$ans == "yy" |PS$ans == "ny", 1, 0)
PS$bid2 <- ifelse(PS$ans1 == 1,  PS$bidh, PS$bidl)
```

##Daraframe

##	bid1	bidhigh	bidlow	answers	answer1	answer2	bid2
## 1	30 000	60 000	15 000	yy	1	1	60 000
## 2	90 000	180 000	45 000	yn	1	0	180 000
## 3	70 000	140 000	35 000	nn	0	0	35 000
## 5	50 000	100 000	25 000	ny	0	1	25 000

There are four possible initial bid values: MNT 30 000, MNT 50 000, MNT 70 000, and MNT 90 000.

Regression analysis

```
db.outcome <- dbchoice(answer1 + answer2 ~ 1+income +burn+childnum|bid1 + bid2, dist = "logistic", data = PS)
db.outcome <- dbchoice(answer1 + answer2 ~ 1+income +burn+childnum|bid1 + bid2, dist = "logistic",data = PS)
> summary(db.outcome)
```

```
Call: dbchoice(formula = answer1 + answer2 ~ 1 + income + burn + childnum |
bid1 + bid2, data = PS, dist = "logistic")
Formula:
1 answer1 + answer2 ~ 1 + income + burn + childnum | bid1 + bid2
Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  0.478841   1.431086  0.3346   0.7379
income       0.375120   0.391435  0.9583   0.3379
burn         0.204654   0.259032  0.7901   0.4295
childnum     0.479156   0.441283  1.0858   0.2776
BID         -0.025282   0.004167 -6.0674   <2e-16 ***
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Distribution: logistic
Number of Obs.: 50
Log-likelihood: -62.599482
LR statistic: 2.308 on 3 DF, p-value: 0.511
AIC: 135.198963 , BIC: 144.759078
Iterations: 95 20
Convergence: TRUE
WTP estimates:
 Mean: 108.309
 Mean: 102.6884 (truncated at the maximum bid)
 Mean: 118.3679 (truncated at the maximum bid with adjustment)
 Median: 105.6639
> set.seed(123)
```

```
> bootCI(db.outcome)
the bootstrap confidence intervals
                       Estimate     LB      UB
Mean                    108.309  86.309 131.55
truncated Mean          102.688  84.735 122.25
adjusted truncated Mean 118.368  89.009 154.96
Median                  105.664  84.044 129.90
> bootCI(db.outcome, nboot=1000)
the bootstrap confidence intervals
                       Estimate     LB      UB
Mean                    108.309  88.082 130.55
truncated Mean          102.688  85.708 121.22
adjusted truncated Mean 118.368  90.684 153.80
Median                  105.664  84.909 128.80
> bootCI(db.outcome, individual = data.frame(burn =
1,childnum=mean.default(PS$childnum),income=mean.default(PS$income)))
the bootstrap confidence intervals
                       Estimate     LB      UB
Mean                     97.520  68.476 130.80
truncated Mean           93.259  66.736 121.94
adjusted truncated Mean 103.865  69.656 154.55
Median                   94.007  61.807 129.20
> bootCI(db.outcome, individual = data.frame(burn =
2,childnum=mean.default(PS$childnum),income=mean.default(PS$income)))
the bootstrap confidence intervals
```

```
                    Estimate      LB     UB
Mean                    104.988  85.427 127.95
truncated Mean           99.821  82.806 119.41
adjusted truncated Mean  113.750  87.977 149.43
Median                  102.102  81.001 125.85
> bootCI(db.outcome, individual = data.frame(burn =
3,childnum=mean.default(PS$childnum),income=mean.default(PS$income)))
the bootstrap confidence intervals
                    Estimate      LB     UB
Mean                    112.564  89.062 139.26
truncated Mean          106.312  86.725 128.63
adjusted truncated Mean  124.516  92.828 170.04
Median                  110.197  85.849 138.13
> bootCI(db.outcome, individual = data.frame(burn =
4,childnum=mean.default(PS$childnum),income=mean.default(PS$income)))
the bootstrap confidence intervals
                    Estimate      LB     UB
Mean                    120.232  78.941 162.90
truncated Mean          112.688  76.165 143.21
adjusted truncated Mean  136.366  80.790 229.78
Median                  118.292  73.374 160.78
> bootCI(db.outcome, individual = data.frame(income =
1,childnum=mean.default(PS$childnum),burn=mean.default(PS$burn)))
the bootstrap confidence intervals
                    Estimate     LB     UB
```

```
Mean                    91.397 54.266 133.07
truncated Mean          87.775 53.172 124.56
adjusted truncated Mean   96.193 54.517 157.05
Median                  87.265 43.560 131.24
> bootCI(db.outcome, individual = data.frame(income =
2,childnum=mean.default(PS$childnum),burn=mean.default(PS$burn)))
the bootstrap confidence intervals
                    Estimate      LB     UB
Mean                   104.988  82.841 125.29
truncated Mean          99.821  80.331 117.96
adjusted truncated Mean  113.751  85.517 144.78
Median                 102.103  78.526 124.07
> bootCI(db.outcome, individual = data.frame(income =
3,childnum=mean.default(PS$childnum),burn=mean.default(PS$burn)))
the bootstrap confidence intervals
                    Estimate      LB     UB
Mean                   118.946  85.254 158.56
truncated Mean         111.633  83.932 141.15
adjusted truncated Mean  134.302  87.996 220.13
Median                 116.941  82.672 157.89
> bootCI(db.outcome, individual = data.frame(childnum =
1,income=mean.default(PS$income),burn=mean.default(PS$burn)))
the bootstrap confidence intervals
                    Estimate      LB     UB
Mean                    94.669  65.081 129.13
```

```
truncated Mean          90.717  63.647 118.67
adjusted truncated Mean  100.249  65.767 151.78
Median                  90.881  56.786 126.61

> bootCI(db.outcome, individual = data.frame(childnum =
2,income=mean.default(PS$income),burn=mean.default(PS$burn)))
the bootstrap confidence intervals
                        Estimate      LB     UB
Mean                   112.222  88.624 135.53
truncated Mean         106.023  86.201 126.80
adjusted truncated Mean  124.011  92.423 162.94
Median                 109.834  85.714 134.49

> bootCI(db.outcome, individual = data.frame(childnum =
3,income=mean.default(PS$income),burn=mean.default(PS$burn)))
the bootstrap confidence intervals
                        Estimate      LB     UB
Mean                   130.282  84.389 183.34
truncated Mean         120.705  81.386 156.97
adjusted truncated Mean  153.773  87.778 330.41
Median                 128.786  80.199 183.25
```

##A visualization of the DBDC model

```
plot(db.outcome, las = 1, xlab = "Bid amounts in MNT", main = "DBDC model",
cex.main = 0.8,
```

```
    font.main = 4, xlim = c(0, 180))
abline(h = 0.5, lty = 1, col = "red")  # adds a horizontal line to the plot


segments(x0 = 105.6, y0 = -1, x1 = 105.6, y1 = 0.5, col = "red", lty = 1)
segments(x0 = 84, y0 = -1, x1 = 84, y1 = 0.5, col = "red", lty = 2)
segments(x0 = 130, y0 = -1, x1 = 130, y1 = 0.5, col = "red", lty = 2)
points(105.6, 0.5, col = "red", pch = 16)
text(0, 1, "Median WTP estimate = 106 00 MNT", pos = 4, cex = 0.7)
```

Appendix 10. R codes for ITS analysis.

```
# #Load the packages
          library(astsa)
          library(forecast)
          library(nlme)
          library(lmtest)
data <- read.csv("data.csv")
head(data)
# This dataset includes the following variables:
  # year
  # month
  # time =  time of the study
  # scalds = count of scald injuries for both sexes per month
  # girlscald = count of scald injuries for girls per month
  # boyscalds = count of scald injuries for boys per month
  # modtotal= count of moderate scald injury for both sexes per month
  # modgirl = count of moderate scald injuries for girls per month
  # modboy = count of moderate scald injuries for boys per month
  # sevtotal = count of severe scald injury for both sexes per month
  # sevgirl = count of scald injuries for girls per month
  # sevboy = count of scald injuries for boys per month
  # minor= count of minor scald injuries for both sexes per month
  # pop = population, Ulaanbaatar per 10,000
  # poptotal =  age-standardized population
  # girls= age-standardized female population
```

girls= age-standardized male population

slope1= trend variable of the intervention, and it coded 0 before and elapsed time after the intervention.

slope2= trend variable of the intervention, and it coded 0 before and elapsed time after the intervention.

step1 = the intervention coded 0 before the intervention, one after

 # #Compute the standardized rates

```
# compute the standardized rates for total scalds
data$TI <- with(data, scalds/poptotal*10^4)
data$TI
# compute the standardized rates for girl's scalds
data$FI<-with(data, girlscald/girls*10^4)
data$FI
# compute the standardized rates for boy's scalds
data$MI<-with(data, boyscalds/boys*10^4)
data$MI
# compute the standardized rates for moderate scalds
data$totmoder<-with(data, modtotal/poptotal*10^4)
data$totmoder
# compute the standardized rates for girl's moderate scalds
data$modergirl<-with(data, modgirl/girls*10^4)
data$modergirl
# compute the standardized rates for boy's moderate scalds
data$moderboy<-with(data, modboy/boys*10^4)
```

```
data$moderboy
# compute the standardized rates for severe scalds
data$totsevere<-with(data, sevtotal/poptotal*10^4)
data$totsevere
# compute the standardized rates for girl's severe scalds
data$severegirl<-with(data, sevgirl/girls*10^4)
data$severegirl
# compute the standardized rates for boy's severe scalds
data$severeboy<-with(data, sevboy/boys*10^4)
data$severeboy
# compute the standardized rates for minor scalds
data$minorscalds<-with(data, minor/poptotal*10^4)
```

##Plot the data and identify any unusual observations

```
plot(TI~time,data=data,ylim=c(0,230),xlab="Year", ylab="Std rate x 10,000",
      bty="l",xaxt="n")
 # Add x-axis with dates
axis(1, at=1:120, labels=data$year)
 # Add a line indicating the policy changes
abline(v=66,lty=2)
abline(v=97,lty=2)
# add a title
title("Total scalds, 2009-2018, Ulaanbaatar")
```

##Tabulate total scalds before and after the intervention

```
summary(data$TI[data$step1==0])

summary(data$TI[data$step1==1])
```

##Log transformation of the variable to improve the model fitting by stabilizing the variance

```
ti=log(data$TI)

#preparing series data

ti_ts <- ts(ti, frequency = 12, start = data$year[1])
```

##Regressors

```
time<-data$time

trend<-data$slope1

ttrend<-data$slope2
```

##ARIMA Model fitting

```
(model_1 <- auto.arima(ti_ts, xreg=cbind(time,trend,ttrend),stepwise = FALSE, trace = TRUE))
```

##OUTCOME: Best model: Regression with ARIMA(1,0,2) errors

```
Series: ti_ts

Regression with ARIMA(1,0,2) errors

  Coefficients:

        ar1     ma1     ma2  intercept    time    trend  ttrend

    -0.7084  1.0527  0.4031     4.8113  0.0051  -0.0318  0.0361
```

s.e. 0.1623 0.1624 0.0894   0.0405 0.0010   0.0027 0.0050

sigma^2 estimated as 0.01489: log likelihood=85.61

AIC=-155.21   AICc=-153.91   BIC=-132.91

Series: ti_ts_

Regression with ARIMA(1,0,2) errors_

Coefficients:

_____ar1   ma1   ma2 intercept   time   trend ttrend

___-0.7084 1.0527 0.4031   4.8113 0.0051 -0.0318 0.0361

s.e. 0.1623 0.1624 0.0894   0.0405 0.0010   0.0027 0.0050

sigma^2 estimated as 0.01489: log likelihood=85.61

AIC=-155.21   AICc=-153.91   BIC=-132.91

Training set error measures:

____________ME   RMSE   MAE   MPE   MAPE   MASE   A

CF1

Training set 0.0004657881 0.1184087 0.09474917 -0.04917265 1.961455

0.4866463 0.002593004.

z test of coefficients:

_______Estimate Std. Error z value   Pr(>|z|)__

ar1   -0.70837737 0.16234406 -4.3634   0.000012803740960 ***

ma1   1.05265309 0.16235024   6.4838   0.000000000089417 ***

ma2   0.40313608 0.08935568   4.5116   0.000006434386971 ***

intercept 4.81126061 0.04053275 118.7006 < 0.00000000000000022 ***

time   0.00512204 0.00097402   5.2586   0.000000145116865 ***

trend   -0.03180933 0.00266679 -11.9279 < 0.00000000000000022 ***

ttrend   0.03606422 0.00499983   7.2131   0.000000000000547 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

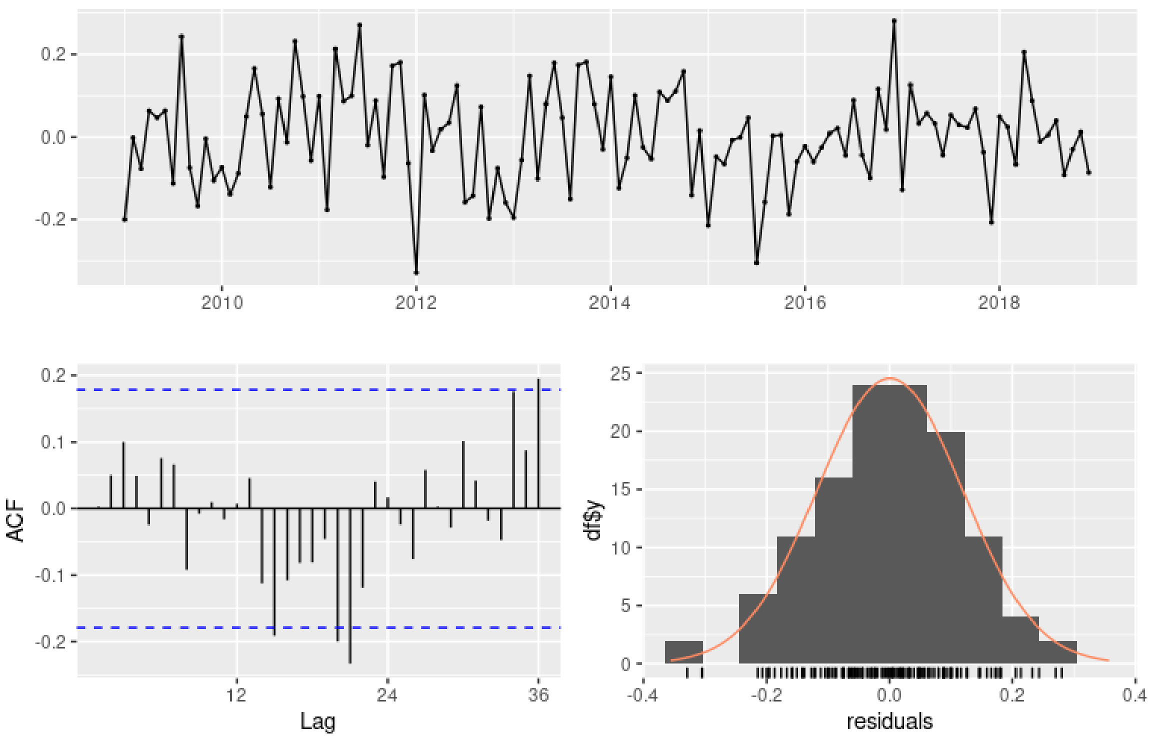
confint(model_1)

	2.5 %	97.5 %
ar1	-1.026565886	-0.390188856
ma1	0.734452473	1.370853713
ma2	0.228002166	0.578270003
intercept	4.731817884	4.890703337
time	0.003212994	0.007031092
trend	-0.037036152	-0.026582517
ttrend	0.026264736	0.045863702

##Model 1 Residuals Diagnostic

checkresiduals(model_1)

Residuals from Regression with ARIMA(1,0,2) errors



Ljung-Box Statistic test

data: Residuals from Regression with ARIMA(1,0,2) errors

Q* = 31.73, df = 17, p-value = 0.01625

Model df: 7.   Total lags used: 24.

confint(model_1)

##Generalized least square model with correlation structure ARMA (0,1) for the errors, fit by maximum likelihood method

ti.gls=gls(ti~time + trend + ttrend, data=data, correlation=corARMA(q=1,p=2),method="ML")

summary(ti.gls)

coeftest(ti.gls)

##OUTCOME: Generalized least squares fit by maximum likelihood

Model: ti ~ time + trend + ttrend

Data: data

____AIC   BIC logLik

_-154.904 -132.6041 85.452

Correlation Structure: ARMA(2,1)

Formula: ~1_

Parameter estimate(s):

___Phi1   Phi2   Theta1_

-0.3994336 0.3718641 0.7179956_

Coefficients:

________Value Std.Error   t-value p-value

(Intercept) 4.807881 0.04742676 101.37486   0 time   0.005187 0.00113682   4.56232   0

trend   -0.031855 0.00313066 -10.17532   0

ttrend   0.035850 0.00580742   6.17314   0

Correlation:

____(Intr) time   trend

time   -0.869________

trend   0.542 -0.802____

ttrend -0.174 0.338 -0.741

Standardized residuals:

____Min   Q1   Med   Q3   Max

-2.78140041 -0.64911093 -0.00310537 0.69940025 2.37126210

Residual standard error: 0.1284787

Degrees of freedom: 120 total; 116 residual

z test of coefficients:

________Estimate Std. Error z value   Pr(>|z|)__

(Intercept) 4.8078812 0.0474268 101.3749 < 0.00000000000000022 ***

time   0.0051865 0.0011368   4.5623   0.0000050592032 ***

trend   -0.0318554 0.0031307 -10.1753 < 0.00000000000000022 ***

ttrend   0.0358501 0.0058074   6.1731   0.0000000006695 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

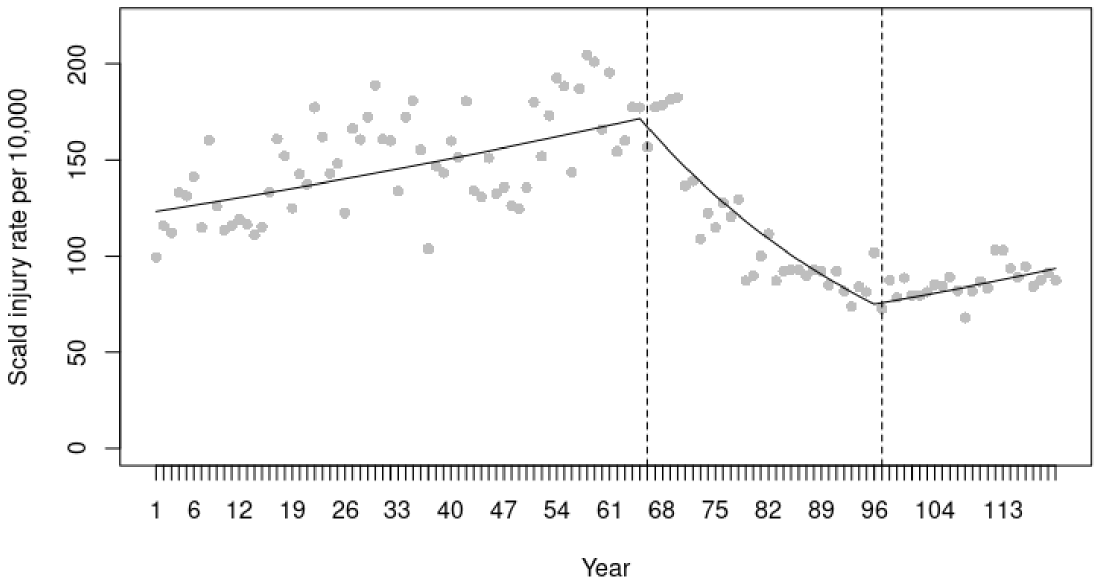
##Plot observed and predicted monthly rate

plot(exp(ti)~ time, data = data, ylab="Scald injury rate per 10,000",

ylim=c(0,220),

xlab="Year",

```
    pch=16,
    col="grey",
    xaxt="n")
axis(1, at=1:120, labels=data$time)
 # Add a line indicating the policy changes
abline(v=66,lty=2)
abline(v=97,lty=2)
# Predicted line
lines(data$time[1:120], exp(fitted(ti.gls)[1:120]), col="black",lwd=1)
```



<u>##ARIMA Models for total scalds for boys</u>

```
mi=log(data$MI)
mi_ts <- ts(mi, frequency = 12, start = data$year[1])
(model_mi <- auto.arima(mi_ts, xreg=cbind(time,trend,ttrend),stepwise = FALSE,
trace = TRUE))
summary(model_mi)
```

```
#model_mi Residuals Diagnostic
checkresiduals(model_mi)
#any auto-correlation beyond the confidence region model_mi
LjungBoxTest(residuals(model_mi), k = 0, lag.max = 20)
```

<u>##ARIMA Models for total scalds for girls</u>

```
fi=log(data$FI)
fi_ts <- ts(fi, frequency = 12, start = data$year[1])
(model_fi <- auto.arima(fi_ts, xreg=cbind(time,trend,ttrend),stepwise = FALSE,
trace = TRUE))
summary(model_fi)
confint(model_fi)
#model_fi Residuals Diagnostic
checkresiduals(model_fi)
#any auto-correlation beyond the confidence region model_fi
LjungBoxTest(residuals(model_fi), k = 0, lag.max = 20)
```

<u>##ARIMA Models for total severe scalds</u>

```
severetotal=log(data$totsevere)
severetotal_ts <- ts(severetotal, frequency = 12, start = data$year[1])
(model_sevtot <- auto.arima(severetotal_ts, xreg=cbind(time,trend,ttrend),stepwise
= FALSE, trace = TRUE))
summary(model_sevtot)
confint(model_sevtot)
#model_sevtot Residuals Diagnostic
```

```
checkresiduals(model_sevtot)

#any auto-correlation beyond the confidence region model_sevtot

LjungBoxTest(residuals(model_sevtot), k = 1, lag.max = 20)
```

##ARIMA Models for severe scalds for boys

```
seboy=log(data$severeboy)

seboy_ts <- ts(seboy, frequency = 12, start = data$year[1])

(model_seboy <- auto.arima(seboy_ts, xreg=cbind(time,trend,ttrend),stepwise =
FALSE, trace = TRUE))

summary(model_seboy)

#model_seboy Residuals Diagnostic

checkresiduals(model_seboy)

#any auto-correlation beyond the confidence region model_seboy

LjungBoxTest(residuals(model_seboy), k = 1, lag.max = 20)
```

##ARIMA Model for severe scalds for girls

```
segirl=log(data$severegirl)

segirl_ts <- ts(segirl, frequency = 12, start = data$year[1])

(model_segirl <- auto.arima(segirl_ts, xreg=cbind(time,trend,ttrend),stepwise =
FALSE, trace = TRUE))

summary(model_segirl)

#model_segirl Residuals Diagnostic

checkresiduals(model_segirl)

#any auto-correlation beyond the confidence region model_segirl

LjungBoxTest(residuals(model_segirl), k = 0, lag.max = 20)
```

##ARIMA Model for total moderate scalds

```
modtot=log(data$totmoder)

modtot_ts <- ts(modtot, frequency = 12, start = data$year[1])

(model_modtot <- auto.arima(modtot_ts, xreg=cbind(time,trend,ttrend),stepwise = FALSE, trace = TRUE))

summary(model_modtot)

confint(model_modtot)

##model_modtot Residuals Diagnostic

checkresiduals(model_modtot)

#any auto-correlation beyond the confidence region model_modtot

LjungBoxTest(residuals(model_modtot), k = 1, lag.max = 20)
```

##ARIMA Model moderate burns for girls

```
modfi=log(data$modergirl)

modfi_ts <- ts(modfi, frequency = 12, start = data$year[1])

(model_modfi <- auto.arima(modfi_ts, xreg=cbind(time,trend,ttrend),stepwise = FALSE, trace = TRUE))

summary(model_modfi)

confint(model_modfi)

#model_modfi Residuals Diagnostic

checkresiduals(model_modfi)

#any auto-correlation beyond the confidence region model_modfi

LjungBoxTest(residuals(model_modfi), k = 1, lag.max = 20)
```

<u>##ARIMA Model moderate scalds for boys</u>

```
modmi=log(data$moderboy)

modmi_ts <- ts(modmi, frequency = 12, start = data$year[1])

(model_modmi <- auto.arima(modmi_ts, xreg=cbind(time,trend,ttrend),stepwise
= FALSE, trace = TRUE))

summary(model_modmi)

confint(model_modmi)

##model_modmi Residuals Diagnostic

checkresiduals(model_modmi)

#any auto-correlation beyond the confidence region model_modmi

LjungBoxTest(residuals(model_modmi), k = 1, lag.max = 20)
```