UiT The Arctic University of Norway

Faculty of Health Sciences

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Evidence basis for injury prevention in Northwestern Russia: a study from the Population-based Shenkursk Injury Registry

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A dissertation for the degree of Philosophiae Doctor – October 2021

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Table of contents

Acknowledgements

In 2014, the project “Community-based injury prevention program and injury surveillance in the Shenkursk District” was launched with funding from the Norwegian Ministry of Health and Care Services. The project was carried out under the leadership of the Norwegian Institute of Public Health, with the involvement of the University Hospital of North Norway, UiT The Arctic University of Norway, Northern State Medical University, and the Administration of the Shenkursk District. The Shenkursk Injury Registry was one of the key project outputs.

Injuries are a public health issue worldwide, and they are preventable. As a doctor in preventive medicine and a researcher, I became interested in the project “Community-based injury prevention program and injury surveillance in the Shenkursk District” because of its practical importance, and decided to base my PhD thesis on the data from the Shenkursk Injury Registry. Within the framework of my PhD study, I described the injury panorama, but the two most important issues I addressed were the causes of injuries and how a person gets injured. In practical terms, this doctoral project was meant to help people in the Shenkursk District prevent injuries and increase safety.

I would like to express my sincerest gratitude and utmost appreciation to:

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Summary (in English)

Background. Injuries are the fourth leading cause of death in the World Health Organization European Region and the third leading cause of death in the Russian Federation. However, injury-related mortality in Russia is far higher than in any other European country. Injuries are preventable, and good-quality injury data are necessary for the development of effective prevention. The Shenkursk Injury Registry (SHIR) was established in the Shenkursk District, Arkhangelsk Region, Northwestern Russia in 2015 for the purposes of primary prevention.

Aims. The specific aims of this PhD thesis were to: 1) describe demographic, medical, spatial, and temporal characteristics of injuries, as well as the mechanisms and circumstances of injuries in the Shenkursk District; 2) assess the completeness, representativeness, and reliability of SHIR data and their suitability as an evidence basis for local injury prevention; 3) study the circumstances of non-fatal accidental fall injuries by age to provide data-driven evidence for the development of injury prevention measures in different age groups; 4) investigate the associations between weather conditions and the frequency of non-fatal accidental outdoor fall injuries (AOFIs) and provide an evidence basis for awareness-raising measures targeting weather-related dangers.

Methods. The present thesis was based on the description of the overall injury panorama and three studies that used SHIR data on medically treated injuries that occurred between 1 January 2015 and 30 June 2018. The completeness, representativeness, and reliability of SHIR data were assessed using a sample of 1696 injuries that occurred between 1 July 2015 and 30 June 2016. The circumstances and mechanisms of non-fatal accidental fall injuries (outdoor and indoor) were studied in four age groups: preschool age, school age, working age, and elderly age. The associations between non-fatal AOFIs and weather conditions were investigated in the cold season (15 October – 14 April) and the warm season (15 April – 14 October).

Main results. A total of 5343 injuries were entered into the SHIR between 1 January 2015 and 30 June 2018. When compared to cases treated at the Shenkursk Central District Hospital, the completeness of the SHIR was 86%. Two independent data entries from standard paper injury registration forms showed a 79% to 99% agreement, depending on the variable considered. Dwellings, homestead lands, and other nearby outdoor areas constituted the most common injury sites (48% of total injuries). The majority of injuries in the SHIR were the result of accidents (88%), predominantly falling (42%). In the preschool age group, fall injuries were most commonly associated with climbing onto or down from home furnishings, play equipment, or stairs, and a loss of balance (64%). The most substantial proportion of fall injuries (36%) in the school age group occurred during physical exercise. The most frequent accident mechanism in the working (32%) and elderly (37%) age groups was slipping on an ice-covered surface. The highest risk of AOFI was observed in the cold season on days with a combination of medium air temperature (-7.0°C – -0.7°C), medium/high precipitation (≥ 0.4 mm), and a ground surface covered with compact or wet snow.

Conclusion. The study demonstrated that SHIR data were sufficiently complete, reliable, and representative of the injury situation in the Shenkursk District. The majority of injuries in the study area were due to falls. SHIR data allowed for the identification of typical scenarios of fall injuries in different age groups. Combining SHIR data with meteorological data allowed for the identification of high-risk days with respect to AOFIs. Thus, SHIR data are applicable for epidemiological research and can serve as an evidence basis for the development of diverse injury prevention measures in the Shenkursk District.

Summary (in Russian)

Актуальность. Травмы являются четвертой ведущей причиной смерти в Европейском регионе ВОЗ и третьей ведущей причиной смерти в Российской Федерации. Однако, смертность от травм в России значительно выше по сравнению с другими Европейскими странами. Травмы предотвратимы и данные хорошего качества о травмах необходимы для разработки эффективных мер профилактики. Шенкурский регистр травм (ШРТ) был создан в 2015 году в Шенкурском районе Архангельской области, Северо-Запад России, для целей первичной профилактики.

Цели. Целями диссертационного исследования были: 1) описать демографические, медицинские, пространственные и временные характеристики травм, а также механизмы и обстоятельства травм в Шенкурском районе; 2) оценить полноту, репрезентативность и надежность данных ШРТ и их применимость в качестве доказательной базы для профилактики травм на местном уровне; 3) изучить обстоятельства несмертельных случайных травм, связанных с падениями, по возрасту, чтобы предоставить обоснования для разработки мер профилактики травм в разных возрастных группах; 4) исследовать связи между погодными условиями и частотой несмертельных случайных травм при падениях вне помещений, чтобы предоставить обоснования для разработки мер по повышению осведомленности об опасностях, связанных с погодой.

Методы. Настоящее диссертационное исследование основано на описании панорамы травм в целом и трех исследований с использованием данных ШРТ, включающего пролеченные травмы, которые возникли за период с 1 января 2015 года по 30 июня 2018 года. Полнота, репрезентативность и надежность данных ШРТ были оценены на выборке

из 1696 случаев травм, которые возникли за период с 1 июля 2015 года по 30 июня 2016 года. Обстоятельства и механизмы несмертельных случайных травм, связанных с падениями (вне и внутри помещений), были изучены в четырех возрастных группах: дети дошкольного возраста, дети школьного возраста, взрослые трудоспособного и пожилого возраста. Связи между погодными условиями и несмертельными случайными травмами, обусловленными падениями вне помещений, были исследованы в холодный сезон (15 октября – 14 апреля) и в теплый сезон (15 апреля – 14 октября).

Основные результаты. За период с 1 января 2015 года по 30 июня 2018 года в ШРТ было зарегистрировано 5343 травмы. При сравнении числа травм в ШРТ с травмами, пролеченными в Шенкурской центральной районной больнице, полнота ШРТ составила 86%. Двойной независимый ввод данных из стандартных бумажных листов учета травм показал уровень согласия 79 – 99% в зависимости от типа переменной. Описание панорамы травм показало, что жилые дома, приусадебные участки и другие рядом расположенные открытые площадки были наиболее распространенным местом получения травм (48% от общего числа травм). Большинство травм, зарегистрированных в ШРТ, произошло в результате несчастного случая (88%), чаще всего при падении (42%). Среди детей дошкольного возраста травмы чаще всего возникали при падении с мебели, игрового оборудования или лестниц в результате потери равновесия (64%). Наиболее значительная доля травм при падении в школьном возрасте (36%) произошла во время физических упражнений с использованием спортивного инвентаря или игрового оборудования. Наиболее частым механизмом несчастных случаев среди лиц трудоспособного возраста (32%) и у пожилых (37%) было поскальзывание на покрытой льдом поверхности. Наибольший риск случайных травм, связанных с падениями вне помещений, наблюдался в холодный сезон года в дни со средней температурой воздуха в диапазоне от -7,0ºС до -0,7ºС в сочетании со средним / значительным количеством осадков (≥ 0,4 мм) и наличием плотного или мокрого снега на поверхности земли.

Заключение. Исследование показало, что данные ШРТ являются достаточно полными, надежными и репрезентативными в отношении описания травматизма в Шенкурском районе. Большинство травм в районе произошло в результате падений. Данные ШРТ позволили выявить различные типичные сценарии травм при падении в разных возрастных группах. Объединение данных ШРТ с метеорологическими данными позволило выявить дни повышенного риска возникновения несмертельных случайных травм при падениях вне помещений. Таким образом, данные ШРТ могут быть использованы для эпидемиологических исследований и могут служить доказательной базой для разработки широкого спектра мер профилактики травматизма в Шенкурском районе.

List of tables

List of figures

List of abbreviations

AI	artificial intelligence
AIS	Abbreviated Injury Scale
AOFI	accidental outdoor fall injury
APC	average percent change
CDH	Central District Hospital
ICD-10	International Statistical Classification of Diseases and Related Health Problems 10^{th} revision
INILA	Insurance Number of Individual Ledger Account
IRF	injury registration form
MIAC	Medical Information Analytical Center
MIS	medical information system
ML	machine learning
NWFD	Northwestern Federal District
REC	Norwegian Regional Committees for Medical and Health Research Ethics
Rosstat	Federal State Statistics Service
SHIR	Shenkursk Injury Registry
WHO	World Health Organization

List of papers

The thesis is based on the following original papers:

Paper I

Unguryanu TN, Grjibovski AM, Trovik TA, Ytterstad B, Kudryavtsev AV. Injury registration for primary prevention in a provincial Russian region: setting up a new trauma registry. Scand J Trauma Resusc Emerg Med 2019;27(1):47.

Paper II

Unguryanu TN, Grjibovski AM, Trovik TA, Ytterstad B, Kudryavtsev AV. Mechanisms of accidental fall injuries and involved injury factors: a registry-based study. Inj Epidemiol 2020;7(1):8.

Paper III

Unguryanu TN, Grjibovski AM, Trovik TA, Ytterstad B, Kudryavtsev AV. Weather conditions and outdoor fall injuries in Northwestern Russia. Int J Environ Res Public Health 2020;17(17):6096.

Chapter 1. Introduction

1.1. Injury definition

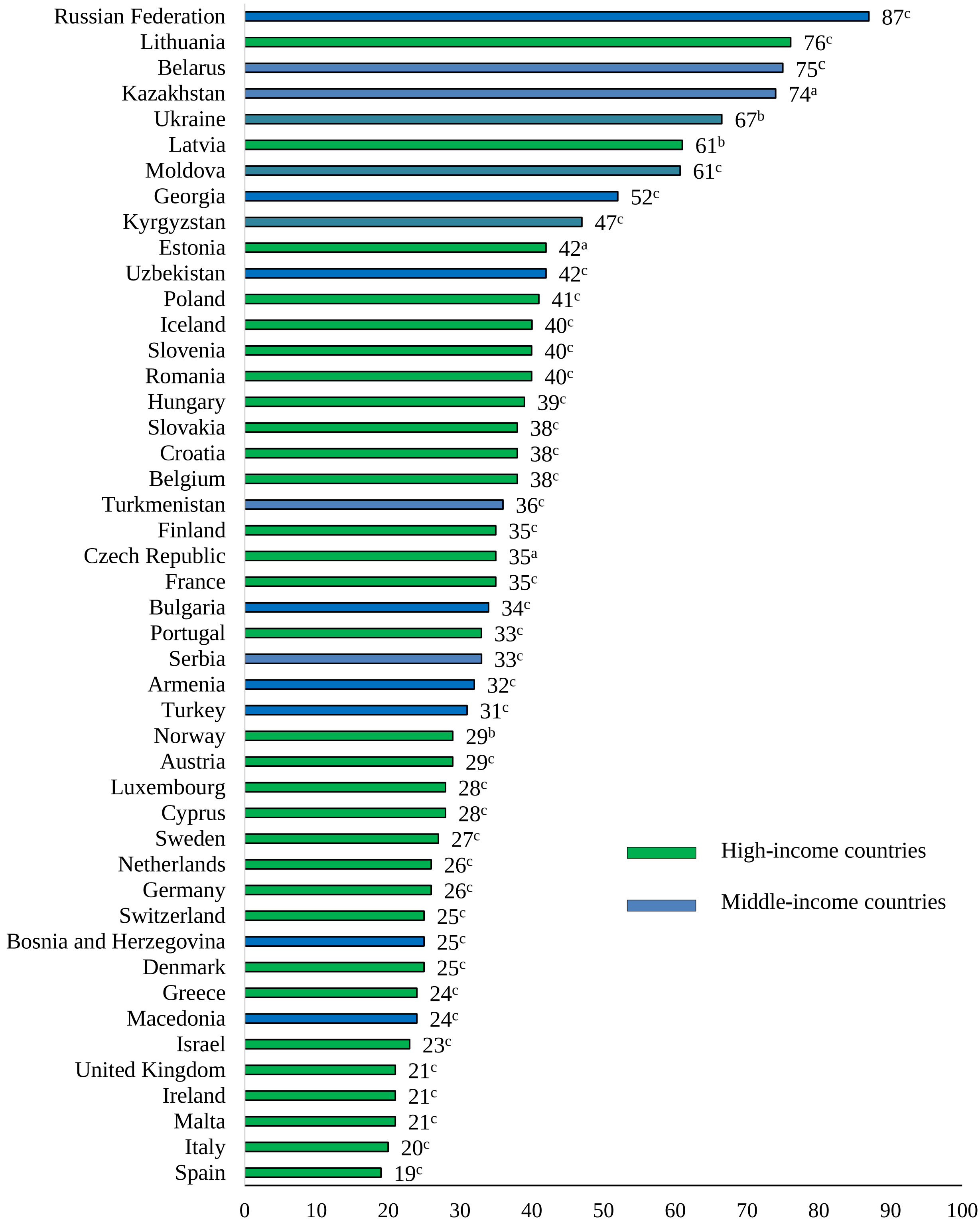
An injury is defined as “the damage caused by the acute transfer of energy, whether physical, thermal, chemical or radiant, that exceeds the physiological threshold, or by the deprivation of a vital element” (1). In the International Statistical Classification of Diseases and Related Health Problems 10th revision (ICD-10), injuries are included in Chapter XIX “Injury, poisoning and certain other consequences of external causes” (ICD-10 codes S00 to T98) and Chapter XX “External causes of morbidity and mortality” (ICD-10 codes V01 to Y98) (Appendix A) (2). Injuries can be further categorized as unintentional or intentional. An injury is classified as unintentional if it is “judged to have occurred without anyone intending harm be done; in many settings these are termed as accidental injuries” (3). Intentional injuries are those resulting “from purposeful human action whether directed at oneself or others, sometimes referred to as violent injuries” (3). In the literature, the terms trauma and injury are used interchangeably; thus, in the present PhD thesis, we consider these terms to be synonyms.

1.2. Global burden of injuries

Due to the concurrent processes of globalization, urbanization, economic growth, and the demographic and nutritional transitions that have occurred during the 20th century, non-infectious diseases and injuries now contribute more to most countries’ epidemiological profiles than infectious diseases (4). At present, injuries are an important cause of health and human capital losses globally, causing over 4.4 million deaths each year (5). According to global trends, between 1990 and 2017 the age-standardized mortality rate from injuries decreased by 31% while the age-standardized incidence rate for injuries decreased by only 1% (6). The decreased mortality rate from injuries in many countries may reflect a changing injury profile due to aging population, the implementation of injury prevention programs, and improvements in healthcare systems (6-8).

Injury-related mortality is unevenly distributed across the world, with a larger proportion occurring in low- and middle-income countries (88%) (9). Injuries are the fourth leading cause of death in the World Health Organization (WHO) European Region and accounted for 465,000 deaths (or 5% of all deaths) in 2019 (5). Mortality rates from injuries in middle-income countries in the WHO European Region were 1.7 times higher than in high-income countries (Fig. 1) (6, 10, 11). Estimates for 2019 showed that the three most common causes of injury-related mortality in the WHO European Region were self-directed injuries (25%), falls (19%), and road traffic injuries (15%). Other injuries, such as violence, drowning, fire-related burns, exposure to mechanical forces, and poisonings, jointly accounted for 17% of injury-related mortality (5).

All age groups are affected by injuries, but people aged 5 – 49 years are at particular risk. Injuries account for a third of all deaths in children aged 5 to14 years, half of deaths in young people aged 15 – 29 years, and a quarter in adults aged 30 – 49 years (10). Road traffic injuries, suicides, and interpersonal violence account for 70% of all injury-related mortality in people aged 15 to 29 years. Falls (40%) are the leading cause of injury-related death among the elderly (aged 70+ years) (12).



Note: a=2019, b=2018, c=2017

Figure 1. Age-standardized mortality rate (per 100,000 population) from injuries in the World Health Organization European Region, 2017 – 2019, both sexes, all ages (6, 11)

Mortality is the most commonly used indicator of the burden of injuries, but it reflects only the tip of the iceberg, as only a small proportion of injuries results in death. The largest proportion of the total burden of injuries is made up of non-fatal injuries. In the WHO European Region, for each death from injury, there are over 20 injury hospitalizations, and nearly 160 emergency department visits (10). Many millions of non-fatal injuries result in varying degrees of long-term disability, mental consequences, and behavioral changes; indeed, non-fatal injuries are responsible for 9% of all disability-adjusted life-years lost (10, 13).

Unlike fatal injuries, there are no significant differences in the rates of non-fatal injuries between middle- and high-income countries in the WHO European Region (Fig. 2). In 2017, the average age-standardized incidence rate for injuries was 13,247 per 100,000 population in middle-income countries and 12,910 per 100,000 population in high-income countries. The difference between the highest and lowest age-standardized incidence rates for injury was 15,648 per 100,000 population in high-income countries and 11,884 per 100,000 population in middle-income countries (6).

According to the European injury database EuroSafe (14), among all injuries treated in a hospital or received ambulatory care, the most frequent causes of non-fatal injuries are falls (36%), followed by road accidents (9%) and cuts/pierces (9%). Males are more commonly treated for road traffic accidents, cuts and pierces, and burns, while females more frequently attend hospitals for falls and poisonings. The largest proportion of non-fatal hospital injuries occur in those of working age (25 – 64 years, 45%) followed by children (0 – 14 years, 21%), the elderly (65+ years, 18%), and young people (15 – 24 years, 16%) (14).

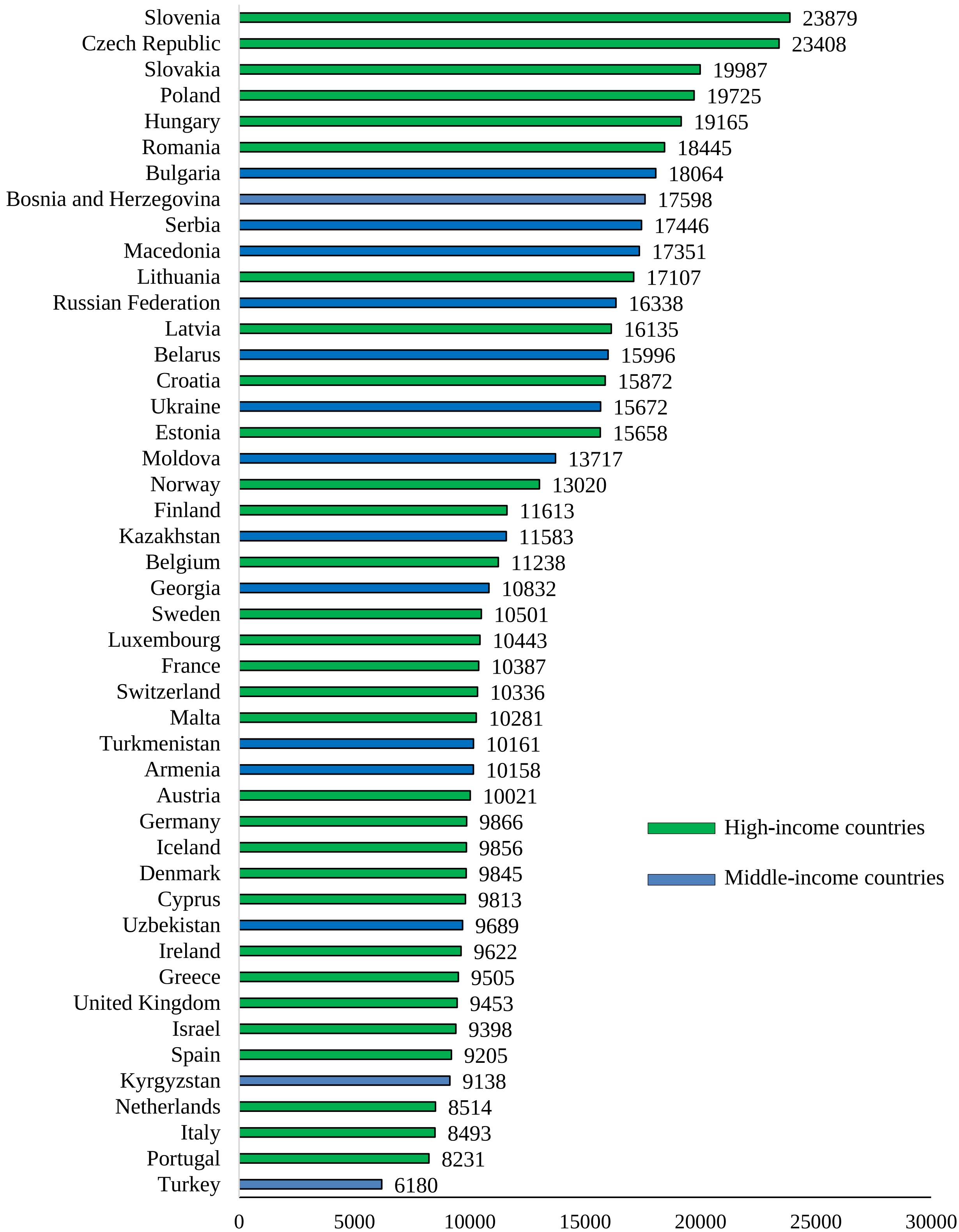


Figure 2. Age-standardized incidence rate (per 100,000 population) for injuries in the World Health Organization European Region, 2017, both sexes, all ages (6)

1.3. Injuries in the Russian Federation

Injuries are the third leading cause of death in the Russian Federation, after diseases of the circulatory system and neoplasms. However, injury-related mortality in Russia is far higher than in any other European country. In 2017, the age- standardized mortality rate from external causes in Russia (87.0 per 100,000) was 1.8 times higher than that in the WHO European Region (49.4 per 100,000) (6, 11, 15).

An encouraging fact is that crude mortality rate from injuries in Russia has decreased from 206.1 per 100,000 in 1999 to 98.6 per 100,000 in 2018 (16) (Fig. 3). During this 20-year period, males were four times more likely to die from injuries than females (17), and 65% of all injury-related deaths occurred in people of working age (18). From 2014 to 2018, the three most common causes of injury-related death in Russia were suicide (14%), road traffic accidents (10%), and alcohol poisoning (8%). Other prevalent causes were homicide (6%), exposure to low temperatures (6%), falls (5%), and drowning (4%) (18).

Despite the clear decrease in mortality rate from injuries in Russia between 1999 and 2018, the incidence rate of non-fatal injuries increased over the same period by 7% (19) (Fig. 3). Consequently, 13 million new non-fatal injuries, poisonings, and other consequences of external causes (89.0 per 1000 population) were registered in Russia in 2018 (20).

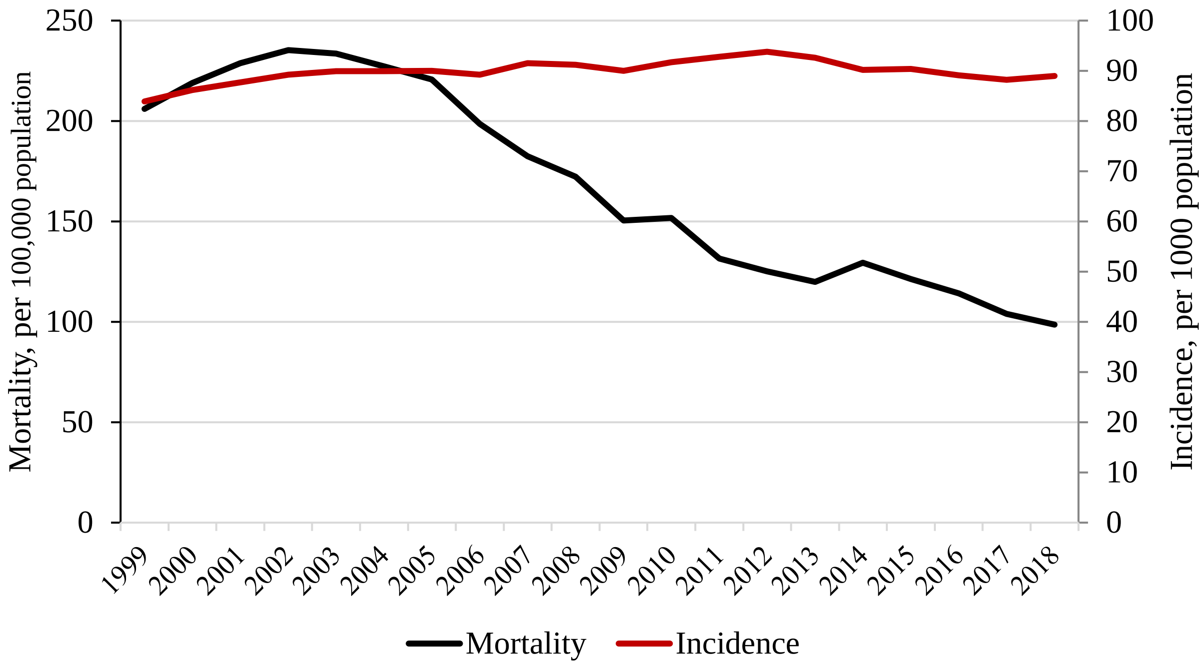


Figure 3. Crude mortality rate (per 100,000 population) from and crude incidence rate (per 1000 population) for injuries, poisonings, and other consequences of external causes in Russia, 1999 – 2018, both sexes, all ages (16, 19)

1.4. Injuries in the Arkhangelsk Region of Russia

The Arkhangelsk Region belongs to the Northwestern Federal District (NWFD) of Russia, which also includes of 9 other regions in the European North of Russia, and Saint Petersburg City. The total area of the Arkhangelsk Region is 311,500 km^2. Due to its northern location, the region has a cold climate, with a mean annual air temperature that ranges from 0.1°C to 2.0°C. The total population of the Arkhangelsk Region was 1,111,031 as of 1 January 2018, with 78% of inhabitants residing in urban settlements (21). The main industries in the Arkhangelsk Region are pulp and paper production, woodworking, forestry, shipbuilding, fishery, and food production.

The age-standardized mortality rates from injuries among males and females in the Arkhangelsk Region for the period 1999 to 2018 were on average 20% higher than those in Russia as a whole, and 20% higher than those in the NWFD (18, 22-28) (Fig. 4). In this period, the age-standardized mortality rates from injuries among males in the Arkhangelsk Region decreased by only 13%, while in Russia as a whole and in the NWFD, these mortality estimates decreased by 22% and 23%, respectively. The age-standardized mortality rates from injury among females in the Arkhangelsk Region decreased by 20%, while in Russia as a whole and in the NWFD it decreased by 23% and 27%, respectively. The five most common external causes of mortality in the Arkhangelsk Region in 2018 were suicide (20%), alcohol poisoning (16%), road traffic accidents (10%), exposure to low temperatures (7%), and homicide (7%) (29).

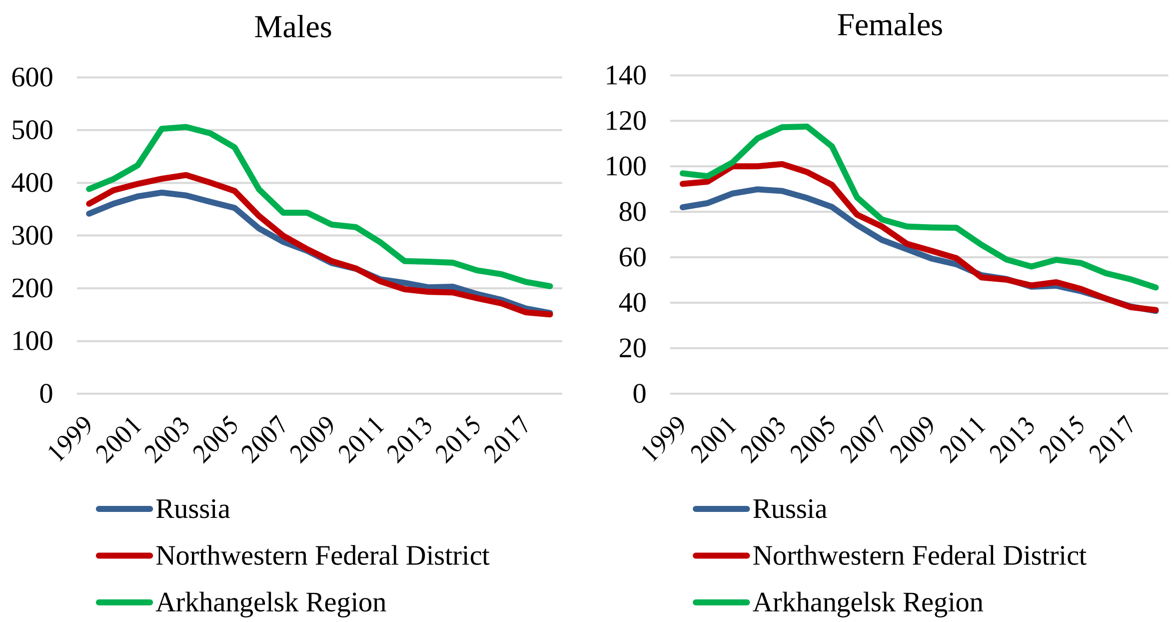


Figure 4. Age-standardized mortality rate (per 100,000 population) from injuries, poisonings, and other consequences of external causes in Russia as a whole, in the Northwestern Federal District of Russia, and in the Arkhangelsk Region, 1999 – 2018, all ages (18, 22-28)

More than 115,000 cases of non-fatal injuries, poisonings, and other consequences of external causes (104.5 per 1000 population) were registered in the Arkhangelsk Region in 2018. The total crude incidence rate for injuries in the Arkhangelsk Region increased by 19% between 1999 and 2018. The total crude incidence rate for injuries from 2014 to 2018 in the Arkhangelsk Region (on average, 106.7 per 1000 total population) was 1.2 times higher than that in Russia as a whole. According to the Arkhangelsk Regional Medical Information Analytical Center (MIAC), one of the highest incidence rates for injuries in the period 2014 to 2018 was in the Shenkursk District (124.7 per 1000 total population).

1.5. Injury registration in Russia

In Russia, registration of a death from an injury, poisoning, or other consequence of external causes requires that a doctor at a hospital or at forensic department completes a medical death certificate. The certificate contains cause of death data, including the proper ICD-10 codes from chapters XIX and XX (2). Issuing medical organizations submit medical death certificates to their regional MIAC and their regional Vital Records Office; the latter then aggregates copies of all medical death certificates and sends the information to the regional office of the Federal State Statistics Service (Rosstat). The regional Rosstat offices use this data to create an electronic database, which they send to the central Rosstat office in Moscow on a monthly basis.

New cases of non-fatal injuries, poisonings, and other consequences of external causes are registered in Russian healthcare institutions, including hospitals, outpatient polyclinics, and primary care units. The registration takes place when an injured person approaches a healthcare institution for medical treatment, and the information about the injured patient and the injury characteristics are entered into the healthcare institution's medical information system (MIS).

In the Arkhangelsk Region, MISs are based on one of two software platforms: "ARIADNA" or "SAMSON", which code injuries using ICD-10 codes (2).

Once a year, Russian healthcare institutions use the data contained in their MIS to compile and submit two standard statistical report forms to their regional MIACs:

- Report form N 12 , named "Information about cases of diseases registered in patients living in the service area of a medical organization", covers ICD-10 codes (A00 – T98) and is stratified by age group: children and adolescents (0 − 1, 1 − 3, 0 − 4, 5 − 9, 0 − 14, and 15 − 17 years), adults (18+ years), and adults over working age (55+ years for females and 60+ years for males) (30).
- Report form N 57 is called "Information about injuries, poisonings, and some other consequences of exposure to external factors" and includes detailed tables that list the number of cases with ICD-10 codes from chapter XIX (Injury, poisoning, and certain other consequences of external causes; S00 − T98) and chapter XX (External causes of morbidity and mortality; V01 − Y98). It is also stratified by age group: children (0 − 17 years), adults (18+ years), and adults over working age (55+ years for females and 60+ years for males) (31).

Reports forms N 12 and N 57 include diagnoses assigned by doctors, but not by nurses, midwives, or feldshers (healthcare workers with secondary medical education who commonly constitute the medical staff of rural primary care units).

Regional MIACs compile and process the information from their regions, and once a year send summarized statistical tables to their regional Rosstat office. Upon receipt of the reports from the regional MIACs, the regional Rosstat offices create summary reports on overall morbidity and on the incidence of injuries in the population (32-34). Because they are based on the aggregated data, these reports contain absolute numbers of cases by ICD-10 code and corresponding incidence estimates for the total population and for its subgroups by age, sex, and place of residence. These reports provide good descriptive overviews of the numbers of medically treated injuries, as well as of the burden of injuries, measured as incidence estimates per population numbers. However, they are of limited use for planning primary prevention, because they lack information about when, where, and how exactly the injuries occurred.

More detailed patient information is available in the MIS of each healthcare institution. There, in addition to diagnosis, age, sex, and place of residence, one can obtain data on selected socio-demographic characteristics, results of medical examinations and laboratory analyses, a description of the treatment provided, and other medical information. These detailed medical records are used for clinical decision-making, planning rehabilitation, as well as for reporting cases and treatment costs to health insurance. However, upstream information about the circumstances of injuries is also lacking in MISs. Therefore, data from other sources must be used when planning primary prevention, like data from road police, criminal records, or population surveys.

1.6. Injury registries

Good-quality injury data are necessary for the development of effective prevention (35-37). Therefore, the first step in the planning of primary injury prevention is to collect injury data through surveillance systems or injury registries (38, 39). An injury (or trauma) registry may be defined as “disease-specific data collection composed of a file of uniform data elements that describe the injury event, demographics, prehospital information, diagnosis, care, outcomes, and costs of treatment of injured patients" (40). There are two types of disease and injury registries: hospital-based and population-based. A hospital-based registry is "a file of all patients seen at a hospital with a particular disease" (41), whereas a population-based registry "collects detailed information about all new cases of a disease in a population of known size and composition" (41). Registries can include data about medically treated injuries at the hospital, regional, state, and national level.

The first injury registries date to the early 1970s in the United States (42). At present, a number of developed countries maintain national injury registries, including Germany, Italy, Israel, the United Kingdom, Australia, New Zealand, Canada, and the United States (36, 43, 44). Although low-income countries face economic barriers to the establishment of injury registries (45), a few countries, such as Peru (46), Pakistan (47), Nigeria (48), and the United Arab Emirates (39) have succeeded in developing single-hospital or regional registries.

Hospital-based (or clinical) injury registries are valuable sources of medical information that aim to support improvements in patient care and evaluate the efficacy of new interventions (36). Such registries serve clinical purposes and include data on first aid, primary care, and complementary exams. For example, the Alberta Trauma Registry in the Calgary Health Region of Canada (43), the Victorian State Injury Registry in Australia (49), the Israel Injury Registry (44), the Injury Registry at the Brazilian University Teaching Hospital (50), and the Swedish Fracture Register (51) include a large amount of clinical information about the injured, including treatment at the scene and in the emergency room, diagnostic and surgical procedures, operating room time, and days spent in the intensive care unit.

Both hospital-based and population-based injury registries can gather information about the mechanisms and circumstances of injuries and can be used for primary injury prevention programs (36). For example, the District Level Hospital-Based Injury Surveillance System in India (52), the Trauma Registry in Cali, Colombia (42), the King Abdul-Aziz Medical City Trauma Registry in Saudi Arabia (53), and the Harstad Injury Registry in Norway (54, 55) include detailed etiological information about injury causes and circumstances: intent, mechanism, nature and site, activity the patient was involved in when the injury occurred, place of injury. These registries serve an evidence basis for primary injury prevention, and as a data source for epidemiological studies.

Since 1987, the Harstad Injury Registry has been systematically collecting data on the epidemiological profile of injuries in the municipality of Harstad, Norway (37, 55, 56), with an emphasis on supporting primary injury prevention through the Safe Community program. Using injury registry data and the Safe Community approach, the municipality of Harstad has achieved substantial success in community-based injury prevention. Implementation of targeted prevention programs based on the registry data has led to substantial reductions in specific injuries. For example, the rate of road traffic injuries among young residents decreased by 59%, and the burn injury rate in children under 5 years of age decreased by 51% (37, 56).

One of the strengths of a population-based registry is that it includes all cases in the target population, so selection bias is minimized. In addition, using population-based registry data for epidemiological research saves time and costs, because researchers can extract routinely collected data. Furthermore, due to large numbers of observations generated over time, a population-based registry data allow researchers to study rare exposures and outcomes, and adjust for confounders that are available for the whole population (57-60). Finally, population-based injury registries can be linked with other population-based registries in order to study injuries in a broader context (60-62).

1.7. Community-based injury prevention and injury surveillance in the Shenkursk District

The success of the Harstad Injury Registry and the high incidence of injuries in the Shenkursk District laid a basis for the project "Community-based injury prevention program and injury surveillance in the Shenkursk District". The project was launched in 2014, with the overall goal of establishing a municipal injury registry and community-based injury prevention program in the Shenkursk District, based on the experience of the Safe Community program in Harstad. The project was supported by a grant from the Norwegian Ministry of Health and Care Services, and the Norwegian Institute of Public Health was the lead institution. The University Hospital of North Norway, UiT The Arctic University of Norway, the Northern State Medical University in Arkhangelsk, and the Administration of the Shenkursk Municipal District were the project partners. As one of the key project outputs, the first Russian population-based injury registry was established in the Shenkursk District on 1 January 2015: the Shenkursk Injury Registry (SHIR). This registry is based on the Harstad Injury Registry model, and its purpose is to facilitate evidence-based primary injury prevention at the municipal level (63, 64). Largely due to the implementation of this approach, in 2017 the town of Shenkursk was certified as an International Safe Community and became the first Russian member of the International Safe Community network (https://isccc.global/).

1.8. Motivation for the study

The motivation for the present thesis was to assess the usefulness of the SHIR as a resource to identify local injury problems and describe the mechanisms and circumstances of their occurrence. Evidence-based knowledge about these injury characteristics is important for the proper planning, development, implementation and evaluation of injury prevention measures.

1.9. Aims of the thesis

Overall aim:

- To provide an evidence basis for injury prevention in the Shenkursk District, Northwestern Russia, using SHIR data

Specific aims:

- To describe the demographic, medical, spatial, and temporal characteristics of injuries, as well as the mechanisms and circumstances of injuries in the Shenkursk District (thesis only)
- To assess the completeness, representativeness, and reliability of SHIR data and their suitability as an evidence basis for local injury prevention (Paper I)
- To study the circumstances of non-fatal accidental fall injuries by age and provide data-driven evidence for the development of injury prevention measures in different age groups (Paper II)
- To investigate the associations between weather conditions and the frequency of non-fatal accidental outdoor fall injuries and provide an evidence basis for awareness-raising measures targeting weather-related dangers (Paper III)

Chapter 2. Materials and methods

2.1. Study design

The present thesis is based on the description of the overall injury panorama and three specific registry-based studies that used SHIR data on medically treated injuries in the Shenkursk District. The study period was from 1 January 2015 to 30 June 2018. Figure 5 reflects the logical structure of the three papers that compose this thesis. The overall description of the injury panorama and of fatal injuries in the Shenkursk District in the study period are included in this thesis only.

Paper I assessed the quality of SHIR data and their applicability for research and prevention purposes. We assessed the completeness, representativeness, and reliability of SHIR data using a sample of 1696 injuries that occurred from July 2015 to June 2016.

Paper II focused on the circumstances of accidental fall injuries (outdoor and indoor) in the Shenkursk District, which is a major problem according to the local injury panorama. We used data on all registered accidental fall injuries that occurred in the district from January 2015 to June 2018 (N = 1551) and described typical scenarios of fall injuries in four age groups: preschool age (0 – 6 years), school age (7 – 17 years), working age (18 – 59 years), and elderly age (60+ years).

In Paper III, we described AOFIs in the Shenkursk District from January 2015 to June 2018 (N = 1125) and their associations with weather conditions, separately for the cold season (15 October – 14 April) and the warm season (15 April – 14 October).

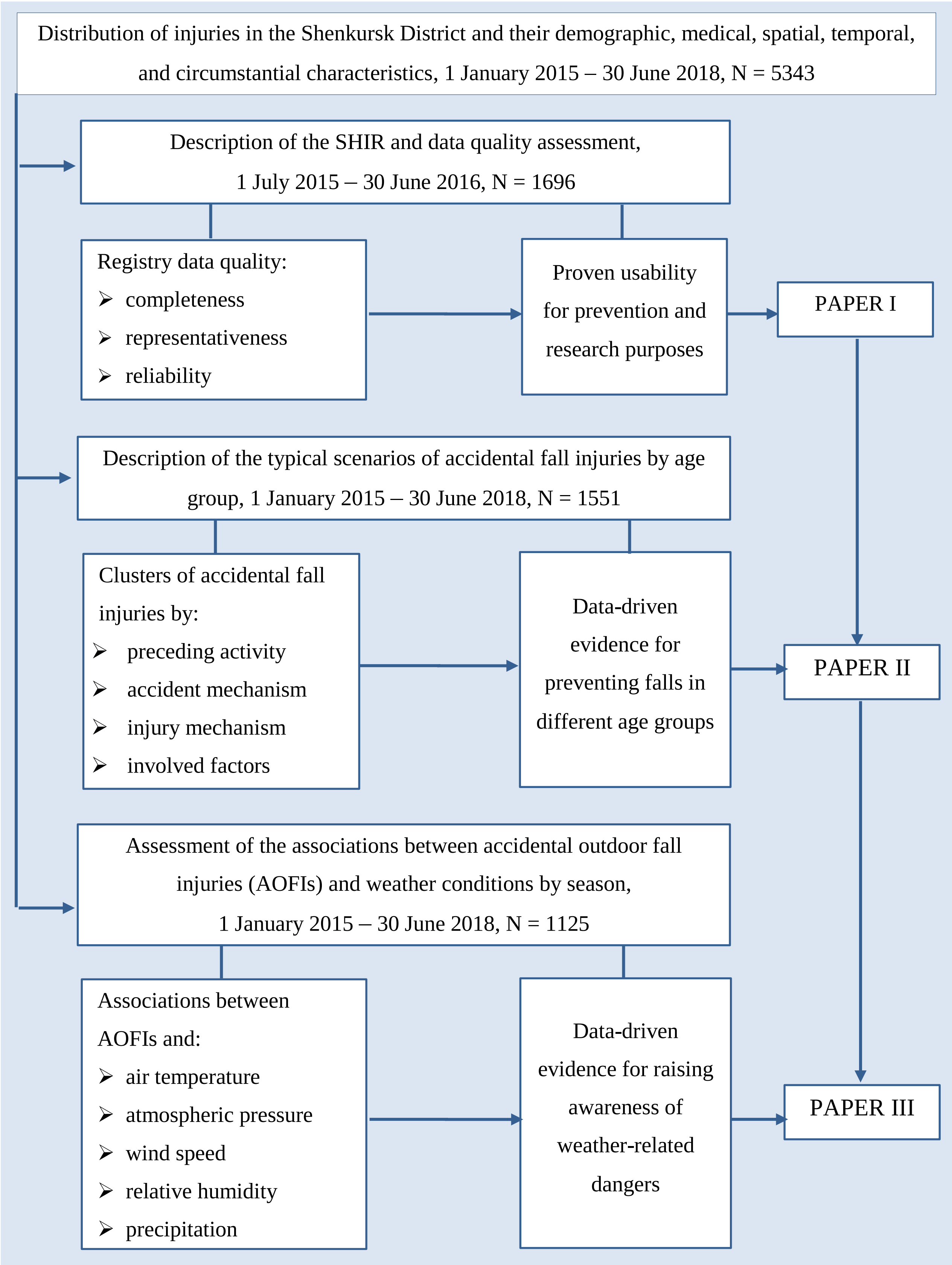


Figure 5. Structure of this thesis and of Papers I – III

2.2. Study setting

The Shenkursk District is located in the Arkhangelsk Region, in the NWFD of Russia (Fig. 6), and has a total area of 11,300 km^2. Due to its northern location (62°06’ N, 42°54’ E), the Shenkursk District has a cold climate, with a mean annual air temperature of 1.4°C. Temperatures below zero prevail from October to April (65).

Figure 6. Map of the Northwestern Federal District of Russia

As of 1 January 2018, the Shenkursk District had a population of 12,610 (Table 1). As a proportion the population, people ages 18 to 59 years represented 50%; those aged 60+ years and 0 to 17 years constituted 28% and 22%, respectively (21). Compared to 1 January 2015, by 1 January 2018 the total population of the district decreased by 7%, with the number of inhabitants aged 0 to 17 years and 18 to 59 years decreasing by 6% and 14%, respectively. However, the number of people aged 60+ years increased by 8%. These changes reflect general demographic tendencies in provincial Russian settings.

Table 1. Population of the Shenkursk District on 1 January by age group, 2015 − 2018 (21, 66-68)

Age group	**2015**	**2016**	**2017**	**2018**
0−17 years	2885	2826	2794	2715
18−59 years	7352	6893	6537	6348
60+ years	3293	3371	3428	3547
Total	13,530	13,090	12,759	12,610

The town of Shenkursk is the administrative center of the Shenkursk District and its only urban settlement, with a total population of 4772 on 1 January 2018. The rest of the population (62%) resides in 253 rural settlements, spread all over the district.

The town of Shenkursk is situated 380 km from Arkhangelsk City, near the M8 Russian Federal highway that links Arkhangelsk City and Moscow. Shenkursk is separated from the highway by the Vaga River, which can be crossed by pontoon bridge, ice crossing, or ferry crossing, depending on the time of the year. The road network, streets, and walkway infrastructure are grossly underdeveloped in the town, and during the study period, most of the local roads were unpaved; walkways were made of concrete or wood, or were covered by gravel; and only major streets in the town had streetlights. By present time, the situation has gradually improved due to the municipal program “Comfortable urban environment”, which is aligned with the Shenkursk Safe Community program.

The main industries in the Shenkursk District are forestry, woodworking, food production, and agriculture. The educational network in the district includes 11 kindergartens, 6 secondary schools and 1 specialty school (school of arts). Healthcare in the district is provided by the Shenkursk Central District Hospital (CDH) and by rural primary care units. The Shenkursk CDH is located in the town of Shenkursk and has inpatient facilities (46 beds) and outpatient polyclinics for adults and children (400 visitors per day). The rural primary care units include two rural outpatient departments and 23 feldsher-midwife stations. Within the framework of the compulsory health insurance program, the Shenkursk CDH and rural primary care units provide free inpatient, outpatient, and emergency medical care to all residents of the Shenkursk District, as well as to visitors from other places. The Shenkursk CDH uses the SAMSON MIS to register all medically treated patients, including patients with injuries.

2.3. The Shenkursk Injury Registry

The establishment of the SHIR started with the translation of the Harstad Injury Registry's user manual and injury registration form (IRF) from Norwegian into Russian (37, 54, 56). The user manual contains registration instructions, as well as the definitions, classifications, and coding lists to be used in the processing of the free-text descriptions of injury setting and circumstances. The classifications used are based on the "Northern European Classification for the Registration of Accidents" published by the Nordic Medico-Statistical Committee (69). Questions about alcohol consumption in the preceding 24 hours, education, and marital status were added to the Russian version of the IRF.

Two seminars were held, one in the municipality of Harstad and one in the town of Shenkursk, during which two nurses from the Shenkursk CDH were trained as injury registrars, using the translated user manual. These nurses were trained in and became responsible for ensuring that the IRF is completed by the appropriate party; for using coding lists to convert free-text descriptions of injury situations into categorical variables that reflect the activity, accident mechanisms, injury mechanisms, and involved factors; and for entering data from the paper IRF into the electronic SHIR database.

In 2014, the SHIR was tested in two pilot studies. The aim of the first pilot study (N = 30) was to assess whether injured patients could easily understand the questions in the IRF. The results showed that patients had no difficulty in completing the IRF. However, questions about education and marital status were found to be distracting and redundant. Several patients questioned the need to collect these data, and the questions were excluded. For this reason, data on education and marital status were not available for this thesis. On 1 January 2017, fields for the medical staff to enter ICD-10 codes for external causes of morbidity and mortality (Chapter XX) and fields to make records on who completed the IRF were added to the IRF.

The final IRF version (Appendix B) is a two-page form. Some sections are to be completed by the injured patient and others by doctors. It collects information on socio-demographic characteristics (sex, date of birth, address of residence, place of work or study), the time and place of the injury, alcohol consumption in the 24 hours before injury, use of protective equipment, and optional sections for descriptions of road traffic and sports injuries. Information on alcohol consumption in the 24 hours before the injury is self-reported. The IRF also has a free-text field, in which a description of how the injury occurred must be given. This field contains three supporting questions to facilitate the descriptions of injury circumstances: “What were you doing?”, “What went wrong?”, and “How were you injured?”, representing the pre-event, event, and post-event stages as described by William Haddon (70). Each of these questions has a supplementary note asking the individual to indicate any involved external objects, persons, or other circumstances. The concluding part of the IRF has several fields that are to be completed by a physician: diagnosis, ICD-10 code, injury severity according to the Abbreviated Injury Scale (AIS), generalized cause of injury (accident, violence, self-inflicted harm), hospitalization (yes/no), and name of the physician.

The second pilot study (N = 68) tested the logistics of the data collection system and the data management system. It was also used as the final step in the training of the injury registrars, allowing them to master the practical skills needed to work with the SHIR. This study demonstrated that the logistics, the data management system, and the practical skills of the registrars were of acceptable level (63).

After these preparatory activities were completed, the SHIR was launched on 1 January 2015 and started gathering information on all people with non-fatal and fatal injuries, poisonings, and certain other consequences of external causes (ICD-10 codes S00 − T78) that receive medical treatment at the Shenkursk CDH (Fig. 7). The SHIR is a population-based injury registry because it collects information about all injuries that occur in the Shenkursk District and are treated at the Shenkursk CDH, regardless of injury severity, or whether the patient was hospitalized or received outpatient care. As the purpose of the SHIR is to provide an evidence basis for primary prevention, patients with repeated visits for the same injury (to monitor the progress of treatment, remove the cast, etc.) are not registered. For the same reasons, complications of injuries, complications due to surgical and therapeutic interventions, and late consequences of injury (ICD-10 codes T79 − T98) are not included in the registry.

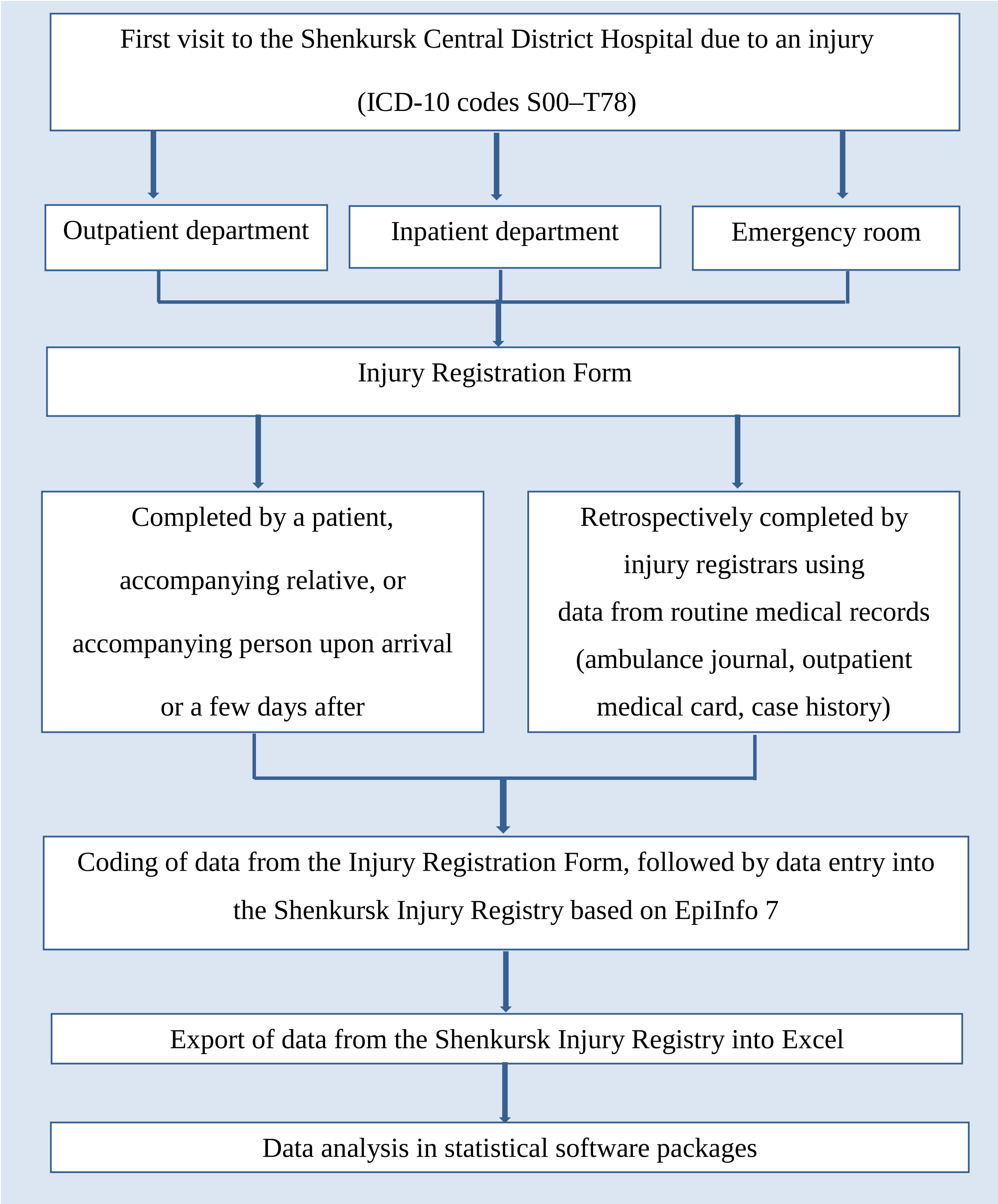


Figure 7. Flow chart of the Shenkursk Injury Registry, Arkhangelsk Region, Russia

According to the established data collection scheme, an injured patient is asked to complete the IRF upon ambulance pick-up bound for the Shenkursk CDH or upon arrival at the outpatient department of the Shenkursk CDH. If a patient has to be hospitalized due to severe injury, the

IRF is offered to be filled out within a few days of hospitalization. If that is difficult for the patient, accompanying relatives, a nurse, or a physician can help to complete the form. When the IRF is not filled out due to a patient's severe condition or other reasons, the injury registrars complete the IRF retrospectively, using data from routine medical records (ambulance journal, outpatient medical card, case history) and the information obtained from the attending physician. In 2017, 59% of IRFs were completed by patients or accompanying relatives, and 41% by registrars. Between 1 January and 30 June 2018, 62% of IRFs were filled in by patients or accompanying relatives, and 38% by registrars.

The SHIR database is constructed using Epi Info 7 (71). From 2015 to 2017, the two injury registrars attended a series of calibration sessions, where they were asked to code and enter the same sets of 20 to 30 IRFs. The two registrars, the author of this thesis, and the main supervisor, discussed any mismatches that occurred, and joint decisions were held on the standard way to code questionable cases.

From its launch, it was decided that the SHIR would not include prehospital fatal injuries (i.e., individuals who perished from their injury before they reached the Shenkursk CDH). This is because Russian regulations require all on-site injury deaths to undergo forensic investigation, and the Shenkursk CDH does not have a forensic department. Therefore, most onsite or other pre-hospital injury fatalities are transported directly to the closest forensic department, situated in the neighboring town of Velsk (140 km of the Shenkursk), for forensic processing; some are sent to the regional forensic center in Arkhangelsk. As there are practical difficulties in collecting data from these two forensic institutions, the Shenkursk CDH administration obtains data on on-site injury fatalities in the Shenkursk District from the Arkhangelsk Regional MIAC. However, as the variables available in the MIAC differ from those in the SHIR, data integration into the SHIR is not possible. Therefore, for the purposes of planning local injury prevention, data on fatal injuries in the Shenkursk District are collected and presented separately.

2.4. Analytic approaches

In the section on the overall injury panorama in the Shenkursk District, we present the distributions of all injuries registered in the study period by selected SHIR variables. We used data from the Arkhangelsk Regional MIAC to describe fatal injuries that occurred in the Shenkursk District during the study period.

In Paper I, the completeness of SHIR data was assessed by linking SHIR records to the Shenkursk CDH MIS, which was assumed to be a "gold standard" with respect to the coverage of patient records. The linkage was performed using the names, dates of birth, and dates of injuries of injured patients. We looked at the data for 1 year (July 2015 − June 2016), and assessed the representativeness of SHIR data by comparing injuries treated at the CDH and registered in the SHIR to those treated at the CDH but not registered in the SHIR. The comparisons were made on a limited number of variables available in the Shenkursk CDH MIS. Similarly, we assessed the representativeness of SHIR data for injuries in rural areas of the district by comparing characteristics of injuries that were treated at the CDH and registered in the SHIR to injuries that were treated at primary care units and were not covered by the SHIR. Again, the comparisons were made on variables available in the Shenkursk CDH MIS. Data reliability in the SHIR was assessed as agreement between the routine IRF data entry performed by the injury registrars and the second independent entry that was performed by the author of the thesis, including the independent coding of free-text descriptions of injury circumstances.

Considering that 42% of all accidental injuries in the SHIR during the study period were due to falls, Paper II addressed this major injury category alone. It identified typical scenarios of fall injuries in the district by clustering the upstream information about fall injury circumstances (preceding activities, accident mechanisms, predisposing and precipitating factors), with the goal of supporting primary injury prevention in a practically useful way. In Paper II, we analyzed data on 1551 non-fatal accidental fall injuries recorded in the SHIR from January 2015 to June 2018. The analyses were stratified by age group: preschool age (0 − 6 years), school age (7 − 17 years), working age (18 − 59 years), and elderly age (60+ years).

In Paper III, we further narrowed our focus to accidental outdoor fall injuries (AOFIs). In order to provide evidence that would increase the local population's awareness of the most "risky days" with respect to AOFIs, we combined SHIR data on the daily frequency of AOFIs in the period from January 2015 to June 2018 with the meteorological data archive for the Shenkursk District for the same period (72). A total of 1125 non-fatal AOFIs were included in the analysis. Associations between daily AOFI frequencies and weather conditions were investigated separately in the two major seasons of the year: the cold season (October 15 − April 14) and the warm season (April 15 − October 14).

2.5. Data presentation

Categorical injury characteristics in the description of the local injury panorama and in Papers I to III are presented as absolute numbers and percentages. Mean and standard deviation were used to present AIS, which was the only variable treated as continuous in the analyses of Paper II.

In Paper III, AOFIs were presented as count numbers on each day in the study period, as mean daily numbers for the warm and the cold seasons, and for the subgroups of days with combinations of selected weather parameters. The continuous weather condition variables such as air temperature (°C), atmospheric pressure (hPa), wind speed (m/s), relative humidity (%), and amount of precipitation (mm) were described using minimum and maximum values, medians, and first and second tertiles, and were categorized into tertile groups for analytical purposes. Weather variables that were originally categorical (e.g., ground surface conditions) were presented as numbers and proportions of days per season with the conditions of interest.

2.6. Data analyses

Throughout the thesis and Papers I to III, chi-square tests were used to analyze categorical injury variables: to assess differences between the registered and missed cases in the SHIR (Paper I), to compare fall injury characteristics between age groups (Paper II), and to compare AOFI characteristics between the cold and warm seasons (Paper III). Cohen's kappa was applied to assess the agreement between independent data entries in Paper I.

In Paper II, a two-step cluster analysis was used to identify the most frequent or typical combinations of fall injury circumstances in the four age groups. The upstream categorical injury variables originating from the free-text descriptions of injury circumstances (mechanism of preceding activity, accident mechanism, injury mechanism, factors involved in the mechanism of preceding activity, and factors involved in the accident mechanism) were included in cluster analyses. By using the Bayesian information criterion, the number of clusters was determined automatically. To indicate the overall goodness of fit, we used the average silhouette measure of cohesion and separation (range: -1 − +1) (73). A silhouette measure of

<0.2 was considered a poor solution, between 0.2 and 0.5 indicated a fair solution, and >0.5 was considered a good solution (74). One-way analysis of variance was used to compare the discovered clusters of fall injuries by AIS.

In Paper III, we applied negative binomial regression for the cold season and zero-inflated Poisson regression for the warm season to assess the associations between daily numbers of AOFIs and weather conditions (75). The "countfit" function in Stata was used to select the most appropriate models, based on the Akaike Information Criterion and Bayesian Information Criterion. Interactions between weather condition variables were investigated by entering the corresponding interaction terms into multivariable models. We used average percent changes (APCs) with 95% confidence intervals to assess changes in daily numbers of AOFIs per one-unit change in each independent weather condition variable. Heat-maps of the mean daily incidence of AOFIs were built separately for the cold and the warm seasons by calculating mean daily incidences (per 100,000 population) of non-fatal AOFIs admitted to the Shenkursk CDH on the days with combinations of weather characteristics that showed independent associations with AOFI numbers in the corresponding multivariable regression models.

Statistical analyses were performed using SPSS, version 25 (SPSS Inc., Chicago, Illinois, United States) (Papers I and II) and STATA v. 16.1 (StataCorp LLC, 2020, College Station, Texas, United States) (Paper III).

2.7. Ethical and legal considerations

The establishment of the SHIR and the corresponding data collection were approved by the Ethics Committee of the Northern State Medical University, Arkhangelsk (protocol 07/10-13 from 9 October 2013). Both medical and non-medical information were collected by the Shenkursk CDH, which holds the rights to do so through local regulations and informed consent of patients. The SHIR does not contain personal identifiers; these are only present in paper IRFs, which are stored according to the rules for storage of medical documentation at the Shenkursk CDH.

The protocol for the present study was approved by the Ethics Committee of the Northern State Medical University, Arkhangelsk (protocol 03/04-17 from 27 April 2017). The study has been evaluated by the Norwegian Regional Committees for Medical and Health Research Ethics (REC) (Remit Assessment 2017/1995/REK nord), which determined that it did not require REC approval. Following the guidance received from the REC, the protocol was submitted for evaluation and approved by the Norwegian Center for Research Data (protocol number № 56817/3/TAL from 21 December 2017) (Appendix C).

Chapter 3. Main findings

3.1. Injury panorama

3.1.1. All injuries

A total of 5343 injuries (ICD-10 codes S00 − T78) were entered into the SHIR between 1 January 2015 and 30 June 2018 (Table 2). Sixty percent of injured patients were males, and more than half were of working age (3054 cases), followed by children (1365 cases) and the elderly (924 cases). The most common ICD-10 codes belonging to the S-section were for injuries of the upper and lower extremities (55% of total injuries); the most common codes from T-section were for a foreign body entering through natural orifice (T15 − T19) (11%), followed by burns and corrosions (T20 − T32) (4%). According to the AIS, 68% of injuries were minor, and only one of every 10 cases was hospitalized.

Almost all registered injuries (87%) took place in the town of Shenkursk or in the rural areas of the Shenkursk District (Table 3). A negligible proportion of injuries (2%) took place outside the Shenkursk District. The proportion of missing values for the place of injury was 10%. During the study period, 72% of minor injuries that occurred in the town of Shenkursk and 58% of minor injuries that occurred in rural areas were registered in the SHIR. The proportion of hospitalization was 7% for injured patients from the town of Shenkursk and 18% for those from rural areas.

Dwellings, homestead lands, and other nearby outdoor areas were the most common injury sites (altogether 48% of total injuries). There was little difference in the annual number of injuries that occurred in between 2015 and 2017. A total of 1511 injuries were registered in 2015, 1638 in 2016, 1507 in 2017, and 687 cases were registered from 1 January to 30 June 2018. Larger proportions of injuries occurred in the warm season (54%). Injuries were almost evenly spread across the weekdays, being slightly more frequent on Sundays and least frequent on Thursdays. Eighteen percent of adults (18+ years) reported that they had used alcohol in the 24 hours before the injury.

The majority of registered injuries were the result of accidents (4678 cases or 88%) (Fig. 8). About 10% of injuries (517 cases) were associated with interpersonal violence, and 1% of injuries (51 cases) were due to intentional self-harm. For 97 cases (2%) the generalized causes of injury were not indicated.

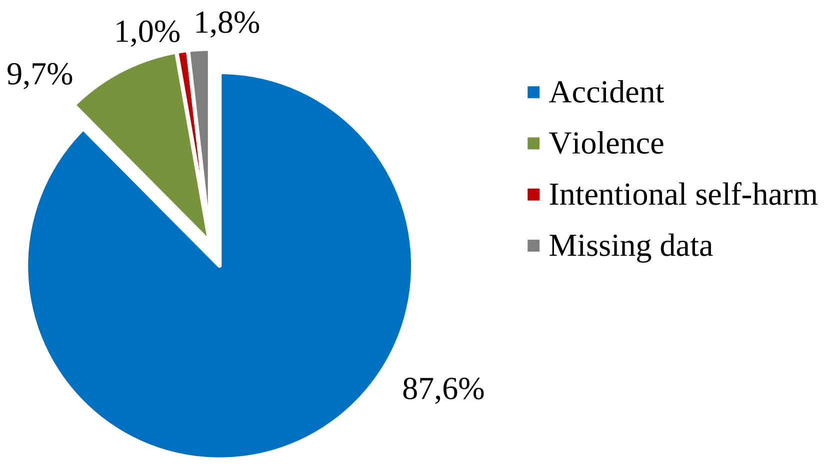


Figure 8. Generalized causes of injury in the Shenkursk District, 1 January 2015 – 30 June 2018

3.1.2. Accidental injuries

Homestead lands or area near a dwelling (23%) and dwelling inside (20%) were the most common accidental injury sites. Also, a large proportion of accidents occurred in public outdoor residential areas (14%) and roadways (12%). The most common mechanism of preceding activity of accidental injuries was walking (30%), followed by working at home or in the garden (18%) (Table 4). Slipping (18%) and error or loss of control when handling an object (15%) were the most frequent accident mechanisms. The majority of accidental injuries (42%) occurred due to falling on a flat surface, from a height, or on stairs. AOFIs constituted 73% of all accidental fall injuries (indoor and outdoor). Other common injury mechanisms were hits due to unintentional contact with material objects, humans, or animals (17%). Twelve percent of adults with accidental injuries reported using alcohol in the 24 hours before the injury.

Three hundred twenty accidental injuries (7%) were associated with sports, with 70% of these injuries occurring in children. The major part of the accidental injuries in children were due to physical exercise at school (35%) and in sports activities (34%). Playing with a ball (football, volleyball, basketball) was the most common injury-related sports activity (53%). Only 5% of injured children used protective equipment during physical exercise and sports activities.

Of the 4678 accidental injuries, 230 (5%) were road traffic injuries. Among the injured, the proportions of motorcyclists, automobile users (drivers and passengers combined), and bicyclists were 21%, 20%, and 18%, respectively. Only 10% of the injured were pedestrians. About 90% of those injured in road traffic accidents while riding in a vehicle did not use proper safety equipment (seat belts for automobile users, and helmets for motorcycle and bicycle riders). Among adults injured in traffic accidents, 37% reported that they had consumed alcohol in the 24 hours before the injury.

The most commonly mentioned factors involved in mechanisms of preceding activity, accident mechanisms, and injury mechanisms were natural events and objects (10%, 17%, and 14%, respectively) and parts of buildings, including stairs (8%, 8%, and 12%, respectively) (Table 5). The category natural events and objects was mainly constituted by ice- and snow-covered surfaces (83% − 89% of total cases in this category). Other common factors involved in mechanisms of preceding activity were transport vehicles (i.e., car, motorcycle, and bicycle) (8%). In accident mechanisms, common factors included particles, fragments, splinters, and structural elements (10%); other humans and animals (mainly dogs and cats) (8%); and transport vehicles (6%). Other common factors involved in injury mechanisms were particles, fragments, splinters, and structural elements (19%) of various materials (mainly wood, metal, and glass), and outdoor treated and natural surfaces (10%).

The proportions of missing values for accident variables in the SHIR ranged from 0.1% to 15% (Tables 2 − 5). The variables age, sex, ICD-10 code, season, and weekday had no missing values, whereas up to 0.5% of values for the variables AIS and hospitalization were missing. The proportion of missing values ranged from 1% to 10% for place of injury, injury mechanism, and factors involved in injury mechanism. The highest proportions of missing values (10% − 15%) were observed for mechanism of preceding activity, accident mechanism, and factors involved in these mechanisms.

3.1.3. Interpersonal violence

According to the ICD-10 codes, the head (55%) was the most commonly injured part of the body due to interpersonal violence, followed by the trunk (16%) and upper extremities (15%). The majority of injuries (72%) associated with violence were minor (Table 2). Among the total cases of interpersonal violence, the proportion of domestic violence (in our case defined as physical abuse at home and/or by a household member) was 19% (96 cases).

Substantial proportions of injuries due to violence occurred in dwellings (indoor and outdoor) (36%) and at outdoor public residential areas (27%). Over one-third of such injuries (33%) occurred on weekends (Table 3). Among the victims, 58% reported consuming alcohol in the 24 hours before the injury. The most common mechanisms of preceding activity were alcohol consumption (18%) and walking (11%). Quarrel, fight, brawl (75%), and release of physical force by a human (10%) were the most frequent violence mechanisms. As for the injury mechanism, the majority of violent injuries (87%) occurred due to a blow from a material object or a human (Table 4). A human was the most commonly mentioned factor involved in the preceding activity (21%), violence mechanism (92%), and injury mechanism (68%). Another common factor involved in the preceding activity was an alcoholic beverage (19%) (Table 5).

Mechanism of preceding activity and factors involved in this mechanism had the highest proportion of missing values for injuries associated with interpersonal violence (Tables 4 and 5). Forty-four percent of the victims did not provide any information about the preceding activity, and 27% did not answer the question about alcohol consumption before injury. The proportions of missing values for place of injury, accident mechanism, and factors involved in accident and injury mechanisms varied from 1% to 10% (Tables 3 − 5). Missing values for the variables AIS, hospitalization, and injury mechanism were up to 1% (Tables 2 and 4).

3.1.4. Intentional self-harm

Upper extremity (55%) was the part of human body most commonly injured due to intentional self-harm, followed by poisoning by drugs, medications, and biological substances (20%). Half of all injuries associated with intentional self-harm were moderate (51%), two cases (4%) were fatal and one-third of self-inflicted cases (28%) were hospitalized (Table 2).

Almost all cases of intentional self-harm (82%) occurred in a dwelling (indoor and outdoor) (Table 3). Every fifth case of intentional self-harm was on a Sunday, and 77% of injured adults (18+ years) reported to have consumed alcohol in the 24 hours before intentional self-harm. The most common mechanism of preceding activity was alcohol consumption (37%), and 43% of patients with self-inflicted injuries did not describe any preceding activity. The most frequent mechanisms of intentional self-harm were self-cutting (47% or 24 cases) and self-poisoning (24% or 12 cases) (Table 4). The most commonly mentioned factors involved in mechanisms of preceding activity were alcoholic beverages (37%) and other humans (14%). Non-mechanical hand tools (i.e., knife) and medicines were the most frequent precipitating factors (mentioned in 22% and 18% cases, respectively, in response to the question, “What went wrong?”) and factors involved in injury mechanisms (39% and 19%, respectively). Another common precipitating factor was another human (22%) (Table 5).

Table 2. Demographic and medical characteristics of injuries in the Shenkursk District, 1 January 2015 − 30 June 2018

	Accidents (N = 4678)		**Violence** (N = 517)		**Self-inflicted** (N = 51)		**All injuries** [a] (N = 5343)	
	N	%	N	%	N	%	N	%
Sex								
Male	2271	59.2	323	62.5	27	52.9	3192	59.7
Female	1907	40.8	194	37.5	24	47.1	2151	40.3
Age (years)								
0−17	1241	26.5	103	19.9	7	13.7	1365	25.5
18−59	2569	54.9	371	71.8	41	80.4	3054	57.2
60+	868	18.6	43	8.3	3	5.9	924	17.3
ICD-10 code								
S00−09: Head	557	11.9	286	55.3	1	2.0	894	16.7
S10−39: Trunk	479	10.2	85	16.4	6	11.8	583	10.9
S40−69: Upper extremity	1499	32.0	78	15.1	28	54.9	1624	30.4
S70−99: Lower extremity	1278	27.3	30	5.8	3	5.9	1319	24.8
T15−19: Foreign body entering through natural orifice	569	12.2	1	0.2	1	2.0	571	10.7
T20−32: Burns and corrosions	175	3.7	7	1.4	1	2.0	187	3.5
T36−50: Poisoning by drugs, medications and biological substances	8	0.2	0	0.0	10	19.6	18	0.3
Others codes	121	2.6	30	5.8	3	5.8	147	2.7
Severity according to AIS								
Minor	3172	67.8	370	71.6	16	31.4	3623	67.8
Moderate	1210	25.9	117	22.6	26	51.0	1375	25.7
Severe, but not life-threatening	272	5.8	21	4.1	5	9.8	303	5.7
Severe, potentially life-threatening and critical, with uncertain survival	14	0.3	7	1.4	2	4.0	24	0.5
Fatal	4	0.1	0	0.0	2	3.9	6	0.1
Missing	6	0.1	2	0.4	0	0.0	12	0.2
Hospitalization								
Yes	472	10.1	67	13.0	14	27.5	561	10.5
No	4192	89.6	449	86.8	37	72.5	4765	89.2
Missing	14	0.3	1	0.2	0	0.0	17	0.3

[a] Including 97 cases with missing data on generalized cause of injury (accident, violence, or self-inflicted injury). ICD: International Statistical Classification of Diseases and Related Health Problems 10th revision, AIS: Abbreviated Injury Scale.

Table 3. Spatial and temporal characteristics of injuries in the Shenkursk District, 1 January 2015 − 30 June 2018

	Accidents (N = 4678)		**Violence** (N = 517)		**Self-inflicted** (N = 51)		**All injuries** [a] (N = 5343)	
	N	%	N	%	N	%	N	%
Place of injury								
Town of Shenkursk	2272	48.6	330	63.8	38	74.5	2670	49.9
Shenkursk District	1838	39.3	140	27.1	11	21.6	2004	37.5
Other place	108	2.3	9	1.7	1	2.0	119	2.2
Missing data	460	9.8	38	7.4	1	2.0	550	10.3
Injury site								
Homestead land, area near a dwelling	1058	22.6	32	6.2	3	5.9	1093	20.5
Dwelling, inside parts (living room, bedroom, kitchen)	936	20.0	107	20.7	22	43.1	1071	20.0
Dwelling, outer parts (roof, porch)	267	5.7	81	15.7	20	39.2	372	7.0
Roadway	543	11.6	23	4.4	0	0.0	569	10.6
Public outdoor residential area	631	13.5	138	26.7	1	2.0	804	15.0
Educational institution (inside and outside, excl. sports facilities)	116	2.5	45	8.7	1	2.0	164	3.1
Sports facilities and playgrounds	331	7.1	11	2.1	0	0.0	343	6.4
Natural surroundings (forest, field, river side)	190	4.1	9	1.7	0	0.0	202	3.8
Other	85	1.8	3	0.6	0	0.0	67	1.3
Missing data	521	11.1	68	13.2	4	7.8	658	12.3
Season of the year								
Cold (15 October−14 April)	2181	46.6	243	47.0	23	45.1	2485	46.5
Warm (15 April−14 October)	2497	53.4	274	53.0	28	54.9	2858	53.5
Weekday								
Monday	704	15.0	68	13.2	8	15.7	792	14.8
Tuesday	662	14.2	73	14.1	7	13.7	761	14.2
Wednesday	682	14.6	57	11.0	6	11.8	752	14.1
Thursday	605	12.9	69	13.3	6	11.8	689	12.9
Friday	646	13.8	77	14.9	7	13.7	746	14.0
Saturday	675	14.4	89	17.2	7	13.7	785	14.7
Sunday	704	15.0	84	16.2	10	19.6	818	15.3

[a] Including 97 cases with missing data on generalized cause of injury (accident, violence, or self-inflicted injury).

Table 4. Circumstantial characteristics of injuries in the Shenkursk District, 1 January 2015 − 30 June 2018

	Accidents (N = 4678)		**Violence** (N = 517)		**Self-inflicted** (N = 51)		**All injuries** [a] (N = 5343)	
	N	%	N	%	N	%	N	%
Mechanism of preceding activity								
Walking	1380	29.5	56	10.8	2	3.9	1441	27.0
Working at home or garden	836	17.9	44	8.5	0	0.0	880	16.5
Physical exercise including running	377	8.1	6	1.2	0	0.0	383	7.2
Movements of body parts	271	5.8	19	3.7	0	0.0	290	5.4
Carrying something	285	6.1	0	0.0	0	0.0	285	5.3
Sitting, laying, or standing	260	5.6	35	6.8	2	3.9	297	5.6
Alcohol consumption	27	0.6	95	18.4	19	37.3	141	2.6
Other activities	608	13.0	36	7.0	7	13.7	651	12.2
Missing data	634	13.6	226	43.7	21	41.2	975	18.2
Accident mechanism								
Slipping	833	17.8	0	0.0	0	0.0	833	15.6
Error or lost control when handling an object	702	15.0	0	0.0	0	0.0	702	13.1
Stepping wrong	378	8.1	0	0.0	0	0.0	379	7.1
Stumbling over something	357	7.6	0	0.0	0	0.0	358	6.7
Jumping on, touching, or taking something	237	5.1	0	0.0	0	0.0	239	4.5
Release of physical force by a human or animal, including unintentional	193	4.1	54	10.4	0	0.0	247	4.6
Quarrel, fight, brawl	0	0.0	388	75.0	10	19.6	398	7.4
Intentional self-harm [b]	0	0.0	0	0.0	36	70.6	36	0.7
Other mechanisms	1388	29.7	47	9.1	5	9.8	1440	27.0
Missing data	590	12.6	28	5.4	0	0.0	711	13.3
Injury mechanism								
Fall on the same level or from a height including falls on stairs	1974	42.2	21	4.1	3	5.9	2009	37.6
Blow due to contact with material objects, humans, or animals	796	17.0	449	86.8	2	3.9	1258	23.5
Gripping, cutting, stabbing, abrasion	773	16.5	32	6.2	29	56.9	841	15.7
Foreign body in ear, nose, mouth (object, substance)	690	14.7	6	1.2	14	27.5	714	13.4
Other mechanisms	389	8.3	5	1.0	2	3.9	397	7.4
Missing data	56	1.2	4	0.8	1	2.0	124	2.3

[a] Including 97 cases with missing data on generalized cause of injury (accident, violence, or self-inflicted injury). [b] self-cutting and self-poisonings

Table 5. Factors involved in mechanisms of preceding activities, accidents, and injuries in the Shenkursk District, 1 January 2015 − 30 June 2018

	Accidents (N = 4678)		**Violence** (N = 517)		**Self-inflicted** (N = 51)		**All injuries** [a] (N = 5343)	
	N	%	N	%	N	%	N	%
Mechanism of preceding activity								
Natural events and objects [b]	484	10.3	2	0.4	0	0.0	486	9.1
Transport vehicles [c]	380	8.1	4	0.8	0	0.0	384	7.2
Parts of buildings [d]	373	8.0	3	0.6	0	0.0	376	7.0
Raw or semi-finished materials, large	244	5.2	1	0.2	0	0.0	245	4.6
Human	104	2.2	107	20.7	7	13.7	218	4.1
Alcohol drinks	72	1.5	97	18.8	19	37.3	191	3.6
Others factors	1915	40.9	22	4.3	1	2.0	1938	36.3
No external factor	433	9.3	55	10.6	3	5.9	491	9.2
Missing data	673	14.4	226	43.7	21	41.2	1014	19.0
Accident mechanism								
Natural events and objects [b]	784	16.8	0	0.0	0	0.0	784	14.7
Particles, fragments	457	9.8	0	0.0	3	5.9	460	8.6
Parts of buildings [d]	389	8.3	0	0.0	3	5.9	393	7.4
Transport vehicles [c]	286	6.1	0	0.0	0	0.0	287	5.4
Hand tools [e]	260	5.6	0	0.0	11	21.6	271	5.1
Treated and natural surfaces, outdoors	255	5.5	0	0.0	0	0.0	255	4.8
Animals	189	4.0	0	0.0	0	0.0	189	3.5
Humans	178	3.8	476	92.1	11	21.6	665	12.4
Alcohol drinks	35	0.7	6	1.2	6	11.8	49	0.9
Medicines	12	0.3	0	0.0	9	17.6	21	0.4
Others factors	1143	24.4	4	0.8	6	11.8	1153	21.6
Missing data	690	14.7	31	6.0	2	3.9	816	15.3
Injury mechanism								
Particles, fragments	882	18.9	25	4.8	5	9.8	914	17.1
Natural events and objects [b]	639	13.7	4	0.8	0	0.0	644	12.1
Parts of buildings [d]	558	11.9	16	3.1	2	3.9	577	10.8
Treated and natural surfaces, outdoors	466	10.0	6	1.2	0	0.0	475	8.9
Transport vehicles [c]	284	6.1	0	0.0	0	0.0	285	5.3
Hand tools [e]	254	5.4	49	9.5	20	39.2	326	6.1
Animals	179	3.8	0	0.0	0	0.0	179	3.4
Humans	85	1.8	354	68.5	0	0.0	441	8.3
Medication	15	0.3	0	0.0	10	19.2	25	0.5
Others factors	1110	23.7	56	10.8	12	23.5	1180	22.1
Missing data	206	4.4	7	1.4	2	3.9	297	5.6

[a] Including 97 cases with missing data on generalized cause of injury (accident, violence, or self-inflicted injury); [b]Natural events and objects (ice- and snow-covered surfaces, frost, and wind); [c] Transport vehicles (car, motorcycle, and bicycle); [d] Parts of buildings including stairs; [e] Hand tools (mechanical, motorized, and non-mechanical)

The variables sex, age, ICD-10 code, AIS, hospitalization, season of the year, weekday, and accident mechanism for injuries associated with intentional self-harm had no missing values (Tables 2 − 4). The proportions of missing values varied from 1% to 10% for place of injury, injury site, injury mechanism, factors involved in accident mechanisms, and factors involved in injury mechanisms (Tables 3 − 5). The highest proportion of missing values was identified for mechanism of preceding activity and factors involved in this mechanism, for which 41% of the victims did not provide any information (Tables 4 and 5).

3.1.5. Fatal injuries and poisonings

The annual mortality rate from injury in the Shenkursk District was 155.2 per 100,000 in 2015, 336.1 per 100,000 in 2016, and 148.9 per 100,000 in 2017. A total of 94 fatal injuries were registered in the Shenkursk District during the study period (Table 6). This was about 2% compared to the total number of non-fatal injuries registered in the SHIR. Seventy-three of the 94 fatal injuries (78%) occurred in males, 64 (68%) in people aged 18 to 59 years, and 29 (31%) in people aged 60+ years. The majority of fatal injuries occurred in the rural areas of the Shenkursk District (79%).

The most common ICD-10 codes belonging to the S-section were injuries of the head (16%) and trunk (13%). The most common codes for the T-section were injuries due to the toxic effect of alcohol (27%), asphyxiation (18%), and drowning (11%), followed by the toxic effect of carbon monoxide (7%).

As for external causes (ICD-10 codes V01 − Y98), the majority of fatal injuries occurred due to accidental poisoning by alcohol (27%) and intentional self-harm by hanging, strangulation, and suffocation (21%). These were followed by injuries due to transport accidents (14%), assault (11%), accidental drowning (9%), exposure to uncontrolled fire in a building or structure (6%), and contact with a blunt object, undetermined intent (6%).

Table 6. Demographic and medical characteristics of fatal injuries in the Shenkursk District, 1 January 2015 – 30 June 2018 (N = 94)

	N	%
Sex		
Male	73	77.7
Female	21	22.3
Age (years)		
0−17	1	1.1
18−59	64	68.1
60+	29	30.9
Place of injury		
Town of Shenkursk	20	21.3
Shenkursk District	74	78.7
Categorization according to ICD-10, Chapter XIX		
S00−09: Head	15	16.0
S10−39: Trunk	12	12.8
T51: Toxic effect of alcohol	25	26.6
T58: Toxic effect of carbon monoxide	7	7.4
T71: Asphyxiation	17	18.1
T75.1: Drowning	10	10.6
Other	8	8.5
Categorization according to ICD-10, Chapter XX		
V01–V99: Transport accident	13	13.8
W65−W74: Accidental drowning and submersion	8	8.5
X00: Exposure to uncontrolled fire in building or structure	6	6.4
X45: Accidental poisoning by and exposure to alcohol	25	26.6
X60−X84: Intentional self-harm by hanging, strangulation and suffocation	20	21.3
X85−Y09: Assault	10	10.6
Y29: Contact with blunt object, undetermined intent	6	6.4
Other	6	6.4

3.2. Results from Papers I, II, and III

3.2.1. Paper I. Injury registration for primary prevention in a provincial Russian region: setting up a new trauma registry

During the 1-year period from 1 July 2015 to 30 June 2016, 1696 injuries were registered in the SHIR, whereas a total of 2305 injuries were registered in the Shenkursk CDH MIS. Of these 2305 injuries, 1863 were treated at the Shenkursk CDH, 1607 (86%) of which were registered in the SHIR. We also identified 89 injuries that were included in the SHIR but were missing in the hospital MIS. Of the injuries registered in the MIS, 442 were rural injuries, which received treatment at rural primary care units that are not covered by the SHIR.

Injuries treated at the CDH and registered in the SHIR (N = 1607) did not differ from injuries that were not registered in the SHIR but were present in the hospital MIS (N = 256) by sex, ICD-10 code (S00 − T78 and V01 − Y98), or weekday of admission. However, the proportions of injured children (34%) and injuries occurring in the summer (46%) were significantly higher among the missed injuries compared to the registered injuries (24% and 27%, respectively). Also, the distribution of treating physicians was different between registered and missed injuries. Rural injuries treated at rural primary care units (N = 442) did not differ from those treated at the Shenkursk CDH and registered in the SHIR (N = 610) by sex and season of the year, but the proportions of child injuries (34%) and injuries of the wrist and hand (20%) treated at rural primary care units were higher, while the proportion of traffic injuries were lower (3%).

A comparison of an independent coding of the information from the IRFs and the SHIR data entered by the registrars found a 98% to 99% agreement for date of birth, date of injury, date of IRF completion, sex, ICD-10 code, alcohol consumption in the 24 hours before injury, generalized cause of an injury, AIS, and hospitalization. The variables derived from free-text descriptions in the IRFs showed lower, but still relatively high levels of agreement: 91% to 95% for mechanism of preceding activity, accident mechanisms, and injury mechanisms, and 79% to 88% for factors involved in the mechanism of preceding activity, accident mechanisms, and injury mechanisms.

3.2.2. Paper II. Mechanisms of accidental fall injuries and involved injury factors: a registry-based study

About half of the fall injuries in the study period from 1 January 2015 to 30 June 2018 occurred in the working age group (736 cases), followed by the elderly (437 cases), the school age group (294 cases), and the preschool age group (84 cases).

About 50% of falls among preschool children took place inside dwellings. Public outdoor residential areas (29%), and sports facilities and playgrounds (23%) were the main sites of falls among children of school age. One-third of fall injuries in the working age and elderly groups occurred on homestead land and other near-dwelling areas. Both groups also had a high proportion of fall injuries inside dwellings (16% and 28%, respectively).

Accidental fall injuries in the preschool age group had two large clusters of circumstances: fall injuries associated with climbing up or down (on furniture, play equipment, or stairs) with a subsequent loss of balance and falling from a height of <1.5 m (cluster 1; 64% of cases); and injuries associated with slipping while walking and falling on the same level (cluster 2; 36% of cases). In the school age group, we identified four clusters of fall injury circumstances: falls that occurred during physical exercise, involving sports or play equipment and a loss of balance (cluster 1; 36% of cases); fall injuries due to slipping on an ice-covered surface while walking (cluster 2; 28% of cases); falls resulting from stepping wrong while walking (cluster 3; 24%); and fall injuries which occurred on stairs in buildings (cluster 4; 12%).

Five clusters of fall injury circumstances were identified for the working age group: falls due to slipping on ice-covered surface while walking (cluster 1; 32% of cases); falls due to stepping wrong while walking (cluster 2; 19% of cases); falls resulting from slipping on an ice-covered surface with carrying something as the mechanism of preceding activity (cluster 3; 18% of cases); fall injuries resulting from slipping on a wet surface outside or inside (cluster 4; 16% of cases); and falls on stairs (cluster 5; 15% of cases). Among the elderly, four clusters of fall injury circumstances were discovered: falls due to slipping on an ice-covered surface while walking (cluster 1; 37% of cases); fall injuries caused by faintness while walking (cluster 2; 25% of cases); falls resulting from slipping on ice-covered surface with carrying something as the mechanism of preceding activity (cluster 3; 19% of cases); and fall injuries while walking with stumbling over something as the accident mechanism (cluster 4; 18% of cases).

3.2.3. Paper III. Weather conditions and outdoor fall injuries in Northwestern Russia

The mean daily number of AOFIs in the cold season (1.10) was 1.7 times higher than in the warm season (0.65). Walking was the most common mechanism of preceding activity both in the cold season (65%) and in the warm season (45%). Slipping was a more frequent accident mechanism in the cold season compared to the warm season (83% vs 27%). The most common accident mechanism in the warm season was stepping wrong or stumbling over something (49%).

In the cold season, AOFIs occurred more frequently on days with medium mean daily air temperature (-7.0°C − -0.7°C; APC = 29.0%; $p = 0.039$) compared to days with high mean daily air temperature (≥ -0.6°C), on days with medium/high precipitation (≥ 0.4 mm; APC = 24.3%; $p = 0.015$) relative to days with low precipitation (0.1 − 0.3 mm), and on days when the ground surface was covered by compact or wet snow compared to days when the ground surface had no snow (APC = 57.9%; $p = 0.003$). The highest daily incidence of AOFIs in the cold season (20.2 per 100,000 population) was observed on the days with a combination of these weather characteristics: air temperature from -7.0°C to -0.7°C, daily amount of precipitation ≥ 0.4 mm, and ground surface covered with compact or wet snow.

In the warm season, daily numbers of AOFIs were higher on days with medium mean daily air temperature (9.0°C − 15.1°C; APC = 15.3%; $p = 0.034$) compared to days with high mean daily air temperature (≥ 15.2°C) and on days with medium mean daily atmospheric pressure (1003.6 − 1010.9 hPa; APC = 15.7%; $p = 0.015$) relative to days with low mean daily atmospheric pressure (≤ 1003.5 hPa). The highest daily incidence of AOFIs in the warm season (7.0 per 100,000 population) was observed on the days when these two weather characteristics (air temperature 9.0°C − 15.1°C and atmospheric pressure 1003.6 − 1010.9 hPa) were combined.

Chapter 4. General discussion

4.1. Discussion of main findings

4.1.1. General injury panorama

The overall aim of the present study was to provide an evidence basis for injury prevention in the Shenkursk District, Northwestern Russia using SHIR data. During the 3.5-year study period, the SHIR included 5343 injuries (ICD-10 S00 − T78), the majority of which were accidents (88%). The proportions of interpersonal violence and intentional self-harm were 10% and 1%, respectively. According to the AIS, 68% of all injuries were minor, only 11% of cases were hospitalized, and 6 cases were fatal. Most of the injuries occurred in males (60%), and the most common locations of injury were dwellings and areas near a dwelling. The majority of accidental injuries (42%) occurred due to falls.

Similarly to our findings in the Shenkursk District, the burden of unintentional injuries in the countries of the WHO European Region is substantially higher than that of intentional injuries (5). This is also consistent with findings from injury registries and surveillance systems in other countries. For example, the proportion of unintentional injuries was 89% in the National Injury Surveillance System of China (76), 88% in the West Midlands of the United Kingdom (77), 85% in Cali, Colombia (42), and 84% in Karnali Province, Nepal (78).

Men represented the majority of the injured in our study, with a ratio of injured men to injured women of 1.5. This ratio is close to the injury distribution by sex in Norway (1.1) (79), Canada (1.4) (80), Nepal (1.6) (78), and China (1.9) (76). However, in many other countries, such as

Spain (81), Singapore (82), Iran (83), Saudi Arabia (53), North India (52), and the United Arab Emirates (39), the proportion of men is much higher, varying from 3:1 to 6:1. In the Shenkursk District, the majority of the injuries occurred in people of working age. This is in line with previous studies in different settings, as this age group normally constitutes the largest proportion of the total population (42, 52, 76, 80, 84, 85).

The upper and lower extremities were the most frequently injured anatomical regions in patients presenting to the Shenkursk CDH, comprising 55% of total injuries. This contradicts the findings of studies carried out in Spain (81), Nigeria (48), and North India (52), which reported the head as the most commonly injured body region (53%, 59%, and 66% respectively). These differences may be explained by different mechanisms of injury and by the inclusion criteria used for cases. For example, clinical registries and studies of hospitalized patients normally contain records of the most severe cases, with a higher representation of head injuries compared with injuries of extremities, which are more likely to be treated without hospitalization.

Our study demonstrated that dwellings and areas near a dwelling were the most common accidental injury sites (43%) in the Shenkursk District. This is different from studies carried out in Northern India (52) and Kampala City, Uganda (86), where roads have been reported as the most common place of injury (67% and 57%, respectively). However, our result is similar to observations from Iran, where homes were the site of more than 60% of injurious accidents (87); and China, where homes were the leading site of injury occurrence (88). Such variations can be explained by differences in registration systems or by the varying characteristics of injuries in different locations. This finding stresses the importance of using local injury data and considering the data characteristics when planning and setting priorities for prevention programs (89).

In the Shenkursk District, falls were the leading cause of non-fatal accidental injuries. This is similar to many other settings. However, the proportion of falls among total injuries in the Shenkursk District (42%) was higher than those observed in China (32%) (76), Fiji (30%) (84), and Missouri and Nebraska in the United States (26%) (90); and lower than that reported in Toronto, Canada (53%) (80) and Finland (46% for males and 74% for females) (8). In addition, our findings that falls were the leading cause of injury contradicted those of studies carried out in Uganda (86, 91), North India (52), Nigeria (48), Saudi Arabia (53), Malawi (92), Iran (83), and Cameroon (85), where road traffic injuries were the greatest contributor (36% − 68%) to injury causes. Again, these comparisons are tricky, as the data on the listed comparisons was not collected identically. During the study period, there were no fatal fall injuries in the Shenkursk District. The vast majority of fall injuries were either minor or moderate according to the AIS. That is an interesting observation when compared, for example, to some WHO reports, which have presented falls as a major cause of deaths from injuries (10, 13).

Road traffic injuries accounted for a relatively small proportion (5%) of non-fatal accidental injuries in the Shenkursk District. Road traffic injuries tend to account for far more severe injuries than fall-related injuries. For instance, according to the German Trauma Registry and the Navarra Major Trauma Registry in Spain, the proportions of severe injuries due to traffic accidents were 56% and 36%, respectively (93). Road traffic injuries in the Shenkursk District were the third leading external cause of death, after accidental alcohol poisoning and intentional self-harm. The generally low proportion of traffic accidents among the causes of non-fatal injuries can be explained by the poorly developed road infrastructure in the district, with few asphalt-covered roads, which results in a low traffic volume and a low speed of travel; though this low proportion might also be due to relatively good prevention.

In the present study, intentional injuries comprised 11% of all non-fatal injuries; 10% were due to interpersonal violence, and 1% due to self-harm. However, suicides were the second leading external cause of death in the Shenkursk District (21% of deaths from external causes). The proportion of intentional injuries among non-fatal injuries was comparable to that reported in previous studies from the United Kingdom (77) and the United States (94), but lower than the proportion in North India (52), Uganda (86), Malawi (92), Kenya (95), and Gambia (96), where it varied from 16% to 24%. However, the proportion of suicides among all external causes of mortality is lower in the study area than in the European countries, the USA, and Canada (5).

A striking finding was that alcohol poisoning was the leading external cause of death, accounting for 27% of all external deaths in the Shenkursk District in the study period. This may reflect existing alcohol problems that are typical for Russia: a high prevalence of severe drinking (consumption of large volumes of alcohol per occasion) (97, 98) as well as possible consumption of alcohol surrogates (99).

4.1.2. Typical scenarios of fall injuries by age

The findings from SHIR data demonstrated that environmental and behavioral circumstances of fall injuries differ by age group. Almost a half of falls in the preschool age group (49%) in the Shenkursk District occurred in dwellings. The most common mechanism of preceding activity in this age group was climbing up or down (on furniture, play equipment, stairs), and the proportion of fall injuries from a height of < 1.5 m was high (38%). These findings are supported by studies in other settings, which showed that home furniture is a leading attribute of fall injuries in the age group 0 to 6 years (100-105).

For example, a study from Canada reported that falls from furniture accounted for 23% of injuries in children < 1 year old (101). Another study from Canada demonstrated that the proportion of falls from furniture and on stairs were the highest in the youngest age groups (< 1 year, 1 − 3 years, and 3 − 5 years), but the proportion of falls from playground equipment was the highest in the age group 5 to 7 years (10%) (106). A retrospective analysis of trauma registry data in Atlanta, Georgia in the United States also documented that furniture (24%), playground equipment (9%), and stairs (6%) were the most common sites of fall injuries for children in the age group 0 to 4 years (102). One more study from the United States showed that home furnishings and fixtures (e.g., beds, tables, chairs) were the leading factors associated with fall injuries in the age groups 0 to 1 year, 1 to 2 years, and 3 to 4 years (46%, 38%, and 35%, respectively) (100).

We found that public outdoor residential areas (29%) and sports facilities and playgrounds (23%) were the most common sites for fall injuries among children of school age in the Shenkursk District. The most common mechanisms of preceding activity in this age group were walking (38%) and physical exercise (27%). Sports and play equipment were the factors involved in the mechanism of preceding activity in one-third of fall injuries in this group. The substantial roles of sports and play in the occurrence of fall injuries among school age children have been described in several earlier studies in various settings (100, 103, 107-109).

A study from the United States showed that 32% of fall-related hospitalizations in the age group 5 to 9 years were caused by falls from playground equipment, and that 24% of fall-related hospitalizations in the age group 10 to 14 years were due to falls from skateboards (103). Two others studies from the United States had similar findings, with one reporting that children aged 5 to 12 years most commonly fell from playground equipment (26%) (105), and the other showing and that children aged 5 to 9 years, 10 to 14 years, and 15 to 19 years most commonly had falls associated with sports and recreation (e.g., basketball, football, soccer) (29%, 38%, and 30%, respectively) (100).

According to the SHIR, AOFIs occurred more frequently than accidental indoor fall injuries (73% vs 27%). This is line with findings from studies carried out in the United States (110), Canada (111), the United Kingdom (112), Japan (113), the Netherlands (114), and Nordic countries (115, 116), where the proportion of AOFIs among adults was between 55% and 75%. In the Shenkursk District, most falls both in the working age group and elderly age group occurred on homestead land or in the area near a dwelling (31% and 33%, respectively).

Our findings indicated that walking was the predominant fall-related preceding activity in people of working age (56%) and the elderly (62%), which is consistent with studies from other settings (113, 114, 117-119). For example, a study from Japan showed that falls occurred most frequently while walking among middle-aged (33%) and elderly (42%) people (113). In a cross-sectional study carried out in the Netherlands, walking was the most prevalent activity up to the moment of a fall among elderly people aged 65+ years (21%) (114). The findings of a study from Baltimore, Maryland (United States) reported that walking was the most frequent activity that caused falls in the age groups 20 to 45 years (32%), 46 to 65 years (45%), and 65+ years (57%) (119). A population-based survey conducted by the National Center for Health Statistics in the United States showed that walking was the predominant preceding activity among adults aged 18+ years and accounted for approximately 3 million, or 37%, of fall injuries annually (117).

4.1.3. Weather conditions and accidental outdoor fall injuries

We identified a seasonal variation in AOFIs, with a higher mean daily incidence observed during the cold season than the warm season (8.4 vs 5.0 per 100,000 population, respectively). In the cold season, slipping (83%) was the most common accident mechanism of AOFIs in the Shenkursk District. "High-risk" days, i.e., days associated with higher risks of AOFIs, in the cold season included a combination of medium air temperature (-7.0°C − -0.7°C), medium/high precipitation (≥ 0.4 mm), and a ground surface covered with compact or wet snow.

Our results are in accordance with those from the Nordic countries and Canada, where numbers of fall-related injuries and fractures were higher in the winter period (115, 120-124). For example, according to the injury registration database at Umeå University Hospital, Sweden, most persons aged 65+ years (81%) had fallen in a public outdoor environment during winter (November − April) (115). A study from Oulu, Finland, demonstrated that the number of distal radius fractures in adults due to outdoor falling from standing height in the wintertime (16 October − 15 April) was higher than in non-wintertime (16 April − 15 October) (60% vs 40%, respectively) (120). A prospective, population-based cohort study in three urban areas in Norway (Stavanger, Trondheim, and Harstad) reported that incidence rates of fractures were higher in the cold season (1 October − 31 March) than in the warm season (1 April − 30 September) among people aged 65 to 79 years and 80+ years (121).

The presence of a seasonal effect on the incidence of hip and arm fractures attributable to falls due to slipping on ice and snow in the winter period was strongly suggested in a prospective population-based cohort study in Norway (121). The results of our study also confirmed that, in the cold season, the majority of AOFIs in the Shenkursk District occurred due to slipping, and a ground surface covered with loose dry snow or compact/wet snow increased the daily numbers of AOFIs by 41% and 63%, respectively, when compared with days without snow. A positive correlation between a ground surface covered by ice or snow and falls/fractures has been reported in several previous studies (122, 125). One study from Oulu, Finland looked at the effect of slippery weather conditions, as assessed by the weather and pavement condition model developed by the Finnish Meteorological Institute, and showed that the number of fractures was greater on slippery winter days than on normal winter days, when compared with non-winter days (2.5 and 1.4 times, respectively) (120). However, in another study from Finland, six slippery condition scenarios in Sotkamo, one of the most popular Finnish tourist resorts, were analyzed. The authors showed that about one-third of the injury accidents occurred when the ground was not at all slippery (126).

Earlier studies have demonstrated that below-zero temperatures increase the incidence of fractures due to falls (115, 122, 123, 127). An ice surface temperature between -6°C and -9°C leads to the minimum value of coefficient of friction (128). This temperature interval is the best for skating, but the worst for walking, because it can lead to slipping and fall accidents (129). However, the range of outdoor temperatures that can lead to higher risks of fall injuries may differ even in countries with a cold climate. In the Shenkursk District, the highest daily numbers of AOFIs occurred on days with outdoor temperatures from -7.0°C to -0.7°C, but in Oulu, Finland, the highest incidence of outdoor falls was on days with temperatures below -20°C (123). In Umeå, Sweden fall-related injuries occurred most frequently during the winter months when an average air temperature were between -10°C and -6°C (115). This indicates the importance of taking the local characteristics of outdoor environments into account in prevention programs.

4.2. Methodological considerations

The present study was assessing the applicability of the SHIR data as an evidence basis for primary injury prevention in the Shenkursk District, Northwestern Russia. The applicability and usefulness of a registry are dependent on the quality, representativeness and generalizability of the data collected.

The quality of the data in a medical registry can be defined as “the totality of features and characteristics of a data set, that bear on its ability to satisfy the needs that result from the intended use of the data” (130). In the context of a trauma registry, three key dimensions of data quality are commonly cited in the literature: case completeness, data completeness, and accuracy (41, 131). There are several threats to the quality of registry data. In this section, we discuss the quality of SHIR data in terms of case completeness, data completeness, and reliability as the measure of the accuracy, but we also focus on coverage, representativeness, and the generalizability of SHIR data in the context of validity and systematic errors.

The validity of a study is defined as “the degree to which the inferences drawn from a study are warranted when account is taken of the study methods and the characteristics of the participants in the study” (132). There are two key types of validity: internal and external (133). The internal validity means “the degree to which a study is free from bias or systematic error” (132), whereas external validity (or generalizability) demonstrates “the degree to which results of a study may apply, be relevant, or be generalized to populations or groups that did not participate in the study” (132). There are two general classes of systematic error: selection bias and information bias (134).

4.2.1. Selection bias

Selection bias can introduced by a number of factors associated with the manner in which individuals are ascertained and selected for study (134). Differences between individuals who accept and refuse to participate in a study with regard to demographic, socioeconomic, cultural, medical, and lifestyle factors may introduce this kind of bias (135). To analyze selection bias in the present study, we described the coverage and assessed the case completeness of the SHIR.

Coverage of the Shenkursk Injury Registry

The SHIR collects data on all injured patients who receive treatment at the Shenkursk CDH and records injuries by ICD-10 code (S00 − T78). Therefore, the SHIR includes some injuries that occur outside the Shenkursk District but are treated at the Shenkursk CDH. To ensure the representativeness of SHIR data in reflecting the mechanisms and circumstances of injuries occurring in the Shenkursk District, injuries from outside the district could have been excluded, but the small number of such cases (only a few injuries occurring outside the Shenkursk District are treated at the CDH per year) should not bias SHIR data to a substantial degree, so they were kept included.

Although the SHIR is a population-based registry, it can overestimate the severity of injuries, especially because minor injuries that occur in rural areas can usually be treated at rural primary care units, and thus are not included in the SHIR. During the study period, the proportion of minor injuries that occurred in the rural areas of the Shenkursk District and were treated in the Shenkursk CDH was 14% lower than the proportion of minor injuries that occurred in the town of Shenkursk. This indicates that the information obtained from the Shenkursk CDH MIS regarding “rural” injuries represents moderate and severe injuries to a larger degree. Moreover, people with minor injuries from both the town and the rural areas may not seek medical treatment at all. A similar limitation was described for the Provincial Injury Surveillance System in Thailand, where injured people with moderate and minor injuries could be treated in a community hospital that is not included in the system, or might not have gone to a hospital at all (136). The Fiji Injury Surveillance in Hospitals system is based on fatal injuries and hospital admissions and does not identify less severe injuries (84). In Norway, the incidence rates for injury in individuals aged 0 to 9 years and 35 to 64 years treated in primary care were higher than those treated in secondary care, which shows that these groups tend to have minor injuries that don’t require specialist treatment (137).

The use of electronic IRFs that could be completed in rural primary care units and then sent to the Shenkursk CDH, or integrating the SHIR into the hospital MIS, could help to avoid the described overestimation of severe injuries in the SHIR. As the use of electronic health information systems is rising substantially in Russia, and as Internet access becomes widely available even in remote areas, this problem is expected to be moot in the near future.

Another important limitation is that the SHIR does not include prehospital fatal injuries, thus it cannot be used to describe the characteristics and circumstances of fatal injuries. Due to the small number of fatal injuries in the Shenkursk District, their absence in the SHIR does not substantially bias the registry-derived priorities for prevention activities. However, the data on injury mortality from the Arkhangelsk Regional MIAC, which we analyzed separately, add important insights to the registry-based injury panorama and show that alcohol poisoning and suicide are the leading external causes of death. One way to ensure that the SHIR has complete data on fatal injuries in the Shenkursk District is to request the regional MIAC or the forensic departments in the district to complete an IRF for each patient, and submit them to the Shenkursk CDH for entry. This is possible; it is just a matter of organizing effective communication between the healthcare institutions.

Case completeness of the Shenkursk Injury Registry

The case completeness, often referred as case capture, is defined as “the proportion of all cases in the target population which appear in the registry database” (according to the inclusion criteria) (41). For a local hospital registry, “all cases of the disease seen at the reporting source should be included” (41). Another, similar definition of case capture is “the extent to which all necessary cases that could have been registered have actually been registered (i.e., How complete is the case ascertainment, given the registry inclusion criteria?)” (131). The case completeness of the SHIR was assessed through linkage to the Shenkursk CDH MIS, assuming that the latter included all injuries.

The present study showed that the case completeness of the SHIR was high, although not perfect (86%). The registry covered the vast majority of the injuries treated in the hospital, and therefore should correctly reflect the true distribution of characteristics of injured patients, as long as there were no systematic biases in probability of getting registered. Similar case completeness was reported in the Harstad Injury Registry (90%) (55), the Alaska Trauma Registry (82%) (138), and the Regional Trauma Registry in Amsterdam, the Netherlands (85%) (139). The completeness of the SHIR was lower than that of the Provincial Injury Surveillance System in Thailand (98%) (136), the Hospital Regional Loreto Trauma Registry in Peru (99%) (46), and the Helsinki Trauma Registry in Finland (97%) (140). However, the completeness we observed was higher than that of the Major Trauma Registry of Navarre in Northern Spain, where 40% of all patients met the inclusion criteria, but were not included in the trauma registry (81).

Different sources can be used to assess case completeness. For example, hip fractures recorded in the Harstad Injury Registry were validated in terms of completeness and correctness in men and women aged 65+ years using medical records, the patient administrative system, and the Norwegian Patient Registry (55). Of the 310 cases of hip fracture recorded in the Harstad Injury Registry from 2002 to 2008, 278 (90%) were confirmed through medical records and additional 15 were identified in the patient administrative system using the relevant ICD codes. The authors concluded that the dataset based on these verified sources represents the “gold standard” and the best available dataset on hip fractures in Harstad. Moreover, the total number of hip fractures in this dataset was the same as the number recorded in the Norwegian Patient Registry.

The Helsinki Trauma Registry includes only patients with new injury severity score above 15. So, to assess case completeness, a registry coder checks the basic information (cause of accident, first diagnosis, and treatment plan) of each patient in the emergency department’s resuscitation bay patient log and calculates the new injury severity score. The list of patients obtained through this process is then compared with the list in the Helsinki Trauma Registry (140). Comparison of the medical records of patients treated in the emergency room and cases in the registry was used to assess the completeness of the Regional Trauma Registry in Amsterdam (139), the Hospital Regional Loreto Trauma Registry (46), and the Major Trauma Registry of Navarre (81). The Hospital Discharge Data Set was used to evaluate case identification in the Alaska Trauma Registry (138). Digital medical records in the Sahlgrenska University Hospital are used to assess the completeness of the Swedish Fracture Register: each week, the medical records are scanned for ICD codes related to fractures, and any missed fracture cases identified are added to the registry. This approach helps to ensure that all patients with a fracture are included in the register (51).

Although comparing registry records to hospital medical records is an established method for evaluating of data quality, we agree with Datta et al. (43) that records in a hospital system may not have 100% validity. The results of the present study confirm this, because we identified injuries that were included in the SHIR, but missing in the Shenkursk CDH MIS. Regular revision of the registry against the hospital system and retrospective completion of IRFs by the registrars through the use of medical records can increase the completeness of the SHIR. The registrars made substantial efforts to achieve the highest possible completeness, although the results are still imperfect. Based on that, and in order to improve the completeness of the SHIR, the administration of the Shenkursk CDH should motivate physicians' to ask their patients to complete IRFs. Another good way to increase completeness is to integrate the SHIR into the hospital MIS, which would help to include injured patients automatically. Indeed, the disadvantage of the SHIR is that it was created as an addition to the hospital MIS and was not fully integrated into the routine hospital data system, which is the reason for its imperfect completeness. This may be a lesson for others who would like to develop a similar registry.

4.2.2. Information bias

Information bias can occur when the data collection methods about the subject are inadequate, and as a result, the information gathered is incorrect (134, 135). To analyze the information bias in the present study, we described the data completeness and assessed the data accuracy of the SHIR through the double entry of a subset of injury records.

Data completeness of the Shenkursk Injury Registry

Data completeness is defined as “the extent to which all cases contain registered data” (130). Shivasabesan et al. (141) divide missing data into non-valid and valid missing data, with non-valid missing data defined as “variables which are left blank” and valid missing data defined as mean variables coded as “missing or unknown (not recorded)”. According to the rating criteria of the evaluation framework for injury surveillance systems (142), data completeness is considered very high if there are no missing, unknown, or unspecified data; high if the proportion of missing, unknown, or unspecified data is less than 25%; low if this proportion is between 26% and 50% and very low if it is between 51% and 100%.

The use of a standardized IRF helped to minimize information bias in the description of the circumstances and mechanisms of injuries that occurred in the Shenkursk District. However, with regard to data completeness, the proportions of missing values in SHIR variables during the study period ranged from 0% to 40%. The problem of missing data has been described in many trauma registries as a potential source of bias. For example, the proportion of missing data for most variables in the Limbe Regional Hospital Trauma Registry in Cameroon ranged from 0.5% to 15%, except for the Revised Trauma Score, which was missing in 57% of cases (85). In the Australia − India Trauma Systems Collaboration Trauma Registry, the extent of missing observations ranged from 0% to 67%, and most variables (86%) had missing data in less than 20% of observations. However, the proportion of missing values for the activity in which the patient was engaged when injured was 49% (141). The percentages of missing data in the Major Trauma Registry of Navarra ranged from 0% (29 variables) to 77%, and the overall average completeness rate for all variables was 93% (143). Good (90% − 95.9%) and excellent

(96% − 100%) data completeness was found in 27 out of 32 variables in the Helsinki Trauma Registry (140).

Data completeness depends on the type of variable. In the SHIR, the most commonly used variables (such as age, sex, ICD-10 code) had 100% of completeness. The higher proportions of missing values observed in the variables characterizing injury mechanisms and involved factors (2% – 40%) can, to a substantial degree, be explained by a lack of description on the part of the patient or witnesses, by a factual absence of any such mechanism or factor, or by the difficulty that registrars may have understanding the written free-text descriptions. Such deficiencies were even more likely when IRFs were completed retrospectively by registrars using medical documentation, instead of by the injured persons themselves. Retrospective completion of the IRF can also lead to information bias caused by incomplete data, especially when it comes to descriptions of injury circumstances, due to poor and often very brief notes in the medical records that may not contain important details on what actually happened and how. Moreover, information bias from surrogate interviews may occur when the IRF is completed by accompanying relatives or others, as they may not have accurate information about the injury circumstances.

Our literature search identified only one other injury registry that collects information about injury circumstances and mechanisms using a free-text description: the Harstad Injury Registry (37, 54, 56). Other trauma registries minimize free-text entries about injury details as much as possible, instead using dropdown menus in computer software (39, 47, 140). However, in most cases, this information is not documented in the original patient files, which can be an important cause of missing values in a registry (50, 140, 144). The adequacy of paper medical records of admitted trauma patients was investigated to assess data completeness for the development of future trauma registries in hospitals in Upper Egypt (145). Among the 539 medical records investigated, 74% of demographic fields, 67% of administrative fields, and 55% of clinical fields were complete. The least complete category was the causal injury, and the mechanism of injury, the activity at the time of injury, and the injury site were documented in 12%, 22%, and 23% of the cases, respectively. This analysis demonstrated that using medical documentation to retrospectively complete injury medical records can lead to bias caused by incomplete data.

The difference in data completeness between the electronic trauma health records used by physicians and paper trauma medical records were investigated at the level I trauma center at Groote Schuur Hospital in Cape Town, South Africa (146). The comparison showed higher completion rates in the data fields of electronic trauma health records compared with their paper predecessor 1 year following the introduction of the electronic system. For example, the fields sex (99% vs 98%), injury date (99% vs 95%), injury setting (89% vs 75%), injury mechanism (96% vs 91%), and injury intentionality (97% vs 76%) all had higher completion rates in the electronic than in the paper records. This study showed the advantages of using a mobile digital platform for trauma surveillance in real time, and then using standardized, complete data as the basis for an electronic trauma registry.

Therefore, better efforts on the part of the Shenkursk CDH to increase the proportion of IRFs completed by patients should improve the completeness of the data at the variable level. The hospital administration can use incentives to motivate physicians to ask their patients to complete the IRF, which may be a good way to increase data completeness in the IRF, and in turn, SHIR completeness. In addition, implementation of an electronic IRF with mandatory fields may reduce the proportion of missing data in the SHIR. The presence of missing values in several variables, and possible explanations, should be considered when using SHIR data to plan prevention strategies.

Information on alcohol consumption before injury was self-reported in the IRF, which could lead to misclassification. Indeed, the proportion of injured patients who consumed alcohol before their injury may be underestimated. The missing data on alcohol consumption may also mask underreporting. Some trauma registries excluded the alcohol consumption variable due to the lack of an objective measure (46, 76). The Fiji Injury Surveillance in Hospitals system documented alcohol use prior to injury in 12% of cases, but information on alcohol use was missing in another 12% of cases. The authors noted that alcohol consumption might have been underestimated, because blood alcohol testing is not routinely done unless requested by police (84). The Injury Surveillance System in North India collects information about alcohol use as part of the details of an injury, but this variable had a high proportion of missing values (52). We believe that laboratory identification is the only reliable tool that could be used to provide real data about alcohol consumption before injury.

The IRF collects little information about socioeconomic characteristics. It only asks about the patient's place of work or study. Therefore, although low socioeconomic status can increase the risk of injuries in general and fall injuries in particular (107, 147-149), the present study cannot estimate any variation in the circumstances of fall injuries by socioeconomic status (Paper II). Variables such as education were excluded from the IRF after the first pilot study in 2014, but we assume that education is an important modifiable factor. As 62% of the population of the Shenkursk District live in rural areas, it would be beneficial if the IRF contained variables like type of house, heating system, water supply system, etc. Another possibility would be to add these variables to the hospital MIS.

The injury data from the Shenkursk CDH MIS and fatal injury data from the regional MIAC are the most complete sources of data on the incidence of and mortality from injuries in the Shenkursk District, but they contain only general information on causality. Therefore, these sources are most suitable for assessments of the overall and subclass-specific injury incidence and mortality (e.g., relative frequencies of injuries and deaths due to road traffic accidents, poisonings, suicides), but they provide little grounds for planning targeted prevention measures in terms of what exactly must be done and where it must be done to prevent an injury from occurring.

The use of SHIR data to assess incidence of and mortality from injuries in the Shenkursk District is limited due to its imperfect coverage and completeness. Its value is in the upstream injury characteristics the registry contains, which allows researchers to understand how, and in what contexts injuries occur. This type of information is key to planning effective primary prevention.

Data reliability in the Shenkursk Injury Registry

Data accuracy, also referred as reliability, is as defined as “the degree of concordance between registered data and ‘true’ data in patients’ files” (130) or “How true is the value of an observation or the content of a cell in a spreadsheet of data, compared to a gold standard?” (131). There are different approaches to evaluating data accuracy; they include checks of internal consistency or domain checks, linking with other data sources, and verification against the source data (131). In the present study, the data reliability of the SHIR was assessed via independent entry and coding of the original text data by the author of the thesis and comparing the resulting variables to those originally produced by the injury registrars.

Indeed, a potential threat to the quality of SHIR data is miscoding during the transformation of the free-text descriptions of injury circumstances into categorical upstream injury variables. Our analysis showed that agreement was almost perfect (91% – 95%) for the variables describing the mechanisms of preceding activity, the accident mechanism, and the injury mechanism; the agreement was lower for variables defining the factors involved in the three mechanisms, but it was still substantial (79% – 88%). The identified reliability deficiencies can be judged as unavoidable when humans' ability to read, understand, and interpret is involved in data processing and coding. The relatively small volume of inconsistencies between the results of an independent data coding and entry procedure, and the standard coding and entries of the registrars show that SHIR data are reasonably reliable.

Several studies have estimated the data accuracy of trauma registries using hospital records as the "gold standard". The data accuracy of variables in the Helsinki Trauma Registry was 95%, and 19 of the 32 evaluated variables had > 96% accuracy, nine variables had an accuracy of 90% to 96%, and four variables had < 90% accuracy (140). The average proportion of complete concordance of parameters in the Major Trauma Registry of Navarra was 98%, and ranged from to 93% (7 variables) to 100% (22 variables). Variables with major deviation proportions included total AIS coded numbers (6%) and injury severity score (5%) (143). High data accuracy (98%) was also documented in the Alberta Trauma Registry (43). These trauma registries do not include free-text variables to collect information about the injured patient, which contributed to the high data accuracy.

Although problems with the coding of free-texts have not been studied in trauma registries, they have been presented for other fields (150, 151). For example, the accuracy of automated coding of free-text medication data was compared with manual coding of handwritten free-text responses in a validation study (151). Manual coding was considered the gold standard and used Anatomical Therapeutic Chemical codes. The sensitivity of the automated approach for exact Anatomical Therapeutic Chemical codes and for blank responses was 79% and 100%, respectively, compared with manual coding. Based on this, manual coding of texts in the SHIR can be considered an advantage, although some mistakes of a human operator are unavoidable.

Given that full agreement is hardly possible, because the SHIR registrars are human beings and may have different subjective understandings of the free-text descriptions in the IRF, the levels of agreement between two independent entries of the SHIR data, particularly for the mechanisms (91% – 95%), were considered sufficiently high. We believe this reflects the usefulness of the series of calibration sessions that we carried out with registrars, in which we asked them to code the same texts, and then jointly compared and discussed the results. With further calibration of injury registrars and regular checks for data accuracy by independent raters, the levels of miscoding can be reduced to even a lower level. Variables describing factors involved in the mechanisms had a higher proportion of miscoding; therefore, they need particular attention during training.

4.2.3. Confounding

Confounding can be defined as “a mixing of the effect of the exposure under study on the disease with that of a third factor” (134). The third factor, or confounder, has to be associated with both the exposure and the disease. The true association between exposure and disease can be overestimated or underestimated due to confounding (133).

Due to the design of our studies, confounding was not a matter of concern in this thesis. The issue of confounding was only addressed when we investigated associations between weather conditions and the frequency of AOFIs (Paper III) using an ecological study design. The outcome was the daily number of AFOIs, and calendar day was the unit of observation. Normally, it is impossible to control for the effects of potential confounding factors in this design (134, 152). However, we were concerned that the associations between weather conditions and daily numbers of AOFIs could be confounded by the varying volumes of alcohol consumption in different weather conditions. We could not control for alcohol consumption as an individual behavioral factor in the ecological study design, so a binary weekend variable (Saturday and Sunday vs weekdays) was added in the regression models as a proxy measure for alcohol consumption. This weekend variable was not found to be associated with the number of AOFIs, nor with weather conditions. Although it is true that using such a crude proxy measure for alcohol consumption may have left some residual confounding, it should not be large, as alcohol consumption should not have a strong association with the weather.

4.2.4. Representativeness and generalizability

The SHIR only covers injuries that received medical treatment at the Shenkursk CDH. About 40% of injuries occurring on adjacent rural areas are treated at primary care units and thus are not recorded in the SHIR. Comparisons of rural injuries treated at the Shenkursk CDH to those treated at rural primary care units showed they did not differ by sex or by season of the year. However, the proportions of child injuries and injuries of the upper extremity treated at rural primary care units were higher, while the proportions of traffic injuries were lower. This indicates that minor injuries are more likely to be treated at the rural primary care level, while more substantial injuries are referred to the CDH. The described differences were significant but not decisively substantial, so SHIR data can be considered fairly representative of all injuries in the Shenkursk District. However, this also means that the SHIR tends to overestimate the severity of injuries that occur in rural areas, and this must be considered when using its data to plan prevention programs.

As for the injuries treated at the CDH, registered and unregistered injuries did not differ by sex, ICD-10 code (S00 − T78), external cause (V01 − Y98), or weekday of admission. However, the proportions of injured children and injuries occurring in the summer were higher among missed injuries compared to registered ones. Also, the distribution of attending physicians was different among missing and registered injuries, meaning that some physicians were less likely to collect IRFs from their patients than others.

The imperfect completeness of the SHIR should not substantially affect its representativeness for the total injuries treated at the Shenkursk CDH, as we saw no evidence of large bias in the registered injuries compared to missed injuries, except for the higher injury severity among those treated at the CDH compared to those treated in the rural primary care units.

Several studies have investigated differences between registered patients and missed patients in a trauma registry. For example, a study of a trauma registry of 10 hospitals in the Netherlands found that 15% of patients who met the inclusion criteria were missing (139). The missing patients did not differ from the included patients by age, sex, vital parameters, probability of survival, or the number of injuries, but hospital level and transfer to another hospital after initial assessment were significant, independent predictors for being missing from the registry. In the Major Trauma Registry of Navarre, 40% patients who met the inclusion criteria were missing (81), and the included and missing patients had differed significantly by age, sex, vital parameters, highest level of hospital care, previous comorbidity, probability of survival, and number of injuries and injured regions. The hospital Revised Trauma Score and the number of injuries were independent predictors of being missing in the trauma registry. Only 30% of all injuries treated by regular general practitioners in Trondheim in April 2008 were included in the National Injury Registry in Norway, which led to an underestimation of the incidence of injury and called into a question the representativeness of the registry (153).

With respect to the generalizability of SHIR data to larger territories, the Shenkursk District can be described as a relatively typical rural setting in Northwestern Russia, with a combination of cold climate and a poorly developed infrastructure. This makes it possible to generalize the findings to other Northern Russian settings. However, generalizing and using the findings beyond this area requires more careful considerations of specific local features.

4.2.5. Required and possible innovations in the Shenkursk Injury Registry

Today, 6 years after the SHIR was launched based on the example of the Harstad Injury Registry, it may look archaic – not up to date with the current level of technological development of other MIS. Although our study has shown that the SHIR may serve as an evidence basis for local primary prevention activities and injury research, based on our practical observations and analysis of the limitations, we can offer several suggestions on how the SHIR can be modernized and improved.

First of all, it would be an advantage to integrate the SHIR within the Shenkursk CDH MIS. That change could increase case completeness and broaden the range of variables available for the description of an injured patient. It could also lead to the addition of variables such as concurrent diseases, treatment, its duration and cost, etc. In addition, integration of the SHIR within the Shenkursk CDH MIS would reduce the injury registrars' workload and the associated costs by avoiding double registration of data already available in the MIS, such as age, sex, residence, ICD-10 codes, and hospitalization. Further on, the free-text description of the injury situation could be replaced by an easy-to-record audio file that can be converted into readable text using modern dictating software, and later automatically categorized into several variables using machine learning (ML) and artificial intelligence (AI) technologies. In addition, the completion of electronic IRFs in the rural primary care units would help to increase the coverage of injuries occurring rural areas.

Another advantage of the integration of the SHIR into the MIS would be the possibility to use the Insurance Number of Individual Ledger Account (INILA) as an additional identifier in the IRF. At present, the only way to identify a SHIR record is through the IRF number. At present, injury registrars complete a new IRF for each injury, even if they occur in the same patient, and each injury is assigned a new number; therefore it is difficult to identify how many injuries a person has sustained within a certain period. The use of the INILA would allow clinicians and researchers to find people with repeated injuries and offer them individual injury prevention programs. The availability of the INILA in the injury data would also allow researchers to link these data to other healthcare registries. To ensure complete data on fatal injuries in the Shenkursk District, the regional MIAC or the regional forensic departments could be asked complete IRFs.

When comparing official statistical reports to the SHIR, it should be mentioned that the goal of official reports is to provide a complete overview of the incidence of and mortality from injuries; they include sparse information about when, where, and how injuries occur. They reflect the size of problems and are not meant to provide guidance on solutions like prevention measures. Conversely, although registries like the SHIR cannot match official reports in completeness, they are still a valuable source of evidence regarding injury mechanisms and circumstances that can be used for planning targeted primary prevention measures. Official statistical reports and registries like the SHIR should complement each other, with one source providing quantitative assessments of the injury burden and the other offering explanatory variables for preventive purposes.

The potential miscoding of the free-text data may be a validity problem, and that was the key concern at the onset of the registry. However, these concerns were addressed by using understandable coding lists and calibration of registrars. With a more frequent and extensive calibration of registrars and regular data accuracy checks by independent raters, the levels of miscoding could be reduced to an even lower level. Variables describing factors involved in the mechanisms had higher proportion of miscoding; therefore, they need particular attention during training. Nevertheless, registrars are humans that are prone to mistakes and may need to be replaced from to time. In addition, a broader implementation of the SHIR model and the possibility to compare injury data from different sites would require proper calibration of a large number of registrars, which may not be achievable on a large scale. An alternative, more modern way to minimize miscoding is to replace the manual coding of free-text descriptions with an automatized processing of the texts using ML and AI techniques. That would help to ensure an efficient, standardized decision-making process with respect to coding texts (154-156). For example, ML and AI are used to predict outcomes in trauma patients, to detect fractures in X-rays and computed tomography scans, and to support treatment decisions (157, 158). In addition, a combination of high-resolution satellite imagery and ML were applied to define an association between alcohol outlets and nearby firearm violence (159).

The possibilities of including ML and AI technologies in the updated version of SHIR are currently being explored. The feasibility of using audio recordings of patients' verbal descriptions of the injury circumstances is also being considered. If successful, these descriptions would be automatically transcribed before they are processed with AI technologies. We believe that asking an injured person to "tell the story", instead of writing it down in a few sentences, may allow for the collection of more detailed and precise information on injury causation − predisposing, precipitating, and damaging factors, accident and injury mechanisms, and environmental contexts.

To conclude, integrating the SHIR into the standard hospital information system, and modernizing it by using state-of-the-art data collection and processing technologies can help improve the quality of the collected data and optimize the functioning of the registry.

Chapter 5. Recommendations for injury prevention

5.1. Using data from the Shenkursk Injury Registry for injury prevention

The SHIR allows collecting high-quality data and provide information about risk factors, circumstances, and mechanisms of injuries in the Shenkursk District. Collection of injury data through the SHIR is the first step in the planning of prevention activities. Good-quality local data can help to identify specific problems associated with injuries. However, successful prevention activities require the cooperation and efforts of many professionals from different sectors. In the Shenkursk District, a Cross-sectoral Group for Injury Prevention and Safety Promotion was established in 2014. The group's members represent key stakeholders who are responsible for safety issues in the Shenkursk District, including: the mayor of Shenkursk, the deputy head of the Shenkursk District administration, the head of the department of civil defense and emergency situations, the chief physician of the Shenkursk CDH, a representative from the department for education of the Shenkursk District administration, the chief state fire inspector, the head of the traffic police, the chairman of the business council, the chairman of the public council, the chairman of the town's council of veterans, the chairman of the town's council of youth, the chief editor of weekly local newspaper "Vazhski Krai", and the SHIR administrators. This is a good example of collaboration between the public, business, and volunteer sector for the purposes of establishing a Safe Community.

The SHIR is the key source of local data that is used as evidence basis for injury prevention and safety promotion in Shenkursk, as well the tool used to evaluate these activities. The Shenkursk Cross-sectoral Group for Injury Prevention and Safety Promotion routinely reviews SHIR data, identifies outstanding injury problems as well as common accident and injury mechanisms and involved factors, and monitors on-going prevention activities. Removable or modifiable factors are identified based on these reviews. A multisectoral approach is also being applied to develop and implement prevention activities in a way that targets removable and/or modifiable factors.

The injury prevention interventions in the Shenkursk District have the following key directions: child safety, elderly safety, traffic safety, home safety, leisure time safety, violence and suicide prevention, disaster preparedness and response, safe public places, sports safety, water safety, and school safety. Organizations representing different public and private sectors are involved in the implementation of the local Safe Community program: the Shenkursk District administration, kindergartens and secondary schools, the police department, the road police, the fire department, the administration of the Department of Civil Defense and Emergency Situations, the Arkhangelsk Regional Rescue Service, the Shenkursk CDH, the Culture and Sports Center, and the Regional Department of Culture, Tourism, Sports and Youth. The findings of the SHIR are published in the local weekly newspaper “Vazhski Krai”.

5.2. Fall injury prevention measures in the Shenkursk District

In the early stages of the present study, we described that falls were the most common injury mechanism for accidental injuries in the Shenkursk District; that fall injuries most commonly occur during leisure, domestic, and other routine activities inside or nearby dwellings; and that ice-covered surfaces were the most common factor involved. Based on these findings, injury prevention measures targeting fall injuries became a priority in the Shenkursk District, targeting a safer outdoor and indoor environment, as well as behavioral factors. For example, anti-friction pads for shoes were distributed among the elderly in the town of Shenkursk and were promoted by the local newspaper. This has reduced the numbers of medically treated falls on ice-covered surfaces in the Shenkursk District from 264 in the cold season that spanned 2015 and 2016, to 217 in the cold season spanning 2017 and 2018. These are small numbers that do not warrant publication in scientific journals, but their publication in the local newspaper caused substantial public interest and, hopefully, an understanding of the value of evidence-based prevention.

In preschool children, prevention of fall injuries was fused with home and kindergarten safety. Almost all families with children received brochures describing common dangers and risky circumstances. The distribution of these brochures was organized at parental meetings in kindergartens and primary schools, as well as to all young couples at the local office of civil registration. The local newspaper published a summary of findings from our Paper II, which outlined the need to create safer home environments for children by installing soft materials on floors near places where children can climb up on furniture or other objects, adding soft corners on exposed furniture, and installing stair rails in the home, as well the need for parental supervision at home and at playgrounds. In school, fall injury prevention in children was primarily addressed through safe sports and play: using helmets, protective padding, and safety nets during sports activities. Educating school teachers how to organize safe sports lessons should also be included in fall injury prevention.

A registry-based program targeting the safety of elderly people led to the creation of an elderly safety checklist, which is used by social workers and volunteers to examine home environments. This list was simply based on the factors that were most commonly mentioned as involved in the injury circumstances of the elderly in SHIR data. The examinations are currently underway, but their effectiveness has not yet been evaluated. Other SHIR-based recommendations on fall prevention among the elderly outline the need to make home and near-home environments safer through the installation of guardrails and soft floorings, and the removal of slippery surfaces and items that may cause stumbling. Preventing weakness, dizziness, and loss of balance through proper medication and balance exercises can also help to prevent fall injuries. Particular emphasis should be placed on reduced alcohol consumption, which is applicable to working-age adults as well.

In terms of practical recommendations, our last paper made it even clearer that efforts to prevent AOFIs in the cold season can substantially reduce the overall burden of falls. Prevention measures should include the removal of slippery ice and snow from ground surfaces (e.g. removing ice from walkways, installing heated sidewalks and porches), and increasing friction on icy surfaces using anti-slip materials (sand, salt, gravel) or slip-resistant footwear.

One preventive approach is to increase people's awareness about when and how fall accidents occur most often, and how to protect themselves. Based on the findings of the most risky days in terms of AOFIs with respect to weather conditions, we recommended to add notifications of "high-risk days" to local weather forecasts. Our expectation is that this will make people aware of the increased risks of outdoor falls on days when the prognoses fit the described high-risk combinations of weather conditions. Text messages from the regional agency for civil defense and emergencies that inform people about the presence of weather conditions associated with a high risk of outdoor falls has good potential to be an effective intervention. Such messages may also support local decision-making with respect to the timely initiation of snow and ice removal and the application of anti-friction materials on walkways. However, this activity has not been implemented yet.

The overall aim of the present study, “to provide an evidence basis for injury prevention”, was partially achieved only in the field of falls, which was the most common injury problem in the Shenkursk District according to the description of the local injury panorama. We described the circumstances and involved factors of falls (Papers II and III). The study demonstrated (Paper I) that the SHIR is a source of valid and useful data for the development of prevention measures, which are not present in other existing sources of injury data. The effectiveness of the prevention measures that were implemented or suggested based on our findings was not assessed due to the time limitations. Nevertheless, in our opinion, the present work is a good example of how local registry data can be an evidence basis for solving specific injury issues.

Conclusion

The case completeness and representativeness of SHIR data were found to be reasonably high, as the data covered the vast majority of injuries treated in the Shenkursk CDH. There were no major differences between registered and missed injuries, except for the higher registration probability among severe cases. SHIR data were also proven reliable by the high level of agreement between independent data entries.

According to the injury panorama in the Shenkursk District, males and people of working age constituted the largest shares of medically treated injury cases. The majority of all injuries were minor, and extremities were the most frequently injured anatomical regions in patients. Dwellings, homestead lands, and other nearby outdoor areas were identified as the most common injury sites, and the majority of registered injuries in the SHIR were the result of accidents.

Falls were the most frequent injury mechanism for accidental injuries in the Shenkursk District. Fall injuries associated with climbing onto or down from home furnishings, play equipment, or stairs were most common in the preschool age group. Among children of school age, the most substantial part of fall injuries occurred during physical exercise involving sports or play equipment. Slipping on an ice-covered surface was the most frequent accident mechanism in the working and elderly age groups.

SHIR data were combined with the meteorological data archive from the Shenkursk weather station, and the associations between the AOFIs and weather conditions were investigated. AOFIs in the Shenkursk District occurred more often in the cold season than in warm season. A combination of low air temperature, medium/high precipitation, and a ground surface covered with compact or wet snow comprised the days with higher risks of AOFIs in the cold season. A combination of medium air temperature and medium atmospheric pressure were attributes of days with higher risks of AOFIs in the warm season.

All in all, although the completeness, representativeness, and reliability of the SHIR are not absolute, SHIR data have reasonable applicability for epidemiological research and undoubtedly deserves to be used as an evidence basis for the development and evaluation of primary prevention measures at the local level. The described injury panorama in the Shenkursk District has a lot in common with other settings, but there are specific local features associated with the characteristics of the study area. Therefore, local injury data are the key to solving injury problems in a particular community.

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Paper I

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Injury registration for primary prevention in a provincial Russian region: setting up a new trauma registry

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Abstract

Background: The Shenkursk Injury Registry (SHIR) was established in the Shenkursk District, Northwestern Russia in 2015 for the purposes of primary prevention. The SHIR covers all injuries (ICD-10 diagnoses from S00 to T78) for which medical aid is given at the Shenkursk central district hospital and includes data about injury circumstances. We used the SHIR data to assess the quality of the SHIR as an evidence basis and for the local preventive applications.

Methods: Completeness, representativeness, and reliability of the SHIR data were assessed using a sample of 1696 injuries which have occurred in July 2015–June 2016. Chi-square tests were used to assess differences between the registered and missed cases in the registry and Cohen's kappa were applied to assess the agreement between independent data entries.

Results: The completeness of the SHIR with respect to the coverage of cases treated at the Shenkursk central district hospital was 86%. There were no differences between the registered and the missed injuries by sex, ICD-10 codes, weekday of admission, but there were differences in their distribution by attending physicians. Also, higher proportions of child injuries and injuries in the summer time were among the missed cases. Signs of lower injury severity (different distribution by ICD-10 codes and lower proportion of traffic injuries) were observed among injuries in rural areas which were not covered by the registry because of treatment at rural primary health care units without referrals to the central hospital. Two independent data entries from standard paper injury registration forms showed a 79–99% agreement, depending on the variable considered.

Conclusion: With consideration of possible insubstantial overestimates of the average injury severity, the SHIR data can be considered sufficiently complete, reliable, and representative of the injury situation in the Shenkursk District. Therefore, SHIR is an adequate evidentiary basis for planning local injury prevention.

Keywords: Injury registry, Shenkursk, Completeness, Reliability

Background

Injuries are the third leading cause of death in the European region, after diseases of the circulatory system and neoplasms [1, 2]. The same applies to the Russian Federation, but its injury-related mortality (126.8 per 100,000) is far higher than that in any other European country [3]. Indeed, the age-standardized mortality rate from external causes in Russia is 1.4 times higher than that in Kazakhstan (88.5 per 100,000), Russia's neighbor to the South, and more than three times higher than that in Norway (37.3 per 100,000) to the North-West [3].

International evidence shows that good-quality injury data are a prerequisite for effective prevention [4–6]. Therefore, collection of injury data through surveillance systems or injury registries should be the first step in the planning of preventive activities [7, 8]. Injury registries are databases that document injuries in specified areas according to defined inclusion criteria and variables. In addition to their use in prevention, injury registries can

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be used for policy development, improvement of the quality of injury care, clinical and epidemiological research [5, 9].

In Russia, injuries, poisonings, and other consequences of external causes are registered by the receiving hospitals. For an injury, the hospital information systems record the code according to the International Statistical Classification of Diseases, 10th Revision (ICD-10) [10], patient's age, sex, time and place of treatment as well as data on treatment provided. Each year, all hospitals pass on their collected information to the Federal State Statistics Service, which creates summaries and reports of the data [11–13]. This system allows a comprehensive descriptive overview of medically-treated injuries, but it has limited use for primary prevention because it lacks information about when, where, and how injuries occur.

A number of countries have gone a step further and created injury registration systems which aim to prevent injuries. Such injury registries and databases have played an important role in lowering injury incidence, injury-related mortality and disabilities [4, 14, 15]. For example, the Harstad Injury Registry in Norway has been systematically collecting injury data for more than 30 years, including detailed records of injury circumstances, mechanisms, and involved factors [6, 16, 17]. The registry data serves an evidence basis for the Harstad Safe Community Program and has been metaphorically called "the locomotive that keeps the injury prevention train on its track" [6, 15, 17]. Based on the experience of the Harstad Injury Registry and with similar purposes, the population-based Shenkursk Injury Registry (SHIR) was established in the Shenkursk District, Northwestern Russia in 2015.

The aims of this study were to assess the quality of the SHIR data for use as an evidence basis and for local preventive applications.

Methods

Study site

The Shenkursk District of the Arkhangelsk Region, Northwestern Russia (Fig. 1) had a population of 13,530 on 1 January 2015. The town of Shenkursk ($n = 5073$) is the administrative center of the district and its only urban settlement [18]. It is situated 380 km of Arkhangelsk City, near the M8 Russian Federal highway that links Arkhangelsk and Moscow.

Fig. 1 Location of the town of Shenkursk in the Arkhangelsk Region, Russia, 2018 (Source: https://en.wikipedia.org/wiki/Shenkursk)

Health care in the district comes from two sources: the central district hospital and rural primary care units. The central district hospital is located in the town of Shenkursk and has in-patient departments (62 beds) as well as adult and pediatric outpatient units. The rural primary care units include two out-patient departments and 23 feldsher-midwife stations. Records of treatment at all of these locations are held at the hospital information system of the Shenkursk central district hospital, according to Russian national healthcare standards.

The Shenkursk injury registry

The SHIR was created using the translated manual for the Harstad Injury Registry [6, 15, 17]. The standard injury registration form (IRF) of the SHIR is developed on the basis of the form used in Harstad Injury Registry, and the registration instructions and coding lists for free-text variables are the translations of those used in Harstad [19]. Before launching the SHIR, pilot tests were done on the IRF, data collection logistics, the data management system; and two nurses were trained as injury registrars and were tested on quality of data entry [19].

The SHIR is intended to cover all injuries (ICD-10 diagnoses from S00 to T78) for which medical aid is given at the Shenkursk central district hospital. The data are initially collected using paper-based IRFs - two-page sheets with sections for recording patients' socio-demographic characteristics (sex, date of birth, address of residence, place of work or study), information about time and place of the injury, alcohol consumption in the 24 h before injury, use of protective equipment, and optional sections for descriptions of road traffic and sport injuries. The IRF also has a free-text field for recording a verbal description of how the injury occurred. This field is supplemented by three supportive questions to facilitate such descriptions: "What were you doing?", "What went wrong?", "How were you injured?". This is consistent with the concepts of pre-crash, crash, and post-crash described by Haddon [20] as well as with the Nordic System [21], facilitating analysis of the injury panorama and targeting local injury prevention. The concluding part of the form has several fields to be completed by a physician: diagnosis, ICD-10 code, injury severity according to the Abbreviated Injury Scale (AIS) [22], generalized cause of injury (accident, violence, self-inflicted harm), hospitalization (yes/no), and the name of attending physician.

Physicians who provide treatment for injuries at the Shenkursk central district hospital or in its ambulance cars are instructed to offer the IRF to each treated patient at their first outpatient or ambulance visit, or within few days after hospitalization. Patients complete the IRFs, often with the assistance of accompanying relatives, a nurse, or a physician. If a patient does not complete the IRF due to a severe condition or other reasons, injury registrars (the two trained nurses) complete the form retrospectively, using data from routine medical records (ambulance journal, outpatient medical card, case history) as well as information obtained from the attending physician.

Once the IRF is completed, its data is manually entered into the SHIR database (based on Epi Info 7) [23] by the two injury registrars. Following the translated Harstad manuals, at this stage of processing the IRFs a series of coding lists are used to transform the free-text descriptions of the injury situations into several categorical variables: type of injury site (place of injury), mechanism of preceding activity, mechanism of accident, mechanism of injury, and three variables to record factors involved at the three phases of an injury event, accordingly. The registrars have detailed instructions on how to enter raw data from paper-based injury registration forms into Epi Info and are calibrated and on how to transform free-text descriptions of injury situations into the categorical variables.

Data analysis

One year of the SHIR data (1 July 2015–30 June 2016, 1696 registered injuries) was used for assessments of the data quality, i.e. data completeness, representativeness, and reliability. The completeness in terms of coverage of injuries treated at the Shenkursk central district hospital was assessed by linkage of the SHIR records to those of the hospital information system, assuming that the latter included all injuries. Record linkage of the SHIR and the hospital system was performed using names (recorded in the hospital system; available for the SHIR records on corresponding paper IRFs), dates of birth, and dates of injuries.

The representativeness of the SHIR data for the Shenkursk District was assessed by comparing registered injuries to those treated at the Shenkursk central district hospital but not registered in the SHIR. As the second step, registered injuries that occurred in rural areas (i.e. rural injuries) and were treated at the Shenkursk central district hospital were compared to rural injuries that were treated at primary care units, and thus have fallen outside the SHIR's coverage. These comparisons were performed based on variables that are present in the hospital system: age, sex, ICD-10 code, and time variables for initial hospital visit (month of year, day of week). Chi-square tests were used to assess differences between the compared groups.

Data reliability in the SHIR was assessed as agreement between the routine data entry from IRFs performed by the two injury registrars; and a second entry that was independently performed by the first author. This second entry included independent coding of original text descriptions of injury circumstances, following the same coding lists and procedures. Variables used for reliability assessments were sex, age, ICD-10 code, date of injury, mechanism of preceding activity, accident mechanism, injury mechanism, factors involved in each of the mechanisms, alcohol consumption in the 24 h before injury, generalized injury cause, AIS [22], and hospitalization. Cohen's kappa was used to assess the agreement.

All statistical analyses were performed using SPSS, version 24 (SPSS Inc., Chicago, IL, USA).

Results

According to the hospital information system, there were 2305 injuries in the Shenkursk District between July 2015 and June 2016 (Fig. 2). Among them, 1863 injuries were treated at the Shenkursk central district hospital and 442 at rural primary care units (i.e. outside the SHIR's coverage). Of the 1863 injuries treated in the central district hospital, the SHIR included 1607 (86.3%) and missed 256 cases, reflecting the data completeness. Moreover, there were 89 injuries included in the SHIR and were missing in the hospital system. That gave a total of 1696 injuries registered in the SHIR in July 2015–June 2016.

There were no differences between the 1607 registered injuries and the 256 missed injuries by sex, ICD-10 diagnostic (S00-T78) and external cause (V01-Y98) codes, or weekday of admission (Table 1). The proportions of injuries occurring in children and in the summer time were higher among the missed injuries compared to the registered ones. Also, missing and registered injuries had different distribution by attending physicians.

Of the 1696 injuries registered in the SHIR in July 2015–June 2016, 610 were rural injuries which received treatment at the central district hospital. As indicated above, the hospital system contained data for another 442 rural injuries treated at rural primary care units which are not covered by the SHIR. Rural injuries treated at rural primary care units did not differ from those treated at the central district hospital and registered in the SHIR by sex and season of the year, but a higher proportion of rural injuries were represented by children and by injuries to the wrist and hand. A lower proportion of rural injuries treated in primary care were represented by injuries to the shoulder and upper arm (Table 2). Besides, the rural injuries treated in primary care were less commonly caused by transport accidents, and more commonly resulted from exposure to animate mechanical forces.

The agreement between two independent data entries for date of birth, date of injury, date of IRF completion, sex, ICD-10 code, alcohol consumption in the 24 h before injury, generalized cause of an injury, AIS, and hospitalization was at the level of 98–99% (Table 3). The agreement in variables that result from coding of the free-text descriptions of injury situations and reflect mechanisms of preceding activities, accidents, and injuries ranged between 91 and 95%. The agreement in

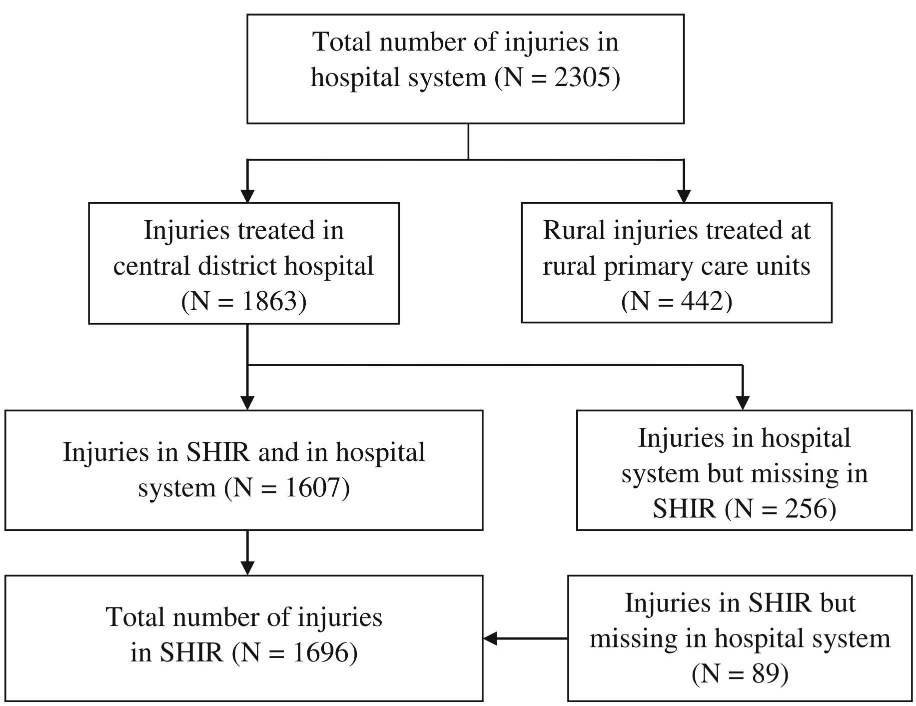

Fig. 2 Distribution of injuries in the hospital system of the Shenkursk central district hospital and in the SHIR, July 2015–June 2016

Table 1 Comparison of injuries registered and missed in the Shenkursk Injury Registry, July 2015–June 2016 ($n = 1863$[a])

Variables	Registered injuries ($N = 1607$)		Missed injuries ($N = 256$)		p
	N	%	N	%	
Sex					
Male	942	58.6	153	59.8	0.729
Female	665	41.4	103	40.2	
Age					
0–17 years	382	23.8	87	34.0	< 0.001
18+ years	1225	76.2	169	66.0	
Injury localization, ICD-10					
S00–09: Head	282	17.5	53	20.7	0.635
S20–29: Thorax	107	6.7	13	5.1	
S40–49: Shoulder and upper arm	109	6.8	16	6.3	
S50–59: Elbow and forearm	130	8.1	21	8.2	
S60–69: Wrist and hand	248	15.4	34	13.3	
S80–89: Knee and lower leg	152	9.5	30	11.7	
S90–99: Ankle and foot	207	12.9	27	10.5	
T15–19: Foreign body entering through natural orifice	153	9.5	19	7.4	
Others codes[b]	435	27.0	72	28.1	
External causes, ICD-10					
W00-W19: Slipping, tripping, stumbling and falls	592	36.8	87	34.0	0.612
W20-W49: Exposure to inanimate mechanical forces	518	32.2	94	36.7	
W50-W64: Exposure to animate mechanical forces	167	10.4	26	10.2	
Others codes[b]	160	10.0	25	9.7	
Missing data	170	10.6	24	9.4	
Season of year					
Winter	368	22.9	54	21.1	0.001
Spring	448	27.9	33	12.9	
Summer	430	26.8	117	45.7	
Autumn	357	22.5	52	20.3	
Weekday					
Monday	289	18.0	42	16.4	0.600
Tuesday	276	17.2	34	13.3	
Wednesday	266	16.6	41	16.0	
Thursday	237	14.7	34	13.3	
Friday	281	17.5	53	20.7	
Saturday	148	9.2	24	9.4	
Sunday	106	6.6	18	7.0	
Attending physicians					
Dr.A	10	0.6	36	14.1	< 0.001
Dr.B	92	5.7	9	3.5	
Dr.C	20	1.2	25	9.8	
Dr.D	379	23.6	55	21.5	
Dr.E	159	9.9	9	3.5	
Dr.F	111	6.9	7	2.7	
Dr.G	128	8.0	8	3.1	
Others[b]	708	44.1	107	41.8	

[a]All analyzed injuries were treated in the Shenkursk central district hospital, as shown in the hospital system for accounting of medical services;
[b]Combines categories accounting for < 5% of observations
ICD International Classification of Diseases

Table 2 Comparison of rural injuries treated at the Shenkursk central district hospital and rural injuries treated at rural primary care units of Shenkursk district, July 2015–June 2016 ($N = 1052$)

	Rural injuries treated at central district hospital ($N = 610$)		Rural injuries treated in primary care ($N = 442$)		p
	n	%	N	%	
Sex					
Male	359	58.9	239	53.6	0.088
Female	251	41.1	207	46.4	
Age					
0–17 years	125	20.5	152	34.1	< 0.001
18+ years	485	79.5	294	65.9	
Injury localization, ICD-10					
S00–09: Head	77	12.6	66	14.8	< 0.001
S20–29: Thorax	54	8.9	28	6.3	
S30–39: Abdomen, lower back, lumbar spine, pelvis and external genitals	30	4.9	29	6.5	
S40–49: Shoulder and upper arm	64	10.5	13	2.9	
S50–59: Elbow and forearm	56	9.2	21	4.7	
S60–69: Wrist and hand	83	13.6	89	20.0	
S80–89: Knee and lower leg	72	11.8	47	10.5	
S90–99: Ankle and foot	77	12.6	68	15.2	
T15–19: Foreign body entering through natural orifice	28	4.6	26	5.8	
T20–32: Thermal and chemical burns	33	5.4	19	4.3	
Others codes[a]	36	5.9	40	9.0	
ICD-10 external cause codes					
V01-V99: Transport accidents	37	6.1	11	2.5	< 0.001
W00-W19: Slipping, tripping, stumbling and falls	237	38.9	173	38.8	
W20-W49: Exposure to inanimate mechanical forces	171	28.0	141	31.6	
W50-W64: Exposure to animate mechanical forces	46	7.5	58	13.0	
Others codes[a]	36	6.0	44	10.0	
Missing data	83	13.6	19	4.3	
Season of year					
Winter	140	23.0	110	24.9	0.812
Spring	163	26.7	114	25.8	
Summer	193	31.6	131	29.6	
Autumn	114	18.7	87	19.7	

[a]Combines categories accounting for < 5% of observations
ICD International Classification of Diseases

variables resulting from coding of factors involved at three phases of injury events ranged from 79 to 88%.

ICD International Classification of Diseases, *AIS* Abbreviated Injury Scale.

Discussion

Injury registries exist in the USA, Australia, Canada, Norway, Germany, and the UK [17, 24], but to our knowledge, the SHIR is the first injury registry in Russia.

Most national or regional injury registries are limited to trauma center hospitals and include only severe injuries (for example, “major trauma” or persons hospitalized for more than 24 h, etc.) [25]. On the contrary, the SHIR is population-based as it covers all injuries treated at the only hospital in Shenkursk District. Moreover, the SHIR collects detailed information on injury circumstances. These two features target the SHIR’s representativeness of the total number of injuries in the coverage area and form an informative evidence basis for primary

Table 3 Agreement between the two independent data entries for the Shenkursk Injury Registry ($N = 1696$)

Variables	Agreement		Cohen's Kappa
	n	%	
Date of birth	1687	99.5	–
Date of injury	1682	99.2	–
Date of form filling	1673	98.6	–
Sex	1965	99.8	0.99
ICD-10 diagnostic code	1680	99.1	0.99
Alcohol consumption	1678	98.9	0.98
Generalized cause of injury	1668	98.3	0.94
Injury severity (AIS)	1685	99.4	0.99
Hospitalization	1690	99.6	0.98
Mechanism of preceding activity	1536	90.6	0.89
Accident mechanism	1605	94.6	0.94
Injury mechanism	1589	93.7	0.93
Factor 1 (preceding activity)	1343	79.2	0.77
Factor 2 (accident)	1487	87.7	0.87
Factor 3 (injury)	1415	83.4	0.83

prevention, according to recommendations for injury monitoring and prevention [4, 26, 27].

Methodological considerations

This study has shown that the completeness of the SHIR with respect to the coverage of cases treated at the central district hospital was 86%, which is lower than that reported from several other registries. For example, Thailand has a provincial injury surveillance system that covers injuries from five large hospitals and has a reported completeness of 98.8% [28], and the trauma registry in Peru includes a reported 99% injuries admitted to the main referral hospital [29]. However, these studies did not specify how completeness was calculated. On the other hand, a similar completeness (90%) was reported in a study of hip fractures in the Harstad Injury Registry in Norway [16].

The approach we used to assess completeness of the SHIR assumed that the hospital system covers all injuries treated in the central district hospital. However, we identified a number of injuries in the SHIR that were treated in the hospital but were missing in the hospital system for unknown reasons. That may indicate that our estimates may be slightly underestimated.

The imperfect completeness of the SHIR may be primarily explained by the difference between missed and registered injuries in their distribution by attending physicians, which reflects unequal efficiency of physicians to collect IRFs from their patients. Practically, injuries with uncompleted IRFs are largely detected by injury registrars through regular checks of the registry against the hospital system. In such cases, the registrars complete the IRFs retrospectively, using available medical documentation and information obtained from physicians. In order to assess the proportion of IRFs competed by registrars, in 2017 the SHIR was added by a variable specifying who completed the IRF. In 2017, 59% of IRFs were completed by patients or accompanying relatives, and 41% were filled in by registrars. This reflects the registrars' substantial efforts to achieve the highest possible completeness, although the results are still imperfect. Based on that and in order to improve the completeness of the SHIR, the administration of the hospital was advised to enhance physicians' motivation to ask their patients to complete IRFs.

According to the information in the hospital information system, there were no substantial differences between registered and missed injuries in the SHIR by sex, weekday of admission, diagnostic and external cause categories, but missed injuries showed a higher proportions of children (34% vs. 24%) and higher proportion of injuries occurring in summer time (46% vs. 27%). The increased probability of failure to register injuries in summer may be explained by the vacation period, when a part of the staff is absent and those remaining must deal with a higher volume of prioritized medical tasks. The higher proportion of missed injuries among children may also be due to higher underregistration in summer time, when children have holidays and are more likely to get injured.

As the proportion of missed injuries in the SHIR was 14% and the missed cases showed only minor differences from those registered, the imperfect completeness of the registry should not substantially affect its representativeness for total injuries treated at the central district hospital. However, there are some underestimates of injury risks among children and in summer time, which should be taken into account when using the data for preventive purposes.

The population covered by the SHIR is rather small ($n = 13{,}530$). This implies that sampling of specific injuries for research purposes may take a long time, or confidence intervals may be broad. However, the primary aim of the SHIR is to identify circumstances, mechanisms and involved factors of the most frequent injuries in the Shenkursk district for planning targeted district-level prevention. Studies of these injuries are expected to have good levels of statistical power. And, the longer the registry is run, the more cases are generated.

A limitation of the SHIR is that it only covers injuries that received medical aid at the Shenkursk central district hospital while about 40% of injuries occurring on adjacent rural areas are treated at primary care units and thus are not recorded in the SHIR. Comparisons of rural injuries treated at the central district hospital to those treated at rural primary care units reflect the real-life situation: more severe cases (e.g. those resulting from traffic accidents) are more commonly referred to the central district hospital, while minor injuries are more often treated at primary care units. The described differences between the two groups were significant but not decisively substantial, so the SHIR data can be considered fairly representative of all injuries in the district. Although, a notation of some overestimations in overall injury severity has to be made.

The difference in coverage of urban and rural injuries by the SHIR also creates difficulty in estimating the incidence. On one hand, not all cases appear in a numerator if we calculate the incidence for the whole district, thus leading to an underestimate. An alternative way can be to limit the numerator to cases in the town, and use the town's population in denominator. But this reduces statistical power and does not represent the situation in the entire district with large rural component. This data deficiency can be compensated by calculating the incidence using the information of hospital system, which covers all rural and urban cases. This would lead to more precise incidence estimates by sex, age or ICD-10, while the registry provides valuable information about typical injury circumstances.

Another limitation is the non-inclusion of prehospital fatal injuries. The reason for that is that such fatalities are referred to a forensic department outside the hospital. Thus, the SHIR cannot be used to estimate the burden and describe the characteristics of fatal injuries. This weakness has to be considered when using the SHIR data for preventive applications, but its elimination would unlikely affect the registry-derived priorities for preventive interventions as fatal injuries constituted, for example, only 2.1% of the total injuries in the Shenkursk District in the study period from July 2015 to June 2016.

In the present study, we expressed data reliability as percentage of agreement between two independent raters. The data value was considered reliable if it was the same for the two raters. According to the classification by Landis and Koch, the agreement was "almost perfect" for variables resulting from simple data entry from IRFs into the SHIR (e.g. date of birth, sex, ICD-10 code) [30]. For variables resulting from free-text descriptions through coding procedures (e.g. mechanism of accident, factor involved in mechanism of accident), the agreement levels ranged from "substantial" to "almost perfect" (lowest Cohen's $k = 0.77$). More frequent disagreements in these variables may be explained by possible variations in the subjective understanding of free-text descriptions and the corresponding codes assigned. Such reliability deficiencies are unavoidable, and their relatively small volumes show that the SHIR data is reasonably reliable.

The presented data reliability assessments referred to the stage when the data is transferred manually from paper-based IRFs into the electronic registry, but the reliability of IRF data can scarcely be assessed. Potential deficiencies were addressed during staff training and in the design of the form. For example, the correct indication of injury severity according to the AIS in the medical part of the form requires a physician to be familiar with this scale. To prevent possible errors due to lacking knowledge of the AIS, the IRF itself contains a detailed description of the AIS, in order to facilitate proper ranking by physicians.

Conclusion

This study has demonstrated that the SHIR can be considered sufficiently complete, accurate, and representative of the injury situation in the district. With a notation of a possible insubstantial overestimate of the average injury severity in the district, it forms a suitable evidence basis for local preventive activities and can be used for injury research.

Abbreviations

AIS: Abbreviated Injury Scale; ICD: International Statistical Classification of Diseases and Related Health Problems; IRF: Injury registration form; SHIR: Shenkursk Injury Registry; WHO: World Health Organization

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Availability of data and materials

The anonymized datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

TNU was involved in conceptualization, design, acquisition of the data, analysis and interpretation of the data, drafting of the manuscript, AMG was leading the establishment of the SHIR, performed critical revision and statistical expertise, TAT participated in conceptualization, design, critical revision, acquisition of funding, BY was involved conceptualization, design, critical revision, AVK was involved in conceptualization, design, acquisition of the data, analysis and interpretation of the data, drafting of the manuscript, critical revision, statistical expertise. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The establishment of the SHIR and the corresponding data collection were approved by the Ethics Committee of the Northern State Medical University, Arkhangelsk (protocol 07/10–13 from 09.10.2013). Both medical and non-medical information were collected by the Shenkursk central district hospital which holds the rights to do so through local regulations and informed consent. The protocol for the present study was approved by the Ethics

Committee of the Northern State Medical University, Arkhangelsk (protocol 03/04–17 from 27.04.2017). The study has been evaluated by the Norwegian Regional Committees for Medical and Health Research Ethics (REC) (Remit Assessment 2017/1995/REK nord) and approved by the Norwegian Center for Research Data (protocol number № 56817/3/TAL from 21.12.2017).

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Paper II

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Mechanisms of accidental fall injuries and involved injury factors: a registry-based study

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ORIGINAL CONTRIBUTION

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Mechanisms of accidental fall injuries and involved injury factors: a registry-based study

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Abstract

Background: Falls are the leading cause of injury-related morbidity and mortality worldwide, but fall injury circumstances differ by age. We studied the circumstances of accidental fall injuries by age in Shenkursk District, Northwest Russia, using the data from the population-based Shenkursk Injury Registry.

Methods: Data on accidental fall injuries (hereafter: fall injuries) occurring in January 2015–June 2018 were extracted from the Shenkursk Injury Registry ($N = 1551$) and categorized by age group (0–6, 7–17, 18–59, and 60+ years). The chi-square test and ANOVA were used to compare descriptive injury variables across age groups, and a two-step cluster analysis was performed to identify homogeneous groups of fall injuries by preceding circumstances.

Results: Half of recorded fall injuries in the 0–6 year age group occurred inside dwellings (49%). The largest cluster of falls (64%) mainly included climbing up or down on home furnishings. In the 7–17 year age group, public outdoor residential areas were the most common fall injury site (29%), and the largest cluster of falls (37%) involved physical exercise and sport or play equipment. Homestead lands or areas near a dwelling were the most typical fall injury sites in the age groups 18–59 and 60+ years (31 and 33%, respectively). Most frequently, fall injury circumstances in these groups involved slipping on ice-covered surfaces (32% in 18–59 years, 37% in 60+ years).

Conclusion: The circumstances of fall injuries in the Shenkursk District varied across age groups. This knowledge can be used to guide age-specific preventive strategies in the study area and similar settings.

Keywords: Fall injuries, Injury registry, Shenkursk, Cluster analysis

Background

Falls follow road traffic accidents as the second leading cause of injury-related mortality worldwide (World Health Organization 2014). Based on the latest Global Health Estimates, 660,320 people died from falls in 2016 in the world (World Health Organization 2018). The proportion of fall injury-related mortality in the World Health Organization European Region increased from 12% in 2000 to 17% in 2016 (World Health Organization 2018; World Health Organization n.d.).

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Children and older people are highly prone to falls. Among children, fall injury-related mortality is rare, but rates of hospitalization and visits to the emergency department are high (Lee et al. 2017; Ali et al. 2019), with falls accounting for 25–52% of hospitalizations among children in developing countries (Kaida et al. 2006). For the elderly, falls are the most common cause of injury-related mortality, the rates of which increase exponentially with age (Yoshida 2007).

Fall injuries occur because of endogenous and environmental factors. Previous studies have described demographic, social, medical, and temporal characteristics of fall injuries (Lee et al. 2017; Kaida et al. 2006; Peel et al. 2002; Stevens and Sogolow 2005). Some studies have examined the environmental and behavioral circumstances of fall injuries by age group: in children (Ali et al. 2019; Istre et al. 2003), young adults, middle-aged adults (Timsina et al. 2017; Dandona et al. 2010), and elderly people (Orces and Alamgir 2014). Fall injuries in preschool-aged children most often occur at home, and the most serious injuries are caused by falls on stairs, from furniture, and from playground equipment (Pickett et al. 2003; Flavin et al. 2006; Chaudhary et al. 2018; Wadhwaniya et al. 2017). The incidence of home injuries among children decreases with age. In school-aged children, fall injuries are more common in school environments, public parks, on highways or roads, and in sports/recreational facilities (Unni et al. 2012). Young and middle-aged adults typically fall outdoors, while and the elderly most commonly fall at home (Talbot et al. 2005). Knowledge of the typical site-specific and group-specific upstream circumstances of fall injuries is required for effective prevention. Therefore, local data on where, when, and how typical fall circumstances occur are necessary to create preventive strategies at a country or community level (Ytterstad 1996).

The Shenkursk Injury Registry (SHIR) is a population-based registry that was established in the Shenkursk District, Northwestern Russia in 2015 for the purposes of primary prevention (Unguryanu et al. 2019), and it shows that falls are the most common injury mechanism in the area. Using data from the SHIR, we studied the circumstances of accidental fall injuries (hereafter referred to as fall injuries) by age to provide data-driven evidence for development of preventive strategies.

Methods

Study site

The population of Shenkursk District was 12,610 on 1 January 2018. The area has a cold climate with a mean annual air temperature of 1.4 °C, and temperatures below zero prevail from October to April (Climate: Shenkursk n.d.). The economy of the district is based on forestry, woodworking, and agriculture. The road network is grossly underdeveloped, and most local roads are unpaved. Health care in the district is largely provided by the central district hospital (CDH), which offers in-patient facilities (62 beds) and out-patient polyclinics for adults and children.

The Shenkursk injury registry and selection criteria

The SHIR records all injuries (ICD-10 diagnoses from S00 to T78) treated at the Shenkursk CDH. Data are collected using a universal injury registration form (IRF) - a two-page sheet with sections for recording patients' socio-demographic characteristics (sex, date of birth, address of residence, place of work or study), information about time and place of the injury, alcohol consumption in the 24 h before injury, use of protective equipment, and optional sections for descriptions of road traffic and sport injuries. The IRF also has a field for a free-text description of how the injury has occurred. This field is supplemented by three supportive questions to facilitate detailed descriptions of injury circumstances: "What were you doing?", "What went wrong?", and "How were you injured?". These free-text descriptions are transformed into several upstream categorical variables using the corresponding coding lists (i.e., mechanism of preceding activity, accident mechanism, and injury mechanism) and factors involved (i.e., factors involved in mechanism of preceding activity, factors involved in accident mechanism, and factors involved in injury mechanism). The concluding part of the IRF has several fields to be completed by a physician, including the diagnosis with corresponding ICD-10 code, injury severity according to the Abbreviated Injury Scale (AIS), and whether the patient was hospitalized. Physicians who provide treatment for injuries at the Shenkursk CDH or in its ambulance cars are instructed to offer the IRF to each treated patient at their first outpatient or ambulance visit, or within few days after hospitalization. Patients complete IRFs, often with the assistance of accompanying relatives, a nurse, or a physician. If a patient does not complete the IRF due to a severe condition or other reasons (about 40% of cases), injury registrars (two trained nurses) complete the form retrospectively, using data from routine medical records (ambulance journal, outpatient medical card, case history) as well as information obtained from the attending physician. A more detailed description of the SHIR, the IRF, and methodological considerations are presented elsewhere (Unguryanu et al. 2019; Unguryanu et al. 2017).

In the present analysis, we used data on nonfatal fall injuries that occurred from January 2015 to June 2018 and were registered in the SHIR. A fall injury was defined as "inadvertently coming to rest on the ground, floor or other lower level" (ICD-10 code W00–19) (Istre et al. 2003).

Data analysis

Fall injuries were categorized into four age groups: preschool age (0–6 years), school age (7–17 years), working age (18–59 years), and elderly age (60+ years). Categorical injury characteristics are presented as absolute numbers and percentages. The AIS is presented as mean (standard deviation). Chi-square test and one-way ANOVA were used when comparing fall injury subgroups.

A two-step cluster analysis was performed to identify homogeneous groups of fall injuries by injury circumstances for each of the four age groups. Five upstream variables originating from free-text descriptions of injury circumstances were included in cluster analyses: mechanism of preceding activity, accident mechanism, injury mechanism, factors involved in mechanism of preceding activity, and factors involved in accident mechanism. The number of clusters was determined automatically using the Bayesian information criterion. The average silhouette measure of cohesion and separation (range: −1 to + 1) was used to indicate the overall goodness of fit (Rousseeuw 1987). It is conventionally accepted that a silhouette measure of < 0.2 is considered poor, between 0.2 and 0.5 indicates a fair solution, and > 0.5 is a good solution (Mooi and Sarstedt 2011). All statistical analyses were performed using SPSS, version 25 (SPSS Inc., Chicago, IL, USA).

Results

Altogether, the SHIR contained data on 1551 fall injuries occurring during the study period (Table 1), which constituted 38% of all registered injuries in the period. There were 84 fall injuries (5.4%) in the preschool age group, 294 (18.9%) in the school age group, 734 (47.3%) in the working age group, and 437 (28.2%) in the elderly age group. The distribution of fall injuries by injury site, injury localization, injury severity, proportion of hospitalizations, and proportion of injuries that occurred in the cold season (15 October-14 April) were significantly different across age groups.

Mechanism of preceding activity, accident mechanism, injury mechanism, and factors involved in the mechanism of preceding activity, accident mechanism, and injury mechanism also differed by age group (Table 2).

Among the preschool age group, the most common fall injury site was inside of dwellings (49%). For the school age group, the most common fall injury site was public outdoor residential areas (29%), while the most common fall injury site for individuals in the working age group and elderly age group was homestead land or area near a dwelling (31 and 33% respectively). Upper and lower extremities were the most commonly injured body parts in all age groups.

According to the AIS, minor injuries constituted about two-thirds of fall injuries in the preschool age, school age, and working age groups (57–70%); and they constituted almost half of fall injuries in the elderly age group (44%). The proportion of hospitalizations was the highest in the elderly age group (20%). The proportion of fall injuries in the cold season in the preschool age group (29%) was a half of that in other age groups. About 19% of fall injuries in the working age group had a report of alcohol consumption in the preceding 24 h.

The most common mechanism of preceding activity in the working and elderly age groups was walking (56 and 62%, respectively), in the preschool age group it was climbing up/down (21%), and in the school age group it was walking (38%) and physical exercise (27%) (Table 2). Slipping was the most frequent accident mechanism in the working (58%) and elderly (49%) age groups. Injury mechanisms showed that most falls were at the same level in all age groups, but the preschool age group had a relatively higher proportion (38%) of fall injuries from a height of < 1.5 m. Most cases in all age groups reported no factors involved in the mechanism of preceding activity. An internal human factor (e.g., loss of balance, dizziness, weakness) was the most commonly mentioned factor involved in accident mechanism in the preschool (55%) and school (39%) age groups. In working and elderly age groups, the most common factor involved in accident mechanism was ice-covered surfaces (46 and 40% of cases, respectively). Surfaces outside were the most frequent category of factors involved in injury mechanism in all age groups except preschool (ranging between 56 and 62%). For the preschool age group, the proportions of surfaces inside and outside that acted as factors involved in injury mechanism were similar (37%).

The fewest fall injuries were recorded in the preschool age group, which formed two clusters (Fig. 1). Cluster 1 (64% of cases) mainly included fall injuries involving climbing up or down (on furniture, play equipment, stairs) and a loss of balance. Cluster 2 (36% of cases) included falls on the same level, most commonly preceded by walking and slipping.

Four clusters of fall injuries were identified in the school age group (Fig. 2). Cluster 1 (36% of cases) largely involved cases which occurred during physical exercise and involved sport or play equipment, and a loss of balance. Cluster 2 (28%) largely constituted fall injuries that resulted from slipping on ice-covered surfaces while walking. Cluster 3 (24%) mainly consisted of cases who walked and fell due to stepping wrong. Fall injuries involving stairs in buildings - walking up or down and falling due to stepping wrong - comprised cluster 4 (12%).

Analyses of the fall injuries in the working age group resulted in five clusters (Fig. 3). For cluster 1 (32% of cases) and cluster 3 (18% of cases), the most common accident mechanism was slipping, with an ice-covered surface being the most common involved factor. The difference between them was in the mechanism of preceding activity: simple walking preceded the fall in almost all cases in cluster 1, while in cluster 3 the mechanism was carrying something. Cluster 2 (19% of cases) mainly constituted fall injuries while walking, which occurred due to stepping wrong. Cluster 4 (16% of cases) was largely constituted by fall injuries resulting from slipping on a wet surface outside or inside. Cluster 5 (15%) was entirely made up of falls on stairs.

Four clusters of fall injuries were identified in the elderly age group (Fig. 4). For cluster 1 (37% of cases) and cluster 3 (19% of cases), the situation was similar to that in the working age group. Cluster 2 (25% of cases) contained cases in which fall injuries mainly occurred due

Table 1 Demographic, medical, and temporal characteristics of accidental fall injuries, Shenkursk District, January 2015–June 2018

	Age groups**			
	Preschool 0–6 years (*N* = 84)	School 7–17 years (*N* = 294)	Working 18–59 years (*N* = 736)	Elderly 60+ years (*N* = 437)
	n (%)	n (%)	n (%)	n (%)
Sex, male	44 (52.4)	168 (57.1)	377 (51.2)	140 (32.0)
Injury site				
Homestead land, area near a dwelling	19 (22.6)	34 (11.6)	227 (30.8)	144 (33.0)
Dwelling, inside parts (living room, bedroom, kitchen)	41 (48.8)	27 (9.2)	119 (16.2)	121 (27.7)
Dwelling, outer parts (roof, porch)	2 (2.4)	12 (4.1)	86 (11.7)	36 (8.2)
Roadway	4 (4.8)	20 (6.8)	73 (9.9)	52 (11.9)
Public outdoor residential area	7 (8.3)	85 (28.9)	133 (18.1)	56 (12.8)
Educational institution (inside and outside, excl. Sports facilities)	2 (2.4)	37 (12.6)	3 (0.4)	1 (0.2)
Sports facilities and playgrounds	8 (9.5)	68 (23.1)	21 (2.9)	—
Natural surroundings (forest, field, river side)	1 (1.2)	3 (1.0)	45 (6.1)	14 (3.2)
Other*	—	8 (2.8)	29 (3.9)	13 (3.0)
Injury localization, ICD-10				
S00–09: Head	27 (32.1)	36 (12.2)	83 (11.3)	31 (7.1)
S20–29: Thorax	5 (6.0)	9 (3.1)	120 (16.3)	72 (16.5)
S30–39: Abdomen, lower back, lumbar spine and pelvis	—	18 (6.1)	45 (6.1)	19 (4.3)
S40–69: Upper extremity	35 (41.7)	122 (41.4)	260 (35.3)	180 (41.2)
S70–99: Lower extremity	17 (20.2)	103 (35.0)	219 (29.8)	127 (29.1)
Other*	—	6 (2.1)	9 (1.3)	8 (1.9)
Injury severity according to the AIS				
1 Minor	55 (65.5)	207 (70.4)	421 (57.2)	190 (43.5)
2 Moderate	20 (23.8)	80 (27.2)	234 (31.8)	162 (37.1)
3 Severe, but not life-threatening	9 (10.7)	6 (2.0)	79 (10.7)	83 (19.0)
4 Severe, potentially life-threatening and critical, with uncertain survival	—	1 (0.3)	2 (0.2)	2 (0.5)
Hospitalization, yes	11 (13.1)	19 (6.5)	89 (12.1)	88 (20.1)
Season				
15 October - 14 April	24 (28.6)	177 (59.9)	483 (65.5)	266 (60.4)
15 April - 14 October	60 (71.4)	117 (40.1)	253 (34.5)	171 (39.6)
Alcohol consumption in preceding 24 h, yes	–	3 (1.0)	136 (18.5)	22 (5.0)

ICD International Classification of Diseases, *AIS* Abbreviated Injury Scale
*Combines categories accounting for < 5% of observations in all age groups
***p*-values for group comparisons on all presented characteristics are < 0.001

to faintness while walking. Cluster 4 (18% of cases) consisted largely of fall injuries during walking, where stumbling over something was the key accident mechanism.

Mean AIS values were significantly different between the clusters of fall injuries only in the school age group (p = 0.002) (Fig. 2). The highest mean AIS value was observed in Cluster 1, which accumulated fall injuries during exercising. Correspondingly, fall injuries in cluster 1 had the highest proportion of hospitalization (10%), but the difference between the clusters was not significant.

Discussion

In the preschool age group, fall injuries were most commonly associated with climbing on to or down from home furnishings. The most substantial part of fall injuries among the school age group occurred during physical exercise involving sport or play equipment. The most frequent accident mechanism in the working and elderly age groups was slipping on an ice-covered surface.

Our findings in preschool children are similar to observations from Bangladesh (Wadhwaniya et al. 2017) and Canada (Flavin et al. 2006), which showed that the

Table 2 Mechanisms of accidental fall injuries and involved factors, Shenkursk District, January 2015–June 2018

	Age groups**			
	Preschool 0–6 years (*N* = 84) n (%)	School 7–17 years (*N* = 294) n (%)	Working 18–59 years (*N* = 736) n (%)	Elderly 60+ years (*N* = 437) n (%)
Mechanism of preceding activity				
Walking	14 (16.7)	111 (37.8)	414 (56.3)	269 (61.6)
Physical exercise	16 (19.0)	79 (26.9)	31 (4.2)	4 (0.9)
Running	13 (15.5)	34 (11.6)	4 (0.5)	—
Climbing up/down	18 (21.4)	18 (6.1)	14 (1.9)	5 (1.1)
Going on stairs	6 (7.1)	29 (9.9)	70 (9.5)	34 (7.8)
Sitting and lying	13 (15.5)	6 (2.0)	14 (1.9)	23 (5.3)
Standing	4 (4.8)	9 (3.1)	59 (8.0)	25 (5.7)
Working at home or garden	—	6 (2.0)	64 (8.7)	29 (6.6)
Carrying something	—	2 (0.7)	66 (9.0)	48 (11.0)
Factors involved in mechanism of preceding activity				
No factor reported	26 (31.0)	150 (51.0)	382 (51.9)	267 (61.1)
Sport and play equipment	13 (15.5)	80 (27.2)	29 (3.9)	4 (0.9)
Stairs in a building	5 (6.0)	24 (8.2)	34 (4.6)	8 (1.8)
Furniture	17 (20.2)	3 (1.0)	3 (0.4)	12 (2.7)
Wooden object	4 (4.8)	4 (1.4)	54 (7.3)	15 (3.4)
Porch	1 (1.2)	6 (2.0)	59 (8.0)	30 (6.9)
Loose household items	—	—	34 (4.6)	34 (7.8)
Other factors*	18 (21.5)	27 (9.2)	141 (19.1)	67 (15.3)
Accident mechanism				
Slipping	13 (15.5)	101 (34.4)	426 (57.9)	216 (49.4)
Stepping wrong	14 (16.7)	68 (23.1)	122 (16.6)	51 (11.7)
Stumbling over something	13 (15.5)	41 (13.9)	74 (10.1)	76 (17.4)
Loss of balance	35 (41.7)	55 (18.7)	47 (6.4)	17 (3.9)
Faintness	—	—	14 (1.9)	62 (14.2)
Other*	9 (10.8)	29 (9.9)	53 (7.2)	15 (3.5)
Factors involved in accident mechanism				
Internal human factor	46 (54.8)	114 (38.8)	161 (21.9)	124 (28.4)
Ice-covered surface	6 (7.1)	85 (28.9)	337 (45.8)	173 (39.6)
Sport and play equipment	6 (7.1)	23 (7.8)	11 (1.5)	3 (0.7)
Another human	6 (7.1)	14 (4.8)	9 (1.2)	—
Part of building inside	2 (2.4)	12 (4.1)	22 (3.0)	26 (5.9)
Wooden object	3 (3.6)	9 (3.1)	39 (5.3)	26 (5.9)
Wet surface outside / inside	1 (1.2)	10 (3.4)	62 (8.4)	35 (8.0)
Furniture	6 (7.1)	2 (0.7)	15 (2.0)	3 (0.7)
Other factors*	8 (9.5)	25 (8.5)	80 (10.8)	47 (10.7)
Injury mechanism				
Fall on the same level	37 (44.0)	220 (74.8)	520 (70.7)	360 (82.4)
Fall on stairs	10 (11.9)	37 (12.6)	138 (18.8)	56 (12.8)
Fall from a height of <1.5 m	32 (38.1)	17 (5.8)	33 (4.5)	17 (3.9)
Fall from a height of > 1.5 m	5 (6.0)	20 (6.8)	45 (6.1)	4 (0.9)

Table 2 Mechanisms of accidental fall injuries and involved factors, Shenkursk District, January 2015–June 2018 *(Continued)*

	Age groups**			
	Preschool 0–6 years (*N* = 84) n (%)	School 7–17 years (*N* = 294) n (%)	Working 18–59 years (*N* = 736) n (%)	Elderly 60+ years (*N* = 437) n (%)
Factors involved in injury mechanism				
Surface outside	31 (36.9)	183 (62.2)	489 (66.4)	245 (56.1)
Surface inside	31 (36.9)	67 (22.8)	119 (16.2)	109 (24.9)
Wooden object	3 (3.6)	13 (4.4)	52 (7.1)	34 (7.8)
Sport and play equipment	—	16 (5.4)	5 (0.7)	—
Furniture	11 (13.1)	1 (0.3)	15 (2.0)	23 (5.3)
Other factors*	8 (9.5)	14 (4.8)	56 (7.6)	26 (5.9)

*Combines categories accounting for < 5% of observations in all age groups
** p-values for group comparisons on all presented characteristics are < 0.001

majority of injuries in the age group 0–6 years occurred at home. In our study, the most common factor involved in mechanism of preceding activity in the preschool age group was furniture, which is in line with findings from other studies (Ali et al. 2019; Pickett et al. 2003; Chaudhary et al. 2018; Unni et al. 2012; Savitsky et al. 2007; Pitone and Attia 2006).

The proportion of head injuries in the preschool age group (32%) was three times higher than that among the school age group, and the proportions of severe injuries (11%) and hospitalization (13%) were five and two times higher, respectively (Park et al. 2004). These findings are supported by studies showing that head injuries are common among the youngest children (Ali et al. 2019; Pickett et al. 2003; Flavin et al. 2006; Wadhwaniya et al. 2017; Pitone and Attia 2006), which may be explained by a limited child's ability to shield the head during a fall (Park et al. 2004). Based on our findings, prevention of fall injuries in preschool children should primarily address the safety of the home environment. It is vitally important to prevent preschool children from climbing high up without parental supervision and to cover floors with soft materials near places where children can climb up on furniture or other objects in the home.

Our study showed that the school age group most commonly sustained fall injuries outside during sport and play activities, and this is comparable to findings in other settings (Ali et al. 2019; Wadhwaniya et al. 2017; Unni et al. 2012; Gupta et al. 2016; Schneuer et al. 2018). Therefore, fall injury prevention in school children should focus on safe sports and play, by promoting the use of helmets, protective padding, and safety nets. Safety education efforts should also include school teachers.

Slipping on ice-covered surfaces was the most frequent fall injury in the working and elderly age groups, which is in concordance with studies carried out in Norway, Finland, the UK, the USA, and Iran (Bulajic-Kopjar 2006; Flinkkilä et al. 2011; Mardani-Kivi et al. 2014; Gevitz et al. 2017; Ralis 1981). These findings suggest that preventive measures in Shenkursk District and settings with similar climatic

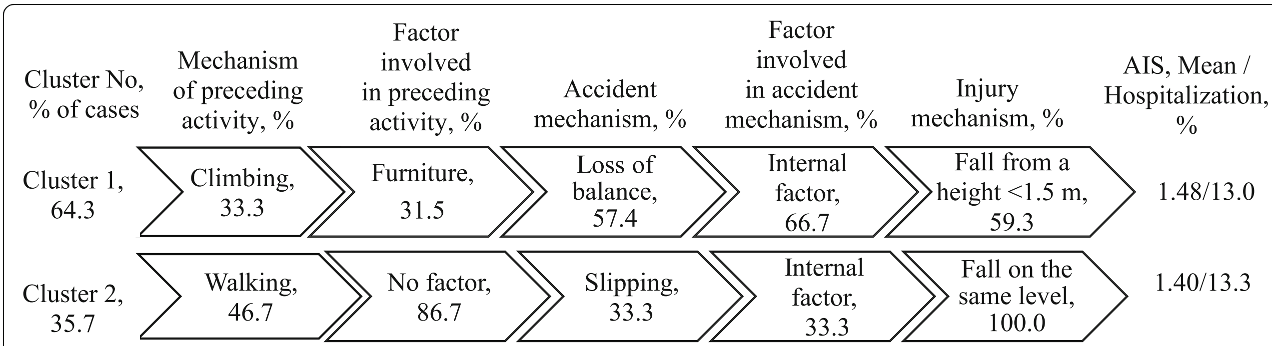

Fig. 1 Clusters of fall injuries, children 0–6 years, Shenkursk District, January 2015–June 2018 (*N* = 84). Average silhouette = 0.4. AIS: Abbreviated Injury Scale

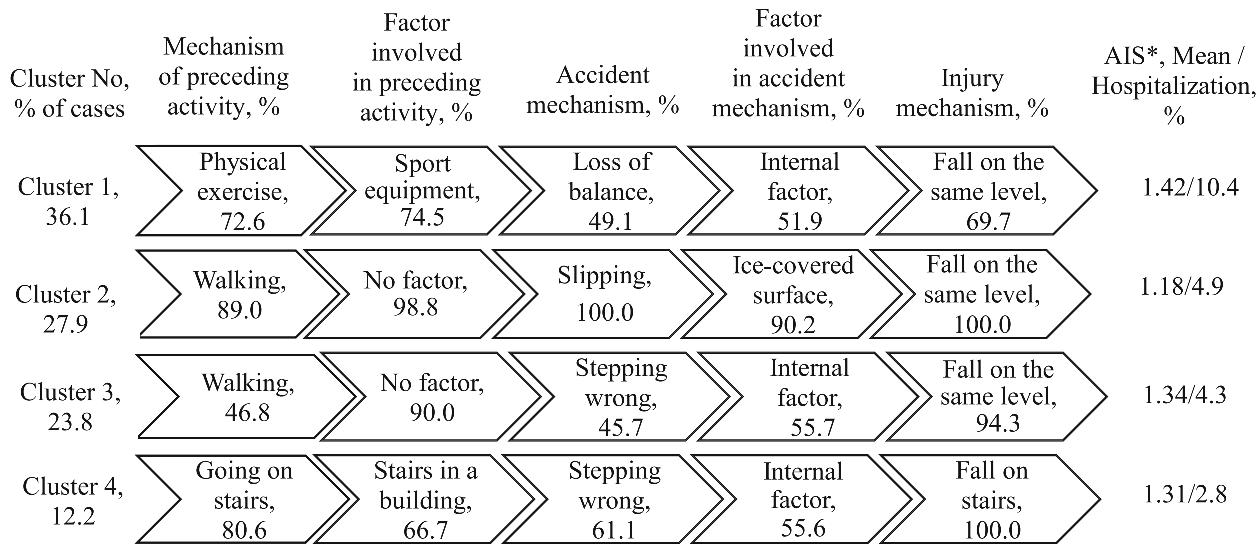

Fig. 2 Clusters of fall injuries, children 7–17 years, Shenkursk District, January 2015–June 2018 ($N = 294$). Average silhouette = 0.5. * $F = 3{,}32$; d.f. = 3, $p = 0.002$ between clusters. AIS: Abbreviated Injury Scale

conditions should primarily target removing ice and preventing slipping on icy surfaces, for example, by spreading sand and wearing shoes with high-friction outsoles or spikes.

It is also worth noting that alcohol consumption in the preceding 24 h was reported in connection to one-fifth of fall injuries in the working age group, and this may be underreported. Due to our concern about the latter, alcohol was not considered as a factor in cluster analyses. When alcohol consumption was reported, internal human factors (dizziness, erroneous actions) were commonly mentioned as a part of the factors involved in the accident mechanism, so some cases that reported no alcohol consumption, but similar "internal factors", may have been attributable to

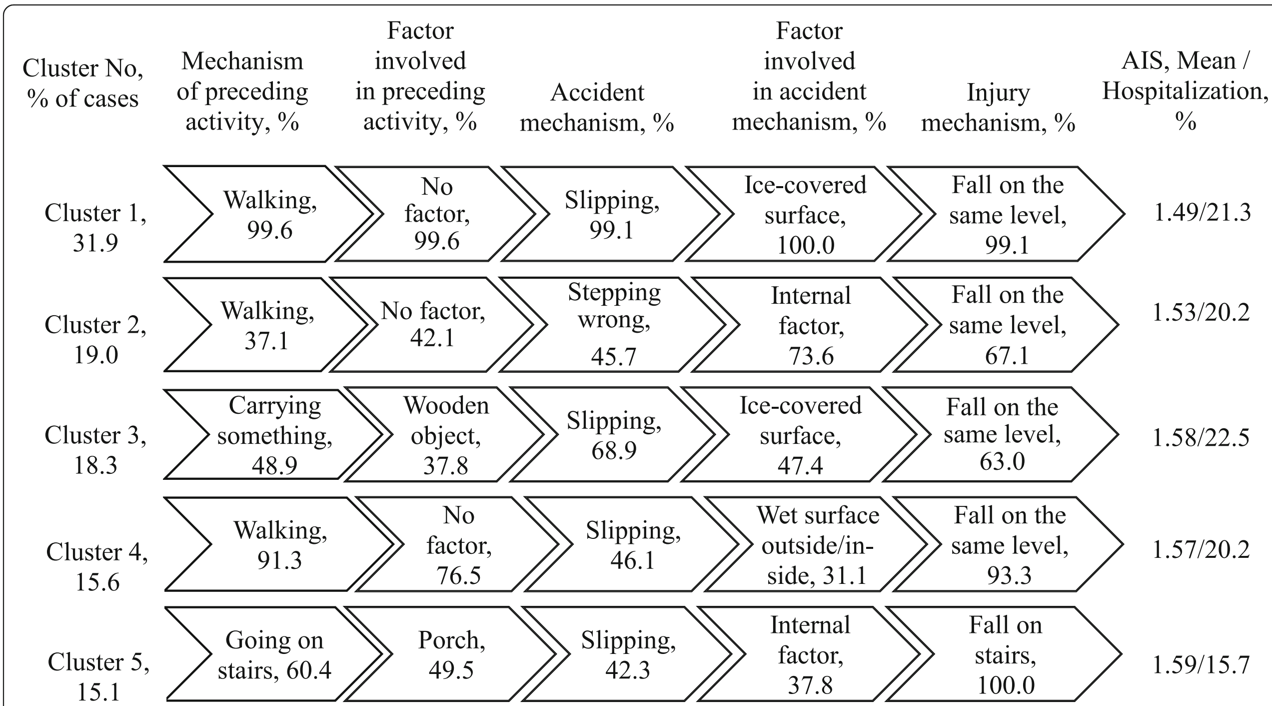

Fig. 3 Clusters of fall injuries, adults 18–59 years, Shenkursk District, January 2015–June 2018 ($N = 736$). Average silhouette = 0.4. AIS: Abbreviated Injury Scale

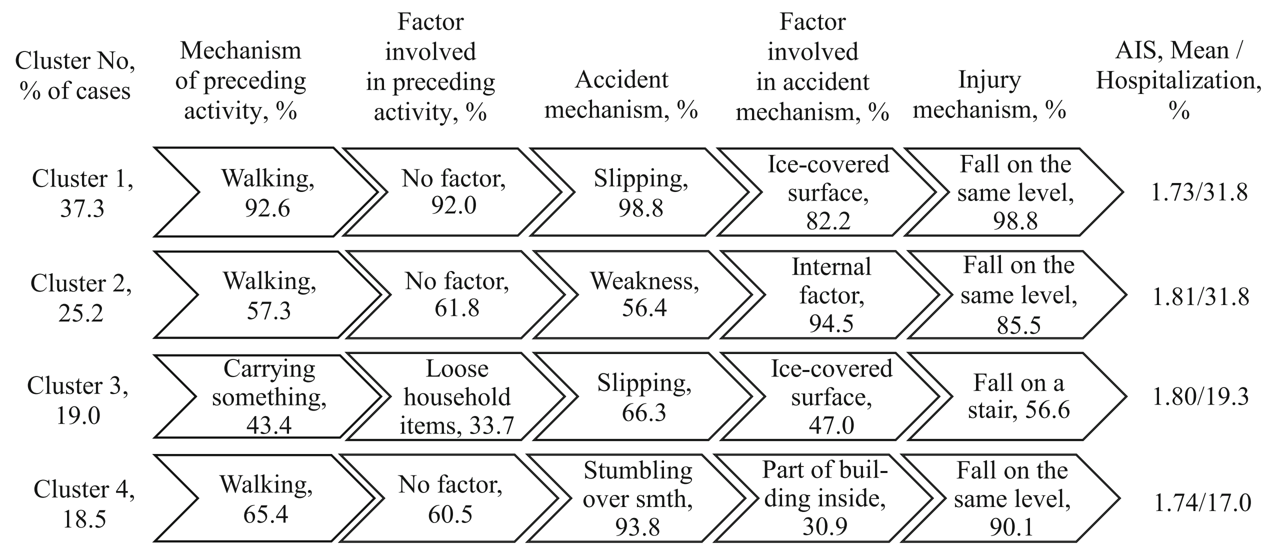

Fig. 4 Clusters of fall injuries, adults 60+ years, Shenkursk District, January 2015–June 2018 ($N = 437$). Average silhouette = 0.5. AIS: Abbreviated Injury Scale

alcohol. Therefore, a reduction in alcohol consumption could prevent a substantial number of fall injuries among adults.

Walking was the most common mechanism of preceding activity for fall injuries among the working and elderly age groups in Shenkursk District, as has been reported in the USA, the Netherlands, Japan, and India (Timsina et al. 2017; Dandona et al. 2010; Bleijlevens et al. 2010; Niino et al. 2000). Inside of a dwelling was the most common fall injury site among the elderly age group in our study, as well as in several studies from Australia and the USA (Peel et al. 2002; Timsina et al. 2017; Talbot et al. 2005). However, for example, in the Netherlands, the majority of falls among the elderly occurred outdoors (Bleijlevens et al. 2010). Our findings indicate that preventing falls among the elderly should primarily be done by addressing the safety of home and near-home environments (removal of slippery surfaces and items which may cause stumbling, installing guardrails, soft floorings) and measures to prevent weakness, dizziness, and loss of balance (proper medication, balance exercises, abstinence from alcohol).

Strengths

This is, to our knowledge, the first Russian registry-based study investigating circumstances of fall injuries. The findings are similar to other studies, but since we failed to identify studies from Russia on this topic, our study adds new information in a cross-national perspective.

The present study was conducted using data from the population-based SHIR, an injury registry covering a defined geographical area. The data were collected using a standard IRF with a free-text field for recording a verbal description of how the injury occurred. These design features should have minimized selection and information biases in the description of the circumstances of fall injuries in the study area. This study also identified clusters of fall injuries in terms of preceding circumstances for each investigated age group, which were described as the most common fall injury circumstances (or “typical fall injury scenarios”), which represents a sensible evidence basis for planning age-specific preventive interventions.

Limitations

The SHIR includes injuries which are treated at the Shenkursk CDH only. Based on our earlier study of completeness, representativeness, and reliability of the SHIR data (Unguryanu et al. 2019), 56% of all injuries in the district occur in rural areas, and 42% of the rural injuries are treated at primary care units. This means that about 20% of total injuries in the district are not treated in the CDH and, therefore, are not covered by the SHIR. Comparisons of rural injuries treated at the CDH to those treated at rural primary care units have shown that more severe cases are more commonly referred to the CDH than minor injuries. Thus, SHIR can be considered representative of all injuries in the district but with a consideration of the possible overrepresentation of severe injuries that occurred in rural areas. The same applies to falls addressed by this paper. However, as the proportion of injuries treated in rural primary health care units is limited to 20%, the bias is minor.

Another methodological consideration is completeness of the SHIR with respect to the coverage of cases treated at the CDH. According to our estimates (Unguryanu et al. 2019), this completeness was 86%. There were no substantial differences between registered and missed injuries in the SHIR by sex, weekday of admission, diagnostic and external cause categories, but missed cases had insubstantially higher proportions of child injuries and injuries in summer time (Unguryanu et al. 2019). However, as the proportion of missed injuries in the SHIR was small and the missed cases were similar to the registered ones, the imperfect completeness of the SHIR should not considerably affect its representativeness for total injuries as well as fall injuries treated at the CDH.

This study summarizes the fall injury panorama in the study area without considering sex differences in circumstances of fall injuries. We observed differences in selected characteristics of fall injuries between men and women, but they were assessed as indecisive for the planning of preventive measures and were therefore omitted.

We did not examine how circumstances of fall injuries in children and adults varied by socioeconomic status, as corresponding data were not available. Previous studies of falls have indicated that people with low socioeconomic status are at an increased risk of fall injuries and injuries in general (Wadhwaniya et al. 2017; Shenassa et al. 2004; Khambalia et al. 2006; Stewart et al. 2015). Logically, the effects of socioeconomic factors on the risk of falls are mediated by higher probabilities of exposures to unsafe environments and risky behaviors, like alcohol abuse and poor parental control. Such factors create fructuous contexts for injury circumstances, and the latter become the most proximate and modifiable factors in the causal chain. For that reason, they make up part of the focus of the data collection for the SHIR and our study.

We did not specifically address seasonal aspects of fall injuries. These require a separate investigation with a focus on fall injuries occurring outdoors. Finally, the results of the study have limited generalizability due to the fact that Shenkursk District is a relatively small area with a cold climate, largely rural characteristics, and a poorly developed infrastructure (low-rise buildings, largely unpaved roads, stove heating, and no tap water in many houses). On the other hand, our findings may be quite applicable in similar rural settings in the North of Russia, which may be considered deprived compared to urban settings.

Conclusion

The circumstances of fall injuries in the study area varied across age groups. Most fall injuries in the preschool age group were due to climbing up on or down from home furnishings, while physical exercise with sport and play equipment were predominant fall circumstances among the school age group. Slipping on ice-covered surfaces was the most frequent fall injury circumstance in the working and elderly age groups. These findings can guide age-specific preventive strategies in the study area and similar settings.

Abbreviations

AIS: Abbreviated Injury Scale; ANOVA: Analysis of variance; CDH: Central district hospital; ICD: International Statistical Classification of Diseases and Related Health Problems; IRF: Injury registration form; SHIR: Shenkursk Injury Registry

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Authors' contributions

TNU, AMG, TAT, BY and AVK substantially contributed to the conception and design of the study. TNU and AVK were involved in acquisition of the data, analysis and interpretation of the data, drafting of the manuscript. AMG performed critical revision and statistical expertise. TAT and BY participated in critical revision. All authors read and approved the final manuscript.

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Availability of data and materials

The anonymized datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The establishment of the SHIR and the corresponding data collection were approved by the Ethics Committee of the Northern State Medical University, Arkhangelsk (protocol 07/10–13 from 09.10.2013). Both medical and non-medical information were collected by the Shenkursk central district hospital which holds the rights to do so through local regulations and informed consent. The protocol for the present study was approved by the Ethics Committee of the Northern State Medical University, Arkhangelsk (protocol 03/04–17 from 27.04.2017). The study has been evaluated by the Norwegian Regional Committees for Medical and Health Research Ethics (REC) (Remit Assessment 2017/1995/REK nord).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Article

Weather Conditions and Outdoor Fall Injuries in Northwestern Russia

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Abstract: This study aimed to investigate associations between the weather conditions and the frequency of medically-treated, non-fatal accidental outdoor fall injuries (AOFIs) in a provincial region of Northwestern Russia. Data on all non-fatal AOFIs that occurred from January 2015 through June 2018 (N = 1125) were extracted from the population-based Shenkursk Injury Registry (SHIR). Associations between the weather conditions and AOFIs were investigated separately for the cold (15 October–14 April) and the warm (15 April–14 October) seasons. Negative binomial regression was used to investigate daily numbers of AOFIs in the cold season, while zero-inflated Poisson regression was used for the warm season. The mean daily number of AOFIs was 1.7 times higher in the cold season compared to the warm season (1.10 vs. 0.65, respectively). The most typical accident mechanism in the cold season was slipping (83%), whereas stepping wrong or stumbling over something was most common (49%) in the warm season. The highest mean daily incidence of AOFIs in the cold season (20.2 per 100,000 population) was observed on days when the ground surface was covered by compact or wet snow, air temperature ranged from −7.0 °C to −0.7 °C, and the amount of precipitation was above 0.4 mm. In the warm season, the highest mean daily incidence (7.0 per 100,000 population) was observed when the air temperature and atmospheric pressure were between 9.0 °C and 15.1 °C and 1003.6 to 1010.9 hPa, respectively. Along with local weather forecasts, broadcasting warnings about the increased risks of outdoor falls may serve as an effective AOFI prevention tool.

Keywords: outdoor fall injuries; injury registry; weather conditions; Shenkursk

1. Background

Falls and fall-related injuries represent a serious health problem worldwide, especially in regions with a cold climate [1–3]. In 2015, age-standardized mortality rates from accidental falls in the Nordic countries and Russia were 1.3 times higher than those for the entire World Health Organization European Region (5.2 per 100,000) [4,5]. Falls are accountable for the largest shares of injury-related deaths and hospitalizations among older adults [6,7], and they are also associated with substantial healthcare expenditures [2,8].

In Northern geographic regions, outdoor falls occur more frequently than indoor falls. Studies carried out in Norway, Sweden, the UK, the USA, and Canada have demonstrated that between 55%

and 62% of falls among middle-aged and older adults occur outdoors [2,9–12]. Streets, sidewalks, and curbs are the most common locations of outdoor falls [7,11,13]. Compared to indoor falls, outdoor falls are associated with a higher level of physical activity [11,14]. A review of prospective observational studies has shown that outdoor falls are more common in elderly people with better health-related parameters like lower body mass index, higher walking speed, and fewer diseases [15]. Moreover, the number of outdoor falls is influenced by environmental hazards, surface irregularities, weather and its seasonal variations [2,11,16,17].

The incidence of fall-related injuries is characterized by the seasonal variation in different geographic regions, including countries with cold climate (Canada, Sweden, Finland, and Norway) [3,13,17,18] and countries with warm and subtropical climate (Taiwan, Spain, Iran, and Hong Kong) [19–22]. Winter-related environmental conditions (low air temperature, snowfalls, and darkness) can cause slipperiness and increased dangerousness of sidewalks and streets [23,24]. Exposure to slippery ground surfaces, such as those covered with ice, melting ice, snow-covered ice, melting snow, and compressed snow is a common attribute of winter-time falls [16,23–25].

The weather conditions of the Russian North can be described as severe, with long, cold winters, sometimes heavy snowfalls, and very strong winds. However, studies investigating the association between weather conditions and outdoor fall injuries at the population level have not been carried out in this region. Knowledge of this association could be used to develop more effective prevention through the creation of risk-reducing environments, as well as through raising population awareness about the risk factors for falls [2,11].

The aim of the study was to investigate associations of weather conditions and the frequency of medically-treated, non-fatal accidental outdoor fall injuries (AOFIs) in a provincial region of Northwestern Russia. An accidental fall injury was defined as "inadvertently coming to rest on the ground, floor or other lower level" (International Classification of Diseases, Revision 10 [ICD-10] codes W00-19) [26]. An outdoor fall was defined as "one occurring outside a dwelling or building" [7,11,14].

2. Methods

2.1. Study Area

The present study was conducted in the Shenkursk District of the Arkhangelsk Region, which is located in Northern European Russia. In 2015, the Shenkursk District had a population of 13,530, which dropped to 12,610 in 2018 [27,28]. The district is largely rural, with 62% of the population living in the countryside. Due to the Northern location of the district (62°06′ N, 42°54′ E), temperatures below zero prevail from October to April [29].

The local economy is based mainly on forestry, woodworking, and agriculture. The street and walkway infrastructure is poorly developed; walkways are largely made of wood or concrete, or have a gravel surface, and street lights are placed only on major streets. Healthcare in the district is provided by one central district hospital (CDH) that has in-patient facilities and out-patient polyclinics and by rural healthcare facilities, including two out-patient clinics and 23 local units served by nurses. Approximately 80% of injuries in the Shenkursk District are treated at the CDH [30].

2.2. Study Population and Injury Data

Data on non-fatal AOFIs were obtained from the Shenkursk Injury Registry (SHIR) for the period from 1 January 2015 through 30 June 2018 [30,31]. The SHIR gathers information on all injuries (ICD-10 codes from S00 to T78) treated at the Shenkursk CDH. Data are collected through the use of a universal injury registration form (IRF)—a two-page sheet with several sections for recording information about injured patients, including socio-demographic characteristics (sex, date of birth, address, place of work or study), information about time and place of injury, alcohol consumption in the 24 h prior to injury, use of protective equipment, and special sections for descriptions of road traffic and sports injuries. The IRF also has a mandatory section in which a free-text description of how the injury occurred is included. This section includes three supportive questions aimed to structure the description of injury circumstances: "What were you doing?", "What went wrong?", and "How were you injured?". The free-text replies to these questions are transformed into categorical variables in the SHIR by trained and calibrated registrars, who define the three corresponding mechanisms (i.e., the mechanism of preceding activity, the accident mechanism, and the injury mechanism) using the appropriate coding lists.

Injured patients who are treated in the Shenkursk CDH are asked to fill out the IRF at their first outpatient or ambulance visit, or within a few days of hospitalization. If necessary, relatives, a nurse, or a physician can help the injured patient complete the IRF. If the IRF is not filled out due to a patient's severe condition or other reasons, injury registrars complete the form retrospectively (about 40% of cases). For that purpose, they use data from routine medical records (ambulance journal, outpatient medical card, case history) and information obtained from the attending physician. Attending physicians have to fill out the concluding part of the IRF, which includes the diagnosis with the corresponding ICD-10 code, injury severity according to the Abbreviated Injury Scale (AIS), and a record on whether the patient was hospitalized. A more detailed description of the SHIR and the IRF can be found elsewhere [30,31].

The SHIR variables used in this study were sex, age, injury localization by ICD-10 code, injury severity according to the AIS, hospitalization (yes, no), day (weekday or weekend) and time of the injury, the mechanism of preceding activity, the accident mechanism, and the injury mechanism.

2.3. Weather Conditions

Data on weather conditions for the period from 1 January 2015 through 30 June 2018 in the Shenkursk District were obtained from the website of the Raspisaniye Pogodi Ltd., St. Petersburg, Russia [32], which includes daily archive records from the Shenkursk weather station. The weather station measures air temperature (°C), atmospheric pressure (hPa), wind speed (m/s), and relative humidity (%) eight times a day (every 3 h); amount of precipitation (mm) per 12 h is measured twice a day (at 6:00 a.m. and 6:00 p.m.; only measurements taken at 6:00 p.m. were used); and ground surface conditions are measured once a day at 6:00 a.m. (dry or moist for the warm season; no snow, covered with loose dry snow, and covered with compact or wet snow for the cold season). All of these variables were used in this study.

Assuming that associations between weather conditions and daily numbers of AOFIs can be non-linear, mean daily air temperature (°C), mean daily atmospheric pressure (hPa), mean daily wind speed (m/s), and mean daily relative humidity (%) were categorized as "low", "medium", or "high" for each season, using the 1st and the 2nd tertiles as cut-off values. The same categorization for each season was used for the amount of precipitation (mm); however, in the warm season, all values below the first tertile were equal to zero. For this reason, the three categories of daily amount of precipitation were labeled as "none", "low", and "medium/high".

2.4. Data Analysis

The associations between the weather conditions and the AOFIs were investigated separately for the cold season (15 October to 14 April) and the warm season (15 April to 14 October). Categorical characteristics of AOFIs are presented as absolute numbers and percentages. Chi-squared tests were used to compare the characteristics of AOFIs in the two seasons.

We applied negative binomial regression for the cold season and zero-inflated Poisson regression for the warm season to model daily numbers of AOFIs, with categorized weather characteristics entered as regressors [33]. The "countfit" function in Stata was used to select the most appropriate models, based on the Akaike Information Criterion and Bayesian Information Criterion [33]. Robust standard errors were calculated for all estimates to adjust for heterogeneity in the models. All two-way interactions between weather condition variables were investigated by entering the corresponding interaction terms into multivariable models. Average percent changes (APCs) with 95% confidence intervals (CIs) were estimated by regression models to assess changes in daily numbers of AOFIs per one-unit change in each independent weather condition variable.

Heat-maps of the daily incidence of AOFIs per 100,000 of the total population of Shenkursk District were built for each season and for combinations of the significant weather predictors. All statistical analyses were performed using STATA v. 16.1 (StataCorp LLC, 2020, College Station, TX, USA).

3. Results

The present study included 651 days of the cold season and 626 days of the warm season. The median air temperature in the cold season was −3.1 °C, and in the warm season, it was 12.2 °C (Table 1). In the warm season, 2.2% of days had a mean daily air temperature <0 °C, while this was the case for 73.1% of days in the cold season. The median atmospheric pressure and amount of precipitation were similar in the two seasons, whereas the median relative humidity was higher in the cold season. Besides, in the cold season, the ground surface was covered with loose dry snow in 64.8% of the total days; it was covered with compact or wet snow in 25.0% of the days (Table 1).

Table 1. Weather conditions in the Shenkursk District by season, 1 January 2015–30 June 2018.

Weather Conditions	Cold Season 15 October–14 April (651 Days)	Warm Season 15 April–14 October (626 Days)
Mean daily air temperature, °C		
Minimum	−39.9	−9.9
1st tertile	−7.0	9.0
Median	−3.1	12.2
2th tertile	−0.6	15.2
Maximum	12.8	31.3
Mean daily atmospheric pressure, hPa		
Minimum	964.2	971.0
1st tertile	1002.2	1003.6
Median	1007.5	1007.6
2th tertile	1013.4	1011.1
Maximum	1048.3	1038.5
Mean daily wind speed, m/s		
Minimum	0.0	0.0
1st tertile	2.4	2.1
Median	2.9	2.5
2th tertile	3.5	2.8
Maximum	10.0	9.0
Mean daily relative humidity, %		
Minimum	20.0	12.0
1st tertile	82.2	65.2
Median	86.0	72.0
2th tertile	88.4	79.1
Maximum	99.0	100.0
Amount of precipitation per 12 h measured at 6:00 p.m., mm		
Minimum	0.0	0.0
1st tertile	0.1	0.0
Median	0.1	0.1
2th tertile	0.4	0.3
Maximum	10.0	14.0
Ground surface condition measured at 6:00 a.m., % of days		
Dry soil	0.0	53.8
Moist soil	10.1	41.1
Loose dry snow	64.8	1.9
Compact or wet snow	25.0	3.2

There were 1125 non-fatal AOFIs recorded in the SHIR in the study period (Table 2). This constituted 21% of all injuries registered in the SHIR for that period and 73% of all accidental fall injuries (indoor and outdoor). The mean daily number of AOFIs in the study period was 0.88, and this number was 1.7 times higher in the cold season compared to the warm season (1.10 vs. 0.65, respectively). Correspondingly, the mean daily incidence of AOFIs in the study period was 6.7 per 100,000 population, 8.4 in the cold season and 5.0 in the warm season. The median daily incidence of AOFIs in the study period was 7.7 per 100,000 population. The distribution of AOFIs by sex, injury severity, proportion of hospitalizations, proportion of AOFIs that occurred on weekends, and by time of day was not significantly different between the two seasons (Table 2). The proportion of AOFIs among children was higher in the warm season ($p < 0.001$), and the proportion of trunk injuries was higher in the cold season ($p = 0.023$). Notably, 12.9% of adults with AOFIs in the cold period and 11.7% in the warm period reported drinking alcohol in the preceding 24 h ($p = 0.774$).

Table 2. Socio-demographic, medical, and temporal characteristics of medically-treated, non-fatal accidental outdoor fall injuries in the Shenkursk District by season, 1 January 2015–30 June 2018.

Characteristics	Cold Season 15 October–14 April, % (*N* = 717)	Warm Season 15 April–14 October, % (*N* = 408)	*p*
Sex, male	48.1	51.7	0.246
Age group, years			<0.001
0–6	1.3	7.4	
7–17	17.6	22.5	
18–59	54.4	45.3	
60+	26.8	24.8	
Injury localization, ICD-10			0.023
S00-09: Head	9.6	10.3	
S10-39: Trunk	21.1	14.2	
S40-69: Upper extremity	40.7	43.1	
S70-99: Lower extremity	28.2	30.9	
Other	0.4	1.5	
Injury severity, AIS			0.816
1 Minor	58.0	56.1	
2 Moderate	31.4	33.1	
3 Severe, but not life-threatening	10.6	10.8	
Hospitalization, yes	10.7	13.2	0.210
Injury occurred on weekend *	29.8	29.4	0.878
Time of injury, hours			0.200
00:00–05:59	4.2	3.7	
06:00–11:59	20.8	18.5	
12:00–17:59	41.8	38.2	
18:00–23:59	26.4	29.6	
Not indicated	6.9	10.1	

* Saturday and Sunday. ICD-10: International Classification of Diseases, Revision 10; AIS: Abbreviated Injury Scale.

The distribution of AOFIs by the mechanism of the preceding activity, accident mechanism, and injury mechanism was significantly different in the two seasons ($p < 0.001$) (Table 3). Walking was a more frequent mechanism of preceding activity in the cold season compared to the warm season (64.7% vs. 45.1%). Such mechanisms of preceding activity as standing and sitting, climbing up/down, and running were more frequent in the warm season. AOFI cases in the warm season who had climbing up/down and running recorded as the mechanism of preceding activity were largely children (13.9% and 27.0% respectively). The most common accident mechanism in the cold season was slipping

(82.7%), while stepping wrong or stumbling over something was the most typical (48.8%) accident mechanism in the warm season. A fall on the same level was the dominating injury mechanism in both seasons, but the proportion of injuries due to falls from a height was relatively higher in the warm season (15.4% vs. 3.5%) (Table 3).

Table 3. Mechanisms of medically-treated, non-fatal accidental outdoor fall injuries in Shenkursk District by season, 1 January 2015–30 June 2018.

Mechanisms	**Cold Season 15 October–14 April, % (*N* = 717)**	**Warm Season 15 April–14 October, % (*N* = 408)**	***p***
Mechanism of preceding activity			<0.001
Walking	64.7	45.1	
Carrying something	10.6	4.9	
Physical exercising	8.1	8.8	
Going on a stairs	7.4	5.6	
Working in a garden	5.2	9.6	
Standing and sitting	2.6	11.3	
Climbing up/down	0.8	5.9	
Running	0.6	8.8	
Accident mechanism			<0.001
Slipping	82.7	27	
Stepping wrong or stumbling over something	7.9	48.8	
Loss of balance and faintness	5.7	14.7	
Other	3.6	9.6	
Injury mechanism			<0.001
Fall on the same level	83.7	71.8	
Fall on a stairs	12.8	12.7	
Fall from a height	3.5	15.4	

The results of univariate regression analyses showed that, in the cold season, daily numbers of AOFIs were associated with air temperature, atmospheric pressure, amount of precipitation, and a ground surface covered by snow (Table 4). Additional regression that used a binary weekend variable (Saturday and Sunday coded as "yes" and other weekdays as "no"; a proxy measure for alcohol consumption) as a regressor was not significant ($p = 0.471$). Multivariable regression for the cold season that included all weather condition variables showed that the highest daily numbers of AOFIs occurred on days when the mean daily air temperature was medium (−7.0 °C to −0.7 °C). Daily numbers of AOFIs were significantly lower on days with high mean daily air temperature (≥−0.6 °C; APC = −29.0%; $p = 0.039$). They were also lower on days with low mean daily air temperature (≤−7.1 °C; APC = −20.7%; $p = 0.058$), but the association did not reach the level of significance. Daily numbers of AOFIs were also significantly higher on days with medium/high precipitation (≥0.4 mm; APC = 24.3%; $p = 0.015$) relative to days with low precipitation (0.1 to 0.3 mm), and on days when the ground surface was covered by compact or wet snow compared to days when the ground surface had no snow (APC = 57.9%; $p = 0.003$) (Table 4). No interactions between independent variables in the cold season were observed.

Table 4. Associations of weather condition variables with daily numbers of medically-treated, non-fatal outdoor accidental fall injuries in the Shenkursk District in the cold season (15 October–14 April).

Weather Conditions	N Days	N Cases	Simple Negative Binomial Regression		Multivariable Negative Binomial Regression *	
			APC, % (95% CI)	*p*	APC, % (95% CI)	*p*
Mean daily air temperature, °C						
Low (≤−7.1)	217	212	−26.7 (−46.9, −6.6)	0.009	−20.7 (−42.0, 0.7)	0.058
Med (−7.0 to −0.7)	217	277	Ref.		Ref.	
High (≥−0.6)	217	228	−20.4 (−41.6, 0.8)	0.072	−29.0 (−56.6, −1.4)	0.039
Mean daily atmospheric pressure, hPa						
Low (≤1002.1)	217	259	1.6 (−19.0, 22.1)	0.882	−1.4 (−21.4, 18.5)	0.888
Med (1002.2 to 1013.2)	217	255	Ref.		Ref.	
High (≥1013.3)	217	203	−22.8 (−43.4, −2.2)	0.03	−15.8 (−36.6, 5.0)	0.137
Mean daily wind speed, m/s						
Low (≤2.3)	233	234	−13.0 (−34.5, 8.4)	0.233	−5.1 (−26.3, 16.1)	0.638
Med (2.4 to 3.4)	208	238	Ref.		Ref.	
High (≥3.5)	210	245	1.9 (−19.1, 23.0)	0.857	−1.2 (−22.5, 20.2)	0.913
Mean daily relative humidity, %						
Low (≤82.1)	219	233	−5.6 (−26.2, 15.0)	0.596	−2.7 (−24.7, 19.2)	0.808
Med (82.2 to 88.3)	216	243	Ref.		Ref.	
High (≥88.4)	216	241	−0.8 (−21.6, 19.9)	0.938	−11.0 (−31.6, 9.6)	0.293
Amount of precipitation per 12 h measured at 6:00 p.m., mm						
No (0.0)	176	186	10.0 (−11.3, 31.3)	0.359	6.2 (−15.5, 28.0)	0.574
Low (0.1 to 0.3)	252	241	Ref.		Ref.	
Med/High (≥0.4)	223	290	30.7 (10.9, 50.6)	0.002	24.3 (4.7, 43.8)	0.015
Ground surface condition measured at 6.00 a.m.						
No snow	66	47	Ref.		Ref.	
Loose dry snow	422	453	41.0 (6.2, 75.8)	0.021	26.7 (−14.4, 67.8)	0.203
Compact/wet snow	163	217	62.6 (25.2, 100.0)	0.001	57.9 (20.1, 95.6)	0.003

* Constant = −6.1 (95% CI: −49.9, 37.6), $p = 0.783$ N: number; APC: average percent change; CI: confidence interval.

In the warm season, the results of univariate regression analyses showed that daily numbers of AOFIs were associated with air temperature and atmospheric pressure (Table 5). The model that included the binary weekend variable rendered insignificant results ($p = 0.848$), as was the case in the cold season. Multivariable regression for the warm season that included all weather condition variables showed that daily numbers of AOFIs were significantly lower on days with high mean daily air temperature (≥15.2 °C; APC = −15.3%; $p = 0.034$) compared to days with medium air mean daily temperature (9.0 °C to 15.1 °C). Additionally, the daily numbers of AOFIs were lower on days with low mean daily atmospheric pressure (≤1003.5 hPa; APC = −15.7%; $p = 0.015$) relative to days with medium mean daily atmospheric pressure (1003.6 to 1010.9 hPa). The testing of two-way interactions between weather condition variables in the warm season detected modifications of the association between mean daily relative humidity and AOFIs by the daily amount of precipitation ($p = 0.048$) and by the ground surface condition ($p = 0.045$). The two corresponding interaction terms were entered into the final multivariable regression model and both sustained statistical significance. Additional stratified analysis of the associations between the mean daily relative humidity and daily AOFI numbers by the daily amount of precipitation and ground surface conditions (not presented) showed that low relative humidity had associations with smaller AOFI numbers (analysis of 56 observations; $p < 0.001$) only when the precipitation was low and soil was dry, while high relative humidity had associations with larger AOFI numbers when there was no precipitation but the soil was moist (114 observations; $p = 0.018$).

According to the heat-map of AOFI incidence, which included only the weather condition variables that reached statistical significance in multivariable regression models (Figure 1), the highest incidence of AOFIs (20.2 per 100,000 population) was observed during the cold season on days when the ground surface was covered by compact or wet snow, there was a medium mean daily air temperature (−7.0 °C to −0.7 °C), and there was medium/high precipitation (≥0.4 mm). The heat-map shows that the AOFI incidence in the warm season was substantially lower than that in the cold season. The relatively high AOFI incidence (7.0 per 100,000 population) in the warm season occurred on days with medium mean daily air temperature (9.0 °C to 15.1 °C) and medium atmospheric pressure (1003.6 to 1010.9 hPa).

Table 5. Associations of weather condition variables with daily numbers of medically-treated, non-fatal accidental outdoor fall injuries in the Shenkursk District in the warm season (15 April–14 October).

Weather Conditions	N Days	N Cases	Simple Zero-Inflated Poisson Regression		Multivariable Zero-Inflated Poisson Regression *	
			APC,% (95% CI)	*p*	APC,% (95% CI)	*p*
Mean daily air temperature, °C						
Low (≤8.9)	210	123	−3.9 (−16.5, 8.7)	0.544	−0.8 (−14.4, 12.8)	0.906
Med (9.0 to 15.1)	208	161	Ref.		Ref.	
High (≥15.2)	208	124	−14.2 (−27.1, −1.3)	0.030	−15.3 (−29.5, −1.1)	0.034
Mean daily atmospheric pressure, hPa						
Low (≤1003.5)	209	136	−13.8 (−26.6, 0.1)	0.035	−15.7 (−28.4, −3.1)	0.015
Med (1003.6 to 1010.9)	210	144	Ref.		Ref.	
High (≥1011)	207	128	−5.3 (−18.3, 7.8)	0.429	−6.0 (−19.6, 7.5)	0.382
Mean daily wind speed, m/s						
Low (≤2.0)	*218*	*141*	*1.9 (−11.0, 14.7)*	*0.779*	*0.6 (−13.3, 14.5)*	*0.935*
Med (2.1 to 2.7)	202	137	Ref.		Ref.	
High (≥2.8)	206	130	0.0 (−12.9, 13.0)	0.994	−1.4 (−14.5, 11.7)	0.834
Mean daily relative humidity, %						
Low (≤65.1)	211	136	2.9 (−10.5, 16.3)	0.676	−4.6 (−35.3, 26.0)	0.766
Med (65.2 to 79.0)	208	128	Ref.		Ref.	
High (≥79.1)	207	144	3.4 (−9.6, 16.4)	0.604	−12.6 (−68.9, 43.7)	0.661
Amount of precipitation per 12 h measured at 6:00 p.m., mm						
No (0.0)	294	195	4.6 (−10.0, 19.1)	0.535	−6.8 (−24.9, 11.4)	0.464
Low (0.1 to 0.2)	129	80	Ref.		Ref.	
Med/High (≥0.3)	203	133	2.5 (−12.9, 18.0)	0.747	−17.2 (−45.0, 10.7)	0.227
Ground surface condition measured at 6.00 a.m.						
Dry	337	233	Ref.		Ref.	
Moist	257	153	−4.9 (−16.0, 6.2)	0.389	4.7 (−11.1, 20.5)	0.561
Loose dry snow	12	8	10.0 (−17.8, 37.9)	0.480	29.8 (−3.3, 62.9)	0.077
Compact/wet snow	20	14	−3.3 (−26.2, 19.6)	0.777	24.5 (−3.6, 52.7)	0.088
Mean daily relative humidity * Amount of precipitation per 12 h					9.1 (−0.2, 18.1)	0.045
Mean relative humidity * Ground surface condition					−10.2 (−19.9, −0.5)	0.039

* constant = 54.0 (95% CI: 28.7, 79.2), $p < 0.001$. N: number; APC: average percent change; CI: confidence interval.

Compact/wet snow, 15 October–14 April

Mean daily air temperature, °C		Amount of precipitation per 12 h measured at 6.00 p.m., mm		
		No	Low 0.1 to 0.3	Med/high ≥0.4
	Low ≤−7.1	n.a.*	n.a.	n.a.
	Med −7.0 to −0.7	13.8	9.2	20.2
	High ≥−0.6	9.2	7.5	10.3

Loose dry snow, 15 October–14 April

Mean daily air temperature, °C		Amount of precipitation per 12 h measured at 6.00 p.m., mm		
		No	Low 0.1 to 0.3	Med/high ≥0.4
	Low ≤−7.1	6.9	7.1	8.1
	Med −7.0 to −0.7	7.9	8.0	11.1
	High ≥−0.6	9.8	7.7	6.9

No snow, 15 October–14 April

Mean daily air temperature, °C		Amount of precipitation per 12 h measured at 6.00 p.m., mm		
		No	Low 0.1 to 0.3	Med/high ≥0.4
	Low ≤−7.1	n.a.	n.a.	n.a.
	Med −7.0 to −0.7	1.9	5.7	3.8
	High ≥−0.6	3.4	5.5	8.2

15 April–14 October

Mean daily air temperature, °C		Mean daily atmospheric pressure, hPa		
		Low ≤1003.5	Med 1003.6 to 1010.9	High ≥1011
	Low ≤8.9	4.8	4.4	4.3
	Med 9.0 to 15.1	5.3	7.0	5.5
	High ≥15.2	4.7	4.6	4.4

0.0–4.9 | 5.0–9.9 | 10.0–14.9 | 15.0–19.9 | ≥20.0

Figure 1. Heat-map of the mean daily incidence (per 100,000 population) of medically-treated, non-fatal accidental outdoor fall injuries in the cold season (15 October–14 April) according to ground-surface conditions, mean daily air temperature, and amount of precipitation per 12 h measured at 6.00 p.m. and in the warm season (15 April–14 October) according to mean daily air temperature and mean daily atmospheric pressure; Shenkursk District, 1 January 2015–30 June 2018. * Mean is not calculated due to lacking observations. N.a.: not applicable.

4. Discussion

To the best of our knowledge, this is the first Russian registry-based study investigating the associations between weather conditions and medically-treated, non-fatal AOFIs in Northwestern Russia. The results demonstrate that the mean daily number of AOFIs in the cold season was 70% higher than that in the warm season. In the cold season, daily numbers of AOFIs were independently associated with air temperature, amount of precipitation, and ground surface conditions. Days that had a combination of air temperature between −7.0 °C and −0.7 °C, 2, an amount of precipitation above 0.4 mm, and a ground surface covered with compact or wet snow were described as the most "risky days" with respect to AOFIs. In the warm season, daily numbers of AOFIs were independently associated with air temperature and atmospheric pressure. The highest AOFI incidence was observed on days with an air temperature between 9.0 °C and 15.1 °C, and an atmospheric pressure between

1003.6 to 1010.9 hPa. However, the highest incidence of AOFIs observed in the warm season was substantially lower than that observed in the cold season.

Adults of working age made up the largest proportion of cases of medically-treated non-fatal AOFIs in the Shenkursk District. However, the proportion of AOFIs in children was greater in the warm season compared to the cold season. Similarly, a study from the UK found that the number of pediatric admissions with injuries and fractures increased in the summer period [34]. This can be explained by the fact that, in the warm season, children have more spare time. They are more often outside, and thus are more likely to fall outdoors.

The seasonal variation in AOFIs that we observed in the Shenkursk District is in accordance with studies carried out both in the Nordic countries and in countries with a warm climate. In Norway, Finland, Sweden, and Canada, the distribution of fall-related injuries and fractures varied by season and had a higher occurrence during the winter months [2,3,17,18,35,36]. For example, in three urban areas in Norway (Stavanger, Trondheim, and Harstad) the incidence rate of arm fractures among older adults was 69% higher during the colder season compared with the warmer season [17]. A study conducted in northern Sweden showed that most of the fall injuries (81%) in public outdoor environments among pedestrians 65 years and older occurred during the winter period (November to April) [2]. Even studies in Hong Kong and Taiwan demonstrated an increasing likelihood of outdoor falls in the winter months, even though the winter temperatures in these countries are well above 0 °C [19,22]. In the Nordic countries, falls occur more often in the cold season because of hazardous winter-related environmental conditions and biological factors, such as a general weakening of the body due to non-optimal vitamin D status [17,36–39]. However, the evidence about the association between vitamin D and falls or fractures is inconclusive [40]. A meta-analysis by Bolland et al. [41] has not shown a preventive effect of vitamin D on fractures or falls while Bischoff-Ferrari et al. [42] has demonstrated a reduction in the total number of fractures and falls by 14% and 12%, respectively, due to consumption of 800–1000 IU vitamin D daily.

Air temperature is a well-known meteorological risk factor for outdoor falls. Many studies have shown an association between below-zero temperatures and a higher incidence of fall-related fractures [2,18,25,35]. In our study, the highest risks of AOFIs were observed on days with an air temperature between −7.0 °C and −0.7 °C. These may be considered relatively comfortable winter temperatures in which people are more likely to participate in outdoor activities compared to colder days, as well as compared to days when temperatures rise above zero and it becomes wet. In addition, De Koning et al. [43] described that the minimum friction coefficient occurs when the ice surface temperature is between −6 °C and −9 °C, which is that the worst outdoor temperature interval for walking outside, as that is when slip and fall accidents are most likely [44]. Contrary to that, a study from Finland described that the incidence of outdoor falls among elderly people was 3.4 times higher when the temperature was below −20 °C than when it was between −10 °C and 0 °C [35]. That means that associations between AOFIs and weather conditions can vary in different settings, even if they have a similar climate. This may be due to different outdoor environments, or varying traditions of outdoor activities in the winter time. This also outlines the importance of using local injury data when planning preventive activities [45].

Ice and snow are well-known causes of fall-related injuries. In the present study, a ground surface covered by loose dry snow or compact/wet snow increased daily numbers of AOFIs in the cold season by 41% and 63%, respectively, compared with days when the ground surface had no snow. A study performed in Canada found a significant, positive correlation (r = 0.33–0.60; $p < 0.001$) between snow depth and the number of snowy days and hip fractures for all age groups and sexes [18]. The city of Philadelphia, Pennsylvania in the USA also recorded increases in fall-related patient visits after snow and ice storms [46].

In the cold season, walking was the most common mechanism of activity preceding an AOFI (65%) in the Shenkursk District, while slipping was the most common accident mechanism (83%). Similar results were obtained in Umeå, Sweden, where 85% of persons injured due to slipping on ice or snow and falling outdoors were walking before the accident [13]. The results from a Finnish study showed that the number of fractures on slippery winter days and on the days immediately following was 2.5 times higher compared to non-wintertime (April 16 to October 15) [3]. During a snow crisis in Iran, slipping was the most common injury mechanism, and the frequency of injuries on icy days was 32.4% higher than that on snowy days [21].

We found that "the riskiest days" in terms of AOFIs in the cold season were the days with a combination of medium air temperature, medium/high precipitation, and a ground surface covered with compact or wet snow. The importance of describing these "high-risk combinations" of weather characteristics has been outlined in other studies. For example, Lépy et al. [24] described six winter scenarios with respect to slippery conditions and identified the most common scenario of slipperiness to be a combination of relative humidity above 95%, surface temperature below 0 °C, and a surface temperature lower than the dewpoint. This type of slipperiness accounted for 50% of injuries. Morency et al. also showed that a combination of below-zero temperatures, snowfalls, and freezing rain leads to excess cases of outdoor falls [25].

Our study demonstrated that, in the warm season, a higher frequency of AOFIs was observed on days with medium air temperature and medium atmospheric pressure. Previous studies of falls have scarcely addressed the role of atmospheric pressure, and only a few reported that atmospheric pressure has an effect on the incidence of hip fractures and trauma admissions [19,20]. However, it is known that low atmospheric pressure can cause headaches, a feeling of dizziness and decreases in blood pressure among weather-sensitive people [47–49]. The association between dizziness and falls among middle-aged adults was found by Peeters et al. [50] during the analysis of data from population-based cohort studies in Australia and the UK. One possible explanation for the phenomenon observed in our study is that days with average air temperatures and atmospheric pressures may be the most comfortable for outdoor activities, and thus the higher incidence could be due to higher outdoor exposure.

As the incidence of AOFIs in the Shenkursk District is the highest in the cold season and slipping is the most common accident mechanism, our study suggests that efforts to prevent AOFIs should primarily target the problem of icy ground surfaces. The common approaches are spreading anti-slip materials (sand, salt, gravel) on walkways and using slip-resistant footwear. The latter may be a feasible solution for a rural setting. Protective effects of gait-stabilizing and anti-slip devices in the winter season were demonstrated in earlier studies [51,52]. In addition to these standard approaches, it may be helpful to inform people about the increased risks when such risks are expected. For that purpose, our descriptions of "high-risk days" can supplement regular weather forecasts, thus increasing people's awareness of the increased risks of outdoor falls on days when the prognoses fit the described high-risk combinations of weather conditions. For example, regional agencies for civil defense and emergencies in Russia inform people by short message service (SMS) about inclement weather, like strong winds and snowstorms. Based on the results of this study and local weather forecasts, SMS warnings about the higher risks of outdoor falls may also become an effective AOFI prevention tool. Such messages may also support local decision making with respect to the timely initiation of snow and ice removal and the application of anti-friction materials on walkways.

The strengths of this study are its population-based design and the geographically defined area. Given the weather and other environmental and socioeconomic contexts in the Shenkursk District are similar to those of other rural settings in Northern Russia and in other northern countries, our findings may be applicable beyond the study area. Another strength is the use of data from a registry with high coverage and representativeness of the total injuries in the district [30]. Finally, we analyzed only AOFIs, while many other studies of seasonal variation in falls did not separate outdoor and indoor fall injuries, even though they have different characteristics [3,17,18,53].

A possible limitation of our study is that the SHIR included only AOFIs that were medically treated at the CDH. Therefore, our results may be less applicable to people with mild AOFI who did not seek medical care.

In this study, we analyzed AOFIs without stratification by sex and age, although some variation in the effect of weather conditions on the incidence of AOFIs is possible by age and sex. This study should be replicated either in a larger population or over a longer period in order to obtain a more detailed age- and sex-specific analysis.

As the study has an ecological design, the outcome variable in our analyses was the daily number of AFOIs, and a calendar day was the unit of observation. This design did not allow us to control for possible behavioral factors on an individual level, e.g., alcohol consumption [54,55]. We tried testing and saw no association between the weekend variable (Saturday and Sunday vs. weekdays) as a proxy for alcohol consumption and the number of AOFIs. Moreover, factors like alcohol consumption are unlikely to be associated with the weather conditions that we identified as being associated with AOFIs. Therefore, confounding from alcohol consumption is unlikely.

5. Conclusions

The AOFIs in the Shenkursk District occurred more often in the cold season than in the warm season. A combination of low air temperature, medium/high precipitation, and a ground surface covered with compact or wet snow were the attributes of days with higher risks of AOFIs in the cold season. In the warm season, the numbers of AOFIs were higher on days with medium air temperature and atmospheric pressure. Larger-scale future research is required to study the impacts of weather conditions on the frequency of AOFIs by age and sex.

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Ethics Approval and Consent to Participate: The establishment of the SHIR and the corresponding data collection were approved by the Ethics Committee of the Northern State Medical University, Arkhangelsk (protocol 07/10–13 from 09.10.2013). Both medical and nonmedical information were collected by the Shenkursk central district hospital, which holds the rights to do so through local regulations and informed consent. The protocol for the present study was approved by the Ethics Committee of the Northern State Medical University, Arkhangelsk (protocol 03/04–17 from 27.04.2017). The study has been evaluated by the Norwegian Regional Committees for Medical and Health Research Ethics (49) (Remit Assessment 2017/1995/REK nord).

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ICD-10: Chapter XIX "Injury, poisoning and certain other consequences of external causes (S00 − T98)"

Codes	Types of injuries
S00 – S09	Injuries to the head
S10 – S19	Injuries to the neck
S20 – S29	Injuries to the thorax
S30 – S39	Injuries to the abdomen, lower back, lumbar spine and pelvis
S40 – S49	Injuries to the shoulder and upper arm
S50 – S59	Injuries to the elbow and forearm
S60 – S69	Injuries to the wrist and hand
S70 – S79	Injuries to the hip and thigh
S80 – S89	Injuries to the knee and lower leg
S90 – S99	Injuries to the ankle and foot
T00 – T07	Injuries involving multiple body regions
T08 – T14	Injuries to unspecified part of trunk, limb or body region
T15 – T19	Effects of foreign body entering through natural orifice
T20 – T32	Burns and corrosions
T33 – T35	Frostbite
T36 – T50	Poisoning by drugs, medicaments and biological substances
T51 – T65	Toxic effects of substances chiefly nonmedicinal as to source
T66 – T78	Other and unspecified effects of external causes
T79 – T79	Certain early complications of trauma
T80 – T88	Complications of surgical and medical care, not elsewhere classified
T90 – T98	Sequelae of injuries, of poisoning and of other consequences of external causes

ICD-10: Chapter XX "External causes of morbidity and mortality (V01 − Y98)"

Codes	Types of injuries
V01 – V99	Transport accidents
W00 – W19	Falls
W20 – W49	Exposure to inanimate mechanical forces
W50 – W64	Exposure to animate mechanical forces
W65 – W74	Accidental drowning and submersion
W75 – W84	Other accidental threats to breathing
W85 – W99	Exposure to electric current, radiation and extreme ambient air temperature and pressure
X00 – X09	Exposure to smoke, fire and flames
X10 – X19	Contact with heat and hot substances
X20 – X29	Contact with venomous animals and plants
X30 – X39	Exposure to forces of nature
X40 – X49	Accidental poisoning by and exposure to noxious substances
X50 – X57	Overexertion, travel and privation
X58 – X59	Accidental exposure to other and unspecified factors
X60 – X84	Intentional self-harm
X85 – Y09	Assault
Y10 – Y34	Event of undetermined intent
Y35 – Y36	Legal intervention and operations of war
Y40 – Y84	Complications of medical and surgical care
Y85 – Y89	Sequelae of external causes of morbidity and mortality
Y90 – Y98	Supplementary factors related to causes of morbidity and mortality classified elsewhere

Shenkursk central district hospital named after N.N. Priorov

INJURY REGISTRATION FORM

(including burns, frostbites, poisonings and other exposures of external causes)

№ ________

It is completed by a patient (injured), his close relative or a health worker accepting a patient. The data relating only to an injured person are specified.

Surname, name, patronymic:	**Sex:** F ☐ M ☐	**Date of birth:**	Day	Month	Year
Address of permanent residence place:					
Place of work / study: (underline as appropriate)		**Contact telephone number:**			

Date of form completing:	Day	Month	Year	**Date of first seeking for medical care:**	Day	Month	Year

Where you have sought for medical care?
☐ In policlinic, appointment to surgeon
☐ In emergency medical care department
☐ Other, specify: ....

Where you were injured? (address, room, place, as far as possible in more detail)

When you were injured?	Day	Month	Year	Time, hours : minutes (format - 24 hours) :	**Were you injured during agricultural works?** ☐ Yes ☐ No

Was the injury sustained during:
☐ on the way to work or from work
☐ paid job
☐ on the way to study or from study
☐ Study
☐ Other, specify:
....
....

Was the injury connected with sport activities or physical trainings?
☐ Yes - >>> answer the second question in this block
☐ No - >>> come to the following block of questions

Specify a type of sport trainings:
☐ Sport trainings in the school (or in other educational institution)
☐ Sport trainings in at the enterprise
☐ Organized sport activities, trainings (sport groups and the like)
☐ Unorganized sports activities, physical culture, trainings

Was the injury as a result of RTA?
☐ Yes - >>> answer the other questions in this block
☐ No - >>> come to the following block of questions

Specify your category of the traffic participant:
☐ Pedestrian
☐ Driver
☐ Passenger, front seat
☐ Passenger, back seat
☐ Passenger in a bus
☐ Other, specify:
....
....
....

What transport vehicle did you use at the time of RTA?
☐ Went on foot
☐ Bicycle
☐ Moped
☐ Scooter
☐ Motorcycle
☐ Car
☐ Lorry
☐ Van
☐ Bus
☐ Tractor
☐ Other, specify:
....
....

Was a collision with other transport vehicle or a person?
☐ No
☐ With pedestrian
☐ With bicycle
☐ With moped
☐ With scooter
☐ With motorcycle
☐ With car
☐ With lorry
☐ With van
☐ With bus
☐ With tractor
☐ Other, specify:
....
....

Did you apply the personal protective equipment, any safety control or protective measures at the time of sustained injury?
☐ No, didn't apply
☐ Safety belt (in car)
☐ Airbag (in car)
☐ Other, specify, what was applied:
....
....

Has been a first medical aid provided to you before your arrival in the hospital? Whom?
☐ No
☐ Yes, by relatives
☐ Yes, by the staff of ambulance
☐ Other, specify: ....

Describe as it is possible in more detail a situation and circumstances of sustained injury

What were you doing?

(your activities, participating objects, things, external factors, circumstances)

What has gone not so?

(occurrence of a dangerous situation: participating objects, things, external factors, circumstances)

How did the injury sustain?

(mechanism of injury: participating objects, things, external factors, circumstances)

....
....
....
....
....
....
....
....
....
....

Were you drinking alcohol during 24 hours before injury?	☐ Yes - >>> answer the second question in this block ☐ No - >>> filling of the form is completed
If you have answered "yes" the previous question, specify, for how many hours before injury did you drink alcohol last time?	For .... hour / hours

Thanks for the help! Further the form is filled by a doctor.

Diagnosis:	**Code ICD-10:**

Reason of treatment: ☐ Accident ☐ Fight, applying of physical strength ☐ Intentional self-injury ☐ There are no data

Assessment of injury severity according to the AIS: (see description below)	☐ **1**	☐ **2**	☐ **3**	☐ **4**	☐ **5**	☐ **6**
	Minor	Moderate	Severe, but not life-threatening	Severe, potentially life-threatening	Critical, with uncertain survival	Unsurvivable

Hospitalization: ☐ Yes ☐ No	**Date of filling:** «____» ______________20____ **Signature of a doctor:** ________________ /_____________________________/

Classification injuries by severity according to the scale AIS

Short injury scale (Abbreviated Injury Scale, AIS) is classification of injuries by level of the threat to patient's life associated with the injury. This scale has got international recognition and is especially widely used in automotive medicine. Poisonings do not include in AIS scale, but in the description provided below are given in the corresponding categories.

1. Minor:	1st and 2nd degree burns involving before 10% of body surface area. Cerebral injury, but no loss of consciousness. Poisoning which isn't demanding treatment. Injuries of teeth. Minor abrasions and contusions. Dislocations and fractures of digits.
2. Moderate:	3rd degree burns involving 1-5% of body surface area. Cerebral injury with less than 15 minutes unconsciousness. Poisoning which is treated by gastric lavage and demands observation without hospitalization. Abrasions and tissue ruptures before 10 cm. Undisplaced long bone, pelvic or skull fractures. Multiple fractures of digits.
3. Severe, but not life-threatening:	3rd degree burns involving 5-30% of body surface area. Cerebral injury and poisoning with more than 15 minutes unconsciousness and brief post-traumatic amnesia (less than 3 hours) with hospitalization. Abrasions and laceration more 10 cm. Multiple rib fractures. Pneumothorax. Dislocation of major joints. Displaced simple long bone fractures. Laceration of the major nerves or vessels of extremities.
4. Severe, potentially life-threatening:	3rd degree burns involving 30-40% of body surface area. Cerebral injury and poisoning with more than 15 minutes unconsciousness and post-traumatic amnesia more than 3-12 hours. Large and multiple abrasions and laceration. Flail chest. Multiple and open fractures. Amputation of limbs.
5. Critical, with uncertain survival:	3rd degree burns involving 40-80% of body surface area. Cerebral injury and poisoning with unconsciousness of more than 24 hours. Intracranial hemorrhage. Spine injuries with tetraplegia. Chest injuries with major respiratory embarrassment. Multiple open limb fractures.
6. Unsurvivable:	Maximal possible injury, which has brought or will probably lead to death.

Шенкурская центральная районная больница им. Н.Н. Приорова

ЛИСТ УЧЁТА ТРАВМ

№ ______

(включая ожоги, обморожения, отравления и иные воздействия внешних причин)

Заполняется пациентом (травмированным), его близким родственником или принимающим пациента медицинским работником. Указываются сведения, относящиеся только к лицу, получившему травму.

Ф.И.О.:	**Пол:** Ж ☐ М ☐	**Дата рождения:**	День	Месяц	Год

Адрес места постоянного жительства:

Место работы / учёбы: (подходящее подчеркнуть)	**Контактный телефон:**

Дата заполнения формы:	День	Месяц	Год	**Дата первого обращения за медицинской помощью:**	День	Месяц	Год

Куда вы обратились за медицинской помощью?
☐ В поликлинику, на прием к хирургу
☐ В службу скорой помощи
☐ Иное, укажите: ....

Где получена травма? (адрес, помещение, место, как можно подробнее)

Когда получена травма?	День	Месяц	Год	Время, часы : минуты (формат - 24 часа) :	**Травма получена во время сельскохозяйственных работ?** ☐ Да ☐ Нет

Травма получена во время:
☐ Пути на работу или с работы
☐ Пути на учёбу или или с учёбы
☐ Иное, укажите: ....
☐ Оплачиваемой работы
☐ Учёбы

Травма связана с занятиями спортом, тренировками или занятиями физкультурой?
☐ Да - >>> ответьте на 2й вопрос в этом блоке
☐ Нет - >>> переходите к следующему блоку вопросов

Укажите вид спортивных занятий:
☐ Занятия спортом в школе (или в ином учебном заведении)
☐ Организованные занятия спортом, тренировки (спортивные секции и т.п.)
☐ Спортивные занятия на предприятии
☐ Неорганизованные занятия спортом, физкультурой, тренировки

Травма получена в результате ДТП?
☐ Да - >>> ответьте на остальные вопросы в этом блоке
☐ Нет - >>> переходите к следующему блоку вопросов

Укажите вашу категорию участника дорожного движения:
☐ Пешеход
☐ Водитель
☐ Пассажир, переднее сиденье
☐ Пассажир, заднее сиденье
☐ Пассажир автобуса
☐ Иное, укажите: ....

Какое транспортное средство вы использовали в момент ДТП?
☐ Передвигался пешком
☐ Велосипед
☐ Мопед
☐ Скутер
☐ Мотоцикл
☐ Легковой автомобиль
☐ Грузовой автомобиль
☐ Фургон
☐ Автобус
☐ Трактор
☐ Иное, укажите: ....

Имело место столкновение с другим транспортным средством или человеком?
☐ Нет
☐ С пешеходом
☐ С велосипедом
☐ С мопедом
☐ Со скутером
☐ С мотоциклом
☐ С легковым автомобилем
☐ С грузовым автомобилем
☐ С фургоном
☐ С автобусом
☐ С трактором
☐ Иное, укажите: ....

В момент получения травмы вами применялись индивидуальные средства защиты, какое-либо защитное оборудование или какие-либо меры безопасности?
☐ Нет, не применялись
☐ Ремень безопасности (в автомобиле)
☐ Подушки безопасности (в автомобиле)
☐ Иное, укажите, что именно применялось: ....

До прибытия в больницу вам была оказана первая медицинская помощь? Кем?
☐ Нет
☐ Да, родственниками
☐ Да, сотрудниками скорой помощи
☐ Иное, укажите: ....

Опишите как можно подробнее ситуацию и обстоятельства получения травмы

Чем вы занимались? ....

(ваши действия, участвующие объекты, предметы, внешние факторы, обстоятельства) ....

....

Что пошло не так? ....

(возникновение опасной ситуации: участвующие объекты, предметы, внешние факторы, обстоятельства) ....

....

Как была получена травма? ....

(механизм получения травмы: участвующие объекты, предметы, внешние факторы и обстоятельства) ....

....

....

Вы употребляли алкоголь в течение 24 часов, предшествующих получению травмы?

☐ Да - >>> ответьте на 2й вопрос в этом блоке

☐ Нет - >>> заполнение формы завершено

Если вы ответили «да» на предыдущий вопрос, укажите, за сколько часов до получения травмы вы принимали алкоголь в последний раз? За .... часа / часов

Спасибо за помощь! Далее форма заполняется врачом.

Диагноз:

Код МКБ-10:

Причина обращения: ☐ Несчастный случай ☐ Драка, применение физической силы ☐ Намеренное самоповреждение ☐ Нет сведений

Оценка тяжести травмы по шкале AIS:

(см. описание ниже)

☐ **1** Лёгкая

☐ **2** Значительная

☐ **3** Тяжёлая, без угрозы для жизни

☐ **4** Тяжёлая, с угрозой для жизни

☐ **5** Критическая, с сомнительным выживанием

☐ **6** Летальная

Госпитализация: ☐ Да ☐ Нет

Дата заполнения: «____» ______________20____

Подпись врача: ________________ /______________________________/

Классификация степени тяжести травм по шкале AIS

Сокращённая шкала травм (Abbreviated Injury Scale, AIS) является классификацией травм по степени их угрозы для жизни пациента. Данная шкала получила международное признание и особенно широко используется в автодорожной медицине. Отравления не входят в шкалу AIS, но в приведённом ниже описании приведены в соответствующих категориях.

1. Лёгкая:	Ожог 1 степени и ожог 2 степени до 10 % тела. Черепно-мозговые травмы без потери сознания. Отравление, не требующее лечения. Травмы зубов. Незначительные порезы и ушибы. Дислокации и переломы пальцев рук и ног.
2. Значительная:	Ожог 3 степени от 1 до 5% поверхности тела. Черепно-мозговые травмы с потерей сознания менее 15 минут. Отравление, которое лечится опустошением желудка, и требует наблюдения без госпитализации. Порезы и разрывы тканей менее 10 см. Переломы длинных костей, таза и черепа без смещения. Раздробление пальцев рук и ног.
3. Тяжёлая, без угрозы для жизни:	Ожог 3 степени от 5 до 30% поверхности тела. Черепно-мозговые травмы, включая отравления с потерей сознания более 15 минут и амнезия менее 3 часов с госпитализацией. Порезы и разрывы тканей более 10 см. Множественные переломы рёбер. Пневмоторакс. Вывихи крупных костей. Переломы длинных костей со смещением. Повреждения нервов или сосудов в конечностях.
4. Тяжёлая, с угрозой для жизни:	Ожог 3 степени от 30 до 40% поверхности тела. Черепно-мозговые травмы включая отравления с потерей сознания более 15 минут и амнезией более 3 часов. Большие и множественные порезы и разрывы тканей. Флотация грудной клетки. Множественные или открытые переломы. Травматическая ампутация конечностей.
5. Критическая с сомнительным выживанием:	Ожог 3 степени от 40 до 80% поверхности тела. Черепно-мозговые травмы, включая отравления с потерей сознания более 24 часов. Внутричерепное кровотечение. Травмы позвоночника с квадриплегией. Значительные травмы грудной клетки. Множественные открытые переломы конечностей.
6. Летальная:	Максимальное повреждение, которое привело или, вероятно, приведет к смертельному исходу.

ETHICS COMMITTEE
NORTHERN STATE MEDICAL UNIVERSITY

163061, Arkhangelsk, Troitsky avenue, 51 Phone: 28-57-84

Partial record of the Ethics Committee meeting at the NSMU

№ 03/04 -17 27. 04. 2017

Present:

1.Chairman of the Ethics Committee at the NSMU - Gudkov AB, DSc., Professor, Head of the Department of Hygiene and Medical Ecology, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia.

2. Responsible secretary of the Ethics Committee at the NSMU - Malkova O.V., Senior lecturer of the Department of Public Health, Healthcare and Social Work, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia.

Members of the Ethics Committee (with decisive vote):

3. Bebyakova N.A. - DSc., Professor, Head of the Department of Medical Biology and Genetics, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;

4.Ievleva S.S. - Clinical pharmacologist, GBUZ AO “Severodvinsk City Children's Clinical Hospital”;

5. Klykov A. K. - Deputy head of the Department of Legal and Personnel Work, Health Ministry of the Arkhangelsk region;

6. Kolodkina OF - CSc., Associate professor of the Department of Therapy, Endocrinology and Emergency Medical Care, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;

7. Makarova V.I. - DSc., Professor, Head of the Department of Propaedeutics of Children's Diseases and Polyclinic Pediatrics, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;

8.Nazarenko N.A. - DSc., Professor of the Department of Pharmacology, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;

9.Popov V.A. - DSc., Professor of the Department of General and Hospital Surgery, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;

10. Svetlichnaya T.G. - DSc., Professor of the Department of Public Health, Healthcare and Social Work, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;

11. Soloviev A.G. - DSc., Professor, Head of the Department of Psychiatry and Clinical Psychology, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;

12.Trescheva N.D. - CSc., Associate professor of the Department of Obstetrics and Gynecology, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;

13. Kharkov O.A. - CSc., Associate professor of the Department of Psychiatry and Clinical Psychology, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia

List of invitees:
1. Bondarenko Elena Georgievna - Associate professor of the Department of Physical Training and Medical Rehabilitation, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;
2. Gerasimova Marta Andreevna - Clinical intern of the Department of Neurology and Neurosurgery, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia;
3. Unguryanu Tatiana Nikolaevna - Associate professor of the Department of Hygiene and Medical Ecology, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia.

The meeting was at the Northern State Medical University on April 27, 2017,
at 13.30 pm, address: Arkhangelsk, 51, Troitskiy avenue

Agenda: Consideration of the approval of a package of scientific research documents within the PhD project framework on the topic "Evidence-basis for injury prevention in Northwestern Russia: the Shenkursk population-based injury registry study"

Researcher: Associate professor of the Department of Hygiene and Medical Ecology, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia - Unguryanu Tatiana Nikolaevna

Main supervisor: Kudryavtsev Alexander Valerevich – PhD, Head of Department of Innovative Programs Central Scientific Research Laboratory, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia

Co-supervisors:
1. Grjibovski Andrej Mechislavovich – PhD, Head of the Central Scientific Research Laboratory, FGBOU VO NSMU (Arkhangelsk) of the Health Ministry of Russia; Professor, Norwegian Institute of Public Health, Oslo, Norway
2. Trovik Tordis – PhD, Professor, Department of Community Medicine, the Arctic University of Norway

Submitted documents:
1. Application for conducting an ethical review
2. Protocol of study (extended).
3. Patient's informed consent for medical intervention (hospital)
4. Patient's informed consent for medical intervention (polyclinic).
5. Injury Registration Form
6. Brief information about the researcher

Voting results:
Voted: "for" -13, "against" - no, "abstained" – no

Resolved: To adopt a positive ethical conclusion on the approval of a package of scientific research documents within the PhD project framework on the topic "Evidence-basis for injury prevention in Northwestern Russia: the Shenkursk population-based injury registry study".

Chairman of the Ethics Committee at the NSMU, DSc., Professor A.B. Gudkov

Responsible secretary of the Ethics Committee at the NSMU O.V. Malkova

REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK nord	Veronica Sørensen	77620758	11.10.2017	2017/1995/REK nord
			Deres dato:	Deres referanse:
			06.10.2017	

Vår referanse må oppgis ved alle henvendelser

Tordis A Trovik
Det helsevitenskapelige fakultet

2017/1995 Skaderegisteret i Shenkursk

Vi viser til innsendt fremleggingsvurderingsskjema datert 06.10.2017. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk i møtet 12.10.2017.

Prosjektleder: Tordis A Trovik

Bakgrunn og formål (original):
Det første russiske befolkningsbaserte skaderegisteret startet i 2015 og registrerer rutinemessig alle traumer som krever medisinsk hjelp i kommunen Shenkursk, i Arkhangelsk-regionen (Shenkursk Injury Registry data; SIRD). Skaderegisteret bygger på skaderegistreringsmodellen som ble brukt i Harstad, Norge. Målet med skaderegistret er å overvåke skadefrekvenser og utvikle evidens-baserte forebyggende tiltak på kommunalt nivå. Kilden til informasjon om skaden er et registreringsskjema (=papir-journalen) som inneholder person-informasjon (for-, mellom- og etternavn, fødselsdato, hjemmeadresse og telefonnummer), informasjon om type skade, skadested, tid, forutgående omstendigheter, mekanismene for ulykken, mekanismene for skade, involverte faktorer, alkoholforbruk, sosio-demografiske bakgrunn til den skadde og kliniske karakteristika av skadene (lokalisering, alvorlighetsgrad). Inkluderings-kriterier for å bli registrert i SIRD er ICD-10-kodene S00-78. Dataregistrering utføres ved bruk av EpiInfo 7. SIRD inneholder, foruten all informasjon om skaden, koblingsnøkkel til papir-journalen og fødselsdato. Innføring av SIRD gjør det mulig å observere skadeomfanget, utføre prognoser for fremtidig skade og muligheter for å forebygge skadehendelser på befolkningsnivå, samt å øke kunnskapen om faktorer som bidrar til belastning etter skade.

Våre studier gjøres med bakgrunn i dette registeret; avidentifiserte personopplysninger blir stillet til rådighet, med koblingsnøkkel til papir-journalen (rå-data). Målet med prosjektet er å skaffe et bevisgrunnlag for skadeforebygging i Shenkursk-området og i lignende områder i Nordvest-Russland gjennom å beskrivende og analysere datagrunnlaget i SIRD. Spesifikke mål i studiet er: i) Å beskrive metoden for å registrere skader i Shenkursk, ii) Å evaluere og presentere kvaliteten av dataene i SIRD, iii) Å studere det lokal panorama av skader og fastslå de største skadeproblemene blant Shenkursks befolkning (fallskader, alkoholrelaterte skader, barneskader etc.), samt å diskutere grunnlaget for å kunne utvikle lokale tiltak, og iv) å evaluere effekten av det samfunnsbasert skadeforebyggende programmet i Shenkursk, med spesielt fokus på barns skader.

Studier for mål i)-iii)-iv) kan utføres med anonyme data, uten koblingsnøkkel til papir-journalen. Studier for mål ii): evaluere skadebeskrivelsen i SIRD opp imot det originale registreringsskjemaet i papir-journalen, må utføres på avidentifiserte data, der en koblingsnøkkel til papir-journalen er kjent.

Forskningsetisk vurdering
Det fremgår av skjema for framleggingssvurdering at en Russisk institusjon (NSMU), er forskningsansvarlig og data har blitt samlet inn i Russland og oppbevares i Russland.

Det finnes en koblingsnøkkel for materialet, men ingen personidentifiserte data eller koblingsnøkkel tas med til Norge.

Prosjektleder er usikker på om REK skal godkjenne prosjektet, siden PhD-studenten er student ved UiT og en av bi-veilederne er ansatt ved UiT.

Helseforskningslovens geografiske virkeområde er regulert i helseforskningsloven § 3. Av bestemmelsens første ledd følger at loven gjelder forskning på norsk territorium eller når forskningen skjer i regi av en forskningsansvarlig som er etablert i Norge.

Slik REK ser det vil det springende punkt i dette prosjektet være om «forskningen skjer i regi av en forskningsansvarlig som er etablert i Norge». Hensikten bak reguleringen er f.eks. å sikre at risikofylt forskning ikke flyttes til land med dårligere regulering enn Norge, med den følge at internasjonalt anerkjente prinsipper ikke overholdes og/eller at forskningsdeltakere blir utilbørlig utnyttet eller utsatt for uakseptabel risiko eller ulempe.

Det er den Russisk institusjonen NSMU som er forskningsansvarlig. Alle data er samlet inn i Russland og alle data oppbevares i Russland i et godkjent register. Studenten er russisk og har russisk hovedveileder. Den norske biveilederen har opplyst pr telefon at studenten er registrert inn ved universitet i Tromsø og skal disputere her. Det er økonomisk støtte fra universitetet i Tromsø som gjør det mulig for studenten å avlegge denne doktorgraden.

Slik REK vurderer organiseringen av dette prosjektet, må det anses som et prosjekt som gjennomføres i Russland i regi av en russisk forskningsansvarlig. Det forhold at det gis økonomisk støtte fra UiT, at det er en norsk biveileder eller at studenten skal disputere ved UiT tillegges ikke å avgjørende vekt i vurderingen.

Med bakgrunn i dette har REK kommet til at forskningen ikke skjer i regi av en forskningsansvarlig som er etablert i Norge, jf.§3.

Godkjenning fra andre instanser
Det påhviler prosjektleder å undersøke hvilke eventuelle godkjenninger som er nødvendige fra eksempelvis personvernombudet ved den aktuelle institusjon eller Norsk senter for forskningsdata (NSD).

Veiledning vedrørende framleggingsplikten
Med hjemmel i hfl. § 3. anser REK at dette prosjektet faller utenfor helseforskingslovens geografiske område og at prosjektet med bakgrunn i dette ikke er fremeggingspliktig for REK.

Vi ber om at alle henvendelser sendes inn via vår saksportal: http://helseforskning.etikkom.no eller på e-post til: post@helseforskning.etikkom.no.

Vennligst oppgi vårt referansenummer i korrespondansen.

Med vennlig hilsen

May Britt Rossvoll
Sekretariatsleder

Veronica Sørensen
seniorrådgiver

Tordis A. Trovik
Postboks 8905
7491 TRONDHEIM

Vår dato: 21.12.2017	Vår ref: 56817 / 3 / TAL	Deres dato:	Deres ref:

Tilrådning fra NSD Personvernombudet for forskning § 7-27

Personvernombudet for forskning viser til meldeskjema mottatt 26.10.2017 for prosjektet:

56817	*Evidence-basis for injury prevention in Northwestern Russia: the Shenkursk Population-based Injury Registry Study*
Behandlingsansvarlig	*UiT Norges arktiske universitet, ved institusjonens øverste leder*
Daglig ansvarlig	*Tordis A. Trovik*

Vurdering

Etter gjennomgang av opplysningene i meldeskjemaet og øvrig dokumentasjon finner vi at prosjektet er unntatt konsesjonsplikt og at personopplysningene som blir samlet inn i dette prosjektet er regulert av § 7-27 i personopplysningsforskriften. På den neste siden er vår vurdering av prosjektopplegget slik det er meldt til oss. Du kan nå gå i gang med å behandle personopplysninger.

Vilkår for vår anbefaling

Vår anbefaling forutsetter at du gjennomfører prosjektet i tråd med:

- opplysningene gitt i meldeskjemaet og øvrig dokumentasjon
- vår prosjektvurdering, se side 2
- eventuell korrespondanse med oss

Meld fra hvis du gjør vesentlige endringer i prosjektet

Dersom prosjektet endrer seg, kan det være nødvendig å sende inn endringsmelding. På våre nettsider finner du svar på hvilke endringer du må melde, samt endringsskjema.

Opplysninger om prosjektet blir lagt ut på våre nettsider og i Meldingsarkivet

Vi har lagt ut opplysninger om prosjektet på nettsidene våre. Alle våre institusjoner har også tilgang til egne prosjekter i Meldingsarkivet.

Vi tar kontakt om status for behandling av personopplysninger ved prosjektslutt

Ved prosjektslutt 31.10.2020 vil vi ta kontakt for å avklare status for behandlingen av personopplysninger.

Se våre nettsider eller ta kontakt dersom du har spørsmål. Vi ønsker lykke til med prosjektet!

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

Vennlig hilsen

Marianne Høgetveit Myhren

Trine Anikken Larsen

Kontaktperson: Trine Anikken Larsen tlf: 55 58 83 97 / Trine.Larsen@nsd.no
Vedlegg: Prosjektvurdering

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 56817

PURPOSE
The purpose of the project is to provide evidence-basis for injury prevention in Shenkursk, Northwestern Russia through descriptive and analytic studies of Shenkursk injury registration data. Specific objectives of the project are to validate the record injury incidents in the Shenkursk Injury Registry data in terms of completeness and correctness, to present local panorama of injuries and investigate major injury problems in Shenkursk population using the injury registry data and provide an evidence basis for development of local interventions, and to estimate the economic burden of injuries in Shenkursk.

SENSITIVE PERSONAL DATA
It is indicated that you intend to process sensitive personal data about health.

ASSESSMENT BY REC
The project has been assessed by the Regional Committee for Medical and Health Research Ethics (REC). REC considers the project not to be mandatory to submit according to the Health Research Act.

PROJECT MANAGER
The responsible institution is UiT Norges arktiske universitet. It is a requirement that the project manager must be employed by the responsible institution. In e-mail dated 20. December 2017, co-supervisor Tordis A. Trovik has confirmed that she can be projectmanager for this project.

LEGAL BASIS
The Data Protection Official considers that the research data can be processed in accordance with the Personal Data Act section 8 d and 9 h. The project is of major public interest and the social benefit exceeds the personal benefit of the data subjects. We emphasize that the information is almost not identifiable for the researcher and that the project period has a short duration.

The Data Protection Official has considered that the project can be exempted from the obligation of concession, cf. personopplysningsforskriften section 7-27, because the research data are limited and the project period has a short duration.

INFORMATION AND CONSENT
It is stated in e-mail dated 14.12.2017 that informed consent has been given when the injury was registered in the Shenkursk Injury Registry. Participants shall not provide new informed consent to the research project. The Data Protection Official presupposes that the student has the necessary approvals from Russia and the research project is conducted in accordance with Russian legislation.

INFORMATION SECURITY

The Data Protection Official presupposes that you will process all data according to the UiT Norges arktiske universitet internal guidelines/routines for information security.

According to your notification form you intend to use of an external transcribing assistant/translator/online survey service provider. Two trained nurses (injury registrators) entered data into the Shenkursk Injury Registry from the original Shenkursk district Hospital paper-journals. The student will access the original paper forms for a one-year period for validation purposes, assessing completeness of the registry and accuracy of the data entry.

PROJECT END DATE AND ANONYMIZATION

The estimated end date of the project is 31.10.2020. According to your notification form/information letter you intend to anonymise the collected data by this date. Making the data anonymous entails processing it in such a way that no individuals can be identified. This is done by:

- deleting all direct personal data (such as names/lists of reference numbers)
- deleting/rewriting indirectly identifiable personal data (i.e. an identifying combination of background variables, such as residence/work place, age and gender)

We draw your attention to the fact that the data processor must also delete personal data linked to the project in its systems. This includes transcriptions, files, logs, links between IP/email addresses and answers.