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Poisonings in Finnish Children



ACADEMIC DISSERTATION

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ACADEMIC DISSERTATION

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LIST OF ORIGINAL PUBLICATIONS

- I Kivistö JE, Arvola T, Parkkari J, Mattila VM: Paediatric poisonings treated in one Finnish main university hospital between 2002 and 2006. *Acta Paediatr.* 2008 Jun; 97(6): 790–794.
- II Kivistö JE, Mattila VM, Arvola T, Paavola M, Parkkari J: Secular Trends in Poisonings Leading to Hospital Admission among Finnish Children and Adolescents between 1971 and 2005. *J Pediatr.* 2008 Dec; 153(6): 820–824.
- III Kivistö JE, Mattila VM, Parkkari J, Kannus P: Incidence of poisoning deaths in Finland in 1971–2005. *Hum Exp Toxicol.* 2008 Jul; 27(7): 567–573.
- IV Kivistö JE, Parkkari J, Mattila VM, Hoppu K: Poisoning deaths among Finnish children from 1969 to 2003. Submitted.

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ABBREVIATIONS

AAPCC	American Association of Poison Control Centers
AC	Activated charcoal
ATC	Anatomical Therapeutic Chemical (Classification System)
CI	Confidence interval
ED	Emergency department
EU	European Union
GI	Gastrointestinal
ICD	International Classification of Diseases
NAC	N-acetylcysteine
NHDR	National Hospital Discharge Register
OCDS	Official Cause-of-Death Statistics
PIC	Poison Information Centre
PSS	Poisoning Severity Score
TESS	Toxic Exposure Surveillance System
WHO	World Health Organization

ABSTRACT

The aim of this study was to investigate the incidence and nature of paediatric poisonings and poisoning deaths in Finland.

The study was based on four databases. First, using the Tampere University Hospital Information System the incidence and distribution of emergency department (ED) visits due to poisonings among 0–15 years old children during 2002–2006 were analysed. Second, the incidence of hospital admissions due to poisoning among Finnish children and adolescents during 1971–2005 was studied. This study was based on the information from the National Hospital Discharge Register (NHDR) and aimed to describe the secular trend of hospitalisations due to poisoning in 0–19 years old children and adolescents. Third aim was to investigate the incidence, nature and secular trend of poisoning deaths in Finland. The incidence of poisoning deaths was studied in all age groups during 1971–2005. This part of the study was based on the Official Cause-of-Death Statistics (OCDS) in Finland. Finally, the aim was more specifically describe poisoning deaths among Finnish children including the causes and distribution of substances involved in fatal poisonings. This part of the study was based on copies of the death certificates of all Finnish children aged 0–15 years who died from poisoning between 1969 and 2003.

This thesis showed that acute paediatric poisonings are relatively common in Finland. The incidence of ED visits due to poisonings among 0–15 years old children was 8.1 per 10,000 person-years during 2002–2006 within the catchment area of the Tampere University Hospital. Nonpharmaceutical agents were suspected to cause 60% and pharmaceuticals 31% of the intoxications. The most common single agent in poisonings was alcohol. Overall mortality in ED visits due to poisonings was 0.3%, indicating that poisoning may still today represent a life-threatening problem.

Annually about 1,000 children and adolescents are admitted to hospital in Finland due to poisoning. During 1971–2005 there were altogether 41,862 hospitalisations due to poisoning among 0 to 19 years old Finnish children and adolescents. The incidence of hospitalisations declined from 91 admissions per 100,000 person-years in boys and 105 in girls in 1971 to 65 and 84 in 2005, respectively. In the 0–4-year age group, admissions declined by 51%. On the other hand, hospitalisations

for alcohol poisoning increased 1.7-fold among boys and 2.4-fold among girls. Of all children and adolescents hospitalised due to poisoning up to 1% has died in subsequent poisoning later (until the end of year 2005).

When investigating the whole population by means of OCDS it was seen that poisoning deaths increased in Finland during 1971–2005. In 1971, the incidence of all poisoning deaths was 12.2 per 100,000 person-years among men and 2.1 in women. In 2005, the corresponding figures were 23.6 and 7.4. Alcohol poisonings comprised the majority of poisoning deaths in Finland during the 35-year study period. Men's risk was markedly higher than women's, but in later years, women's risk was increasing.

During 1969–2003 altogether 121 children aged 0 to 15 years died from poisoning in Finland. Among 0–4-year-olds the incidence of poisoning deaths declined to practically zero by the beginning of 1980s. Most of these deaths were unintentional poisonings. Among 5–15-year-olds the incidence of poisoning deaths varied during the study period. At this age the majority of the poisonings were intentional. Girls predominated in suicides while substance abuse was more common among boys.

In conclusion, paediatric poisonings remain a relatively frequent problem in Finland. In spite of child-resistant packaging, heightened parental awareness, and other protective measures, such as interventions by the Finnish Poison Information Centre and specially trained healthcare professionals, paediatric poisonings occur in Finland. Moreover, despite the declining secular trend seen in paediatric poisoning deaths, the risk of death from both intentional and unintentional poisoning persists in children. Health promotion programmes should be continued and improved especially to promote the well-being of families and to prevent unintentional poisonings among young children, teenage suicides and substance abuse, collateral suicides and chemical assaults.

TIIVISTELMÄ

Tämän väitöskirjatutkimuksen tarkoituksena oli selvittää lasten myrkytysten yleisyyttä, aikatrendejä ja ominaispiirteitä sekä myrkytyskuolemien ilmaantuvuutta Suomessa.

Tutkimus pohjautui neljään aineistoon. Aluksi selvitettiin Tampereen yliopistollisen sairaalan potilasrekisteristä tehdyn haun perusteella, mikä oli myrkytysten aiheuttamien ensiapukäyntien ilmaantuvuus 0–15-vuotiaiden lasten keskuudessa vuosina 2002–2006. Lisäksi tutkittiin, miten myrkytykset jakautuivat iän, sukupuolen ja aiheuttaneiden aineiden mukaan. Toisessa osatyössä tutkittiin, mikä oli sairaalahoitoon johtaneiden myrkytysten ilmaantuvuus ja trendi maassamme 0–19-vuotiaiden lasten ja nuorten keskuudessa vuosina 1971–2005. Tämän tutkimuksen aineisto perustui Sosiaali- ja terveysalan tutkimus- ja kehittämiskeskuksen (Stakes) ylläpitämään sairaaloiden hoitoilmoitusjärjestelmään. Kolmas osatyö selvitti myrkytyskuolemien ilmaantuvuutta ja ominaispiirteitä Suomessa kaikissa ikäryhmissä vuosina 1971–2005. Tutkimus perustui Tilastokeskuksen kuolinsyyrekisterin tietoihin. Neljäs osatyö kuvasi tarkemmin lasten myrkytyskuolemien ilmaantuvuutta, myrkytyskuolemiin johtaneita syitä ja kuolemia aiheuttaneiden aineiden kirjoa. Tämä osa tutkimuksesta pohjautui Suomessa vuosina 1969–2003 myrkytyksiin kuolleiden 0–15-vuotiaiden lasten kuolintodistusten analysointiin.

Tampereen yliopistollisesta sairaalasta kerätyn aineiston perusteella vuosina 2002–2006 myrkytysten aiheuttamien ensiapukäyntien ilmaantuvuus 0–15-vuotiailla lapsilla oli 8.1 kymmentätuhatta henkilövuotta kohti. Kokonaiskuolleisuus myrkytysten aiheuttamissa ensiapukäynneissä oli 0.3 %, mikä osoittaa, että lasten myrkytykset voivat edelleen olla henkeä uhkaavia. Yksittäiset lääkeaineet aiheuttivat 31 % ensiapukäynneistä. Myrkytystapauksista 60 % oli muiden kuin lääkkeiden aiheuttamia. Yleisin yksittäinen myrkytyksiä aiheuttanut aine oli alkoholi.

Tutkimuksemme mukaan vuosittain Suomessa joutuu myrkytyksen vuoksi sairaalahoitoon noin tuhat lasta ja nuorta. Vuosina 1971–2005 Suomessa oli yhteensä 41 862 myrkytysten aiheuttamaa sairaalahoitojaksoa 0–19-vuotiaiden lasten ja nuorten keskuudessa. Sairaalahoitojen ilmaantuvuus laski seurantajakson aikana. Vuonna 1971 pojilla oli 91 ja tytöillä 105 myrkytyksen aiheuttamaa sairaalahoitoa jokaista 100 000 henkilövuotta kohti. Vuonna 2005 vastaavat luvut olivat pojilla 65 ja tytöillä 84. Nuorimpien, 0–4-vuotiaiden lasten ikäryhmässä sairaalahoidot

vähenevät 51 %. Alkoholin aiheuttamien sairaalahoitojen ilmaantuvuus sen sijaan kasvoi pojilla 1.7-kertaiseksi ja tytöillä 2.4-kertaiseksi 35 vuoden seurantajakson aikana. Kaikista myrkytyksen vuoksi sairaalahoitoon joutuneista lapsista ja nuorista prosentti on kuollut myöhemmin elämässään myrkytykseen (vuoden 2005 loppuun mennessä).

Koko väestössä havaittiin myrkytyskuolemien määrän kasvu vuosina 1971–2005 kuolinsyyrekisteriin perustuvassa tutkimuksessa. Vuonna 1971 myrkytyskuolemien ilmaantuvuus oli miehillä 12.2 ja naisilla 2.1 jokaista 100 000 henkilövuotta kohti. Vastaavat luvut olivat vuonna 2005 miehillä 23.6 ja naisilla 7.4. Alkoholi aiheutti suurimman osan myrkytyskuolemista tämän 35-vuotisen seurantajakson aikana. Miesten myrkytyskuolemariski oli selvästi suurempi kuin naisten, mutta naisten suhteellinen osuus kasvoi seurantajakson aikana.

Vuosina 1969–2003 yhteensä 121 alle 16-vuotiasta lasta kuoli myrkytyksiin Suomessa. 0–4-vuotiaiden ikäryhmässä myrkytyskuolemien ilmaantuvuus laski käytännössä nolnaan 1980-luvun aikana. Suurin osa tämän ikäryhmän myrkytyksistä oli tahattomia. 5–15-vuotiaiden ikäryhmässä myrkytyskuolemien ilmaantuvuus vaihteli seurantajakson aikana. Tässä ikäryhmässä suuri osa myrkytyksistä oli tahallisia. Tyttöjen myrkytysitsemurhat olivat selvästi yleisempiä kuin poikien. Sen sijaan pojilla oli enemmän myrkytyskuolemia, jotka olivat aiheutuneet päihtymistarkoituksessa käytettyjen aineiden yliannoksesta.

Yhteenvedon voidaan todeta, että lasten myrkytykset ovat edelleen suhteellisen yleinen ongelma Suomessa. Maassamme otetaan päivittäin 2–3 lasta ja nuorta sairaalahoitoon myrkytyksen takia. Huolimatta lapsiturvallisten pakkausten yleistymisestä ja vanhempien tietomäärän lisääntymisestä sekä mm. Myrkytystietokeskuksen toiminnasta, lasten myrkytyksiä tapahtuu edelleen. Vaikka lasten myrkytyskuolemien määrä on vähentynyt viime vuosikymmeninä Suomessa, sekä tahattomien että tahallisesti aiheutettujen myrkytyskuolemien riski on yhä olemassa. Terveystieteiden tutkimusohjelmia myrkytysten estämiseksi tulee uudistaa ja kehittää maassamme. Erityishuomiota on kiinnitettävä perheiden hyvinvointiin, jotta tapaturmaiset pikkulasten myrkytyskuolemat, nuorten itsemurhat ja päihdekäyttö sekä laajennetut itsemurhat ja kemialliset pahoinpitelyt saataisiin estettyä.

INTRODUCTION

Poisonings form a specific entity among injuries. According to the Annual Report of the American Association of Poison Control Centers (AAPCC) there were over 2,400,000 human exposures reported during 2004 in the United States (Watson et al. 2005).

Poisonings cause considerable morbidity and mortality worldwide (The World Health Report 2004). According to estimates from the World Health Organization (WHO) some 350,000 people die yearly from poisoning (The World Health Report 2004). Poisonings are often reported together with injuries and in ICD-coding they are identified as a subgroup of injuries. Injuries and poisonings in the European Union (EU) alone kill 250,000 people each year (Injuries in the European Union ... 2007). It has been suggested that the proportion of accidental poisonings is 4% of this (Injuries in the European Union ... 2007).

Poisonings in the paediatric age group have a bimodal distribution with the highest peak in young children and a continuous increase in adolescence (Goepp 1996). A male predominance has been reported in younger children but gender distribution reverses in teenage years (Watson et al. 2005).

Most of the poisonings in young children are asymptomatic and do not require long hospitalisation (Gauvin et al. 2001). However, the symptoms and severeness do not always correlate due to possible delayed toxicity in some poisonings (Bryant and Singer 2003). Sometimes intoxication in children can lead to life-threatening complications, and even death (Liebelt and DeAngelis 1999). In many countries studies have shown that the incidence of paediatric poisonings has decreased during the last few decades (Rajka et al. 2007). Moreover childhood poisoning deaths have been reported to have declined markedly (Flanagan et al. 2005). This favourable development has been attributed to factors such as child-resistant packaging, interventions by poison information centres, and advances in health care such as development of new antidotes and abandonment of old ineffective treatments (Liebelt and DeAngelis 1999).

Paediatric poisonings have been mainly studied in the United States and some European reports also exist (Lamireau et al. 2002, Mintegi et al. 2006). Developing countries have also published some statistics (Paudyal 2005, Rashid et al. 2007).

International epidemiological studies concerning poisonings in Finnish children are scarce. The Finnish Poison Information Centre receives altogether 40,000 phone calls annually, most of them concerning children (Myrkytystiedustelujen kuukausittainen jakauma 2006–2008 2008). One published report claims that paediatric poisoning deaths have vanished in Finland (Itkonen et al. 1996). According to another report, however, fatal poisonings in children occur annually (Parkkari et al. 2000).

There is a lack of information on how common and severe paediatric poisonings are in Finland and if they differ from those in other countries. For example, the fact that in Finland the age-adjusted monthly drunkenness among adolescents has been fairly common is known (Lintonen et al. 2000), but it is uncertain how common alcohol poisonings are compared to other poisonings.

The purpose of this study was to conduct an epidemiological investigation of paediatric poisonings in Finnish children. The more specific aims were to describe the secular trends in poisoning deaths in all age-groups, with particular emphasis on children; to provide an update on the epidemiological information of hospitalisations related to paediatric poisonings; and to describe the nature and incidence of emergency department (ED) visits due to paediatric poisonings. This information would enable the development of more effective primary prevention programmes against paediatric poisonings.

STUDY BACKGROUND

The concept of poisoning

Poisoning definition

Defining the term poisoning totally unequivocally is somewhat difficult. According to the International Classification of Diseases (ICD) poisonings are included in the category of injuries (International Statistical Classification ... 1992). In addition, in international publications poisonings are regularly reported together with other injuries (Injuries in the European Union ... 2007). Poisonings, however, differ from other injuries (e.g. falls, traffic accidents etc.) and form a separate entity.

In a Finnish medical dictionary poison has been defined as an agent that is life-threatening or harmful to health even in low doses when swallowed, injected, inhaled or delivered through the skin into the human body (Lääketieteen termit 1997). In this dictionary poisoning has been defined as a poison-induced disorder in the human body (Lääketieteen termit 1997). In the medical dictionaries in the United States poisoning has been defined as taking a substance that is injurious to health or can cause death (Webster's New World Medical Dictionary 2003).

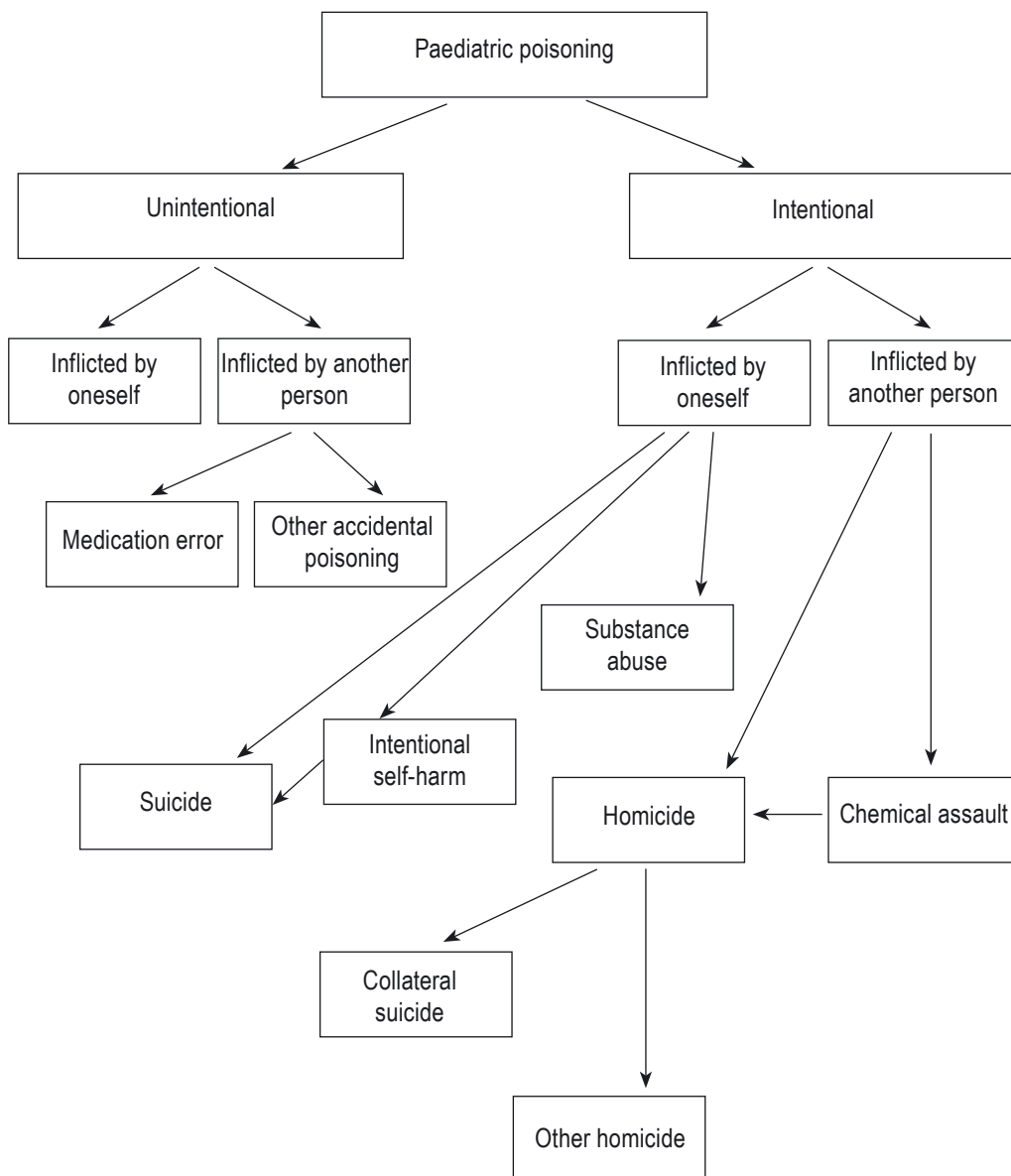
Injuries have traditionally been classified into two distinct categories regarding deliberateness: intentional and unintentional (Parkkari et al. 2000). Recent literature suggests, however, that these two categories form a continuum (Mattila et al. 2008). Distribution into intentional and unintentional is also appropriate with regard to poisonings (Table 1). Most of the unintentional poisonings occur among the youngest children (under 5 years of age). As part of normal cognitive development, young children may put almost anything into their mouths when discovering the environment (Lamireau et al. 2002), while older children are assumed to have passed this oral development phase (Uziel et al. 2005). Unintentional poisonings also include poisonings caused by another person without intent, such as medication errors in the home or at hospital.

Intentional poisonings can be further divided into intentional self-poisonings and intentional poisonings by another person (Table 1). Most of the adolescent poisonings are intentional poisonings. Poisoning is a well-known method for

suicide attempt in adolescent girls (Shepherd and Klein-Schwartz 1998). Moreover, poisonings due to substance abuse are common among teenagers (Cheng et al. 2006).

Poisonings by another person include chemical assaults, homicides and collateral suicides (Table 1). Chemicals are known as a form of child abuse, especially among

TABLE 1. Classification of paediatric poisonings.



infants (Agran et al. 2003), with homicides and collateral suicides representing the worst kind of chemical assault (Flanagan et al. 2005). Collateral suicide refers to a suicide in which a parent simultaneously kills his/her children and him/herself.

In conclusion poisoning can be defined as taking or otherwise being exposed to a substance or substances injurious to health and in the worst case causing death through a chemical mechanism.

Data sources and measurement for poisoning occurrence

Occurrence of poisonings can be measured with various data sources. Prospective studies performed in emergency departments or primary health care are traditionally used to investigate occurrence of poisonings (Lamireau et al. 2002, Mintegi et al. 2006, Rajka et al. 2007). In these studies, the required parameters are usually collected with questionnaires or other specific forms (Lamireau et al. 2002). Other sources of data and possibilities to measure occurrence of poisonings include hospital registers, cause-of-death statistics, injury surveillance systems, ambulatory surveys, telephone interviews and poison information centre statistics.

Hospital registers

Many developed countries maintain hospital discharge registers (Fazen et al. 1986, Smith 1991, Marbella et al. 2005). These registers can be used in epidemiological studies. Occurrence of poisonings can be determined by computer search on these hospital registers. Hospital information systems are based on mandatory ICD-coding and poisoning patients can be searched from the system with the use of specific diagnostic or external cause-of-injury codes (International Statistical Classification ... 1992).

In Finland, the data on hospitalisations is obtained from the National Hospital Discharge Register (NHDR), which contains all basic hospitalisation data from all Finnish hospitals (Ailasmaa 2006). This includes the patient's age, place of domicile, basic information on the institution or department, time of hospitalisation, length of hospital stay and diagnosis (Lamminpää et al. 1993, Ailasmaa 2006).

The Finnish NHDR was established in 1969 (Ailasmaa 2006). From the beginning it has been based on the ICD coding. The ICD Eighth revision was used from 1969 to 1987 (ICD-8) and the Ninth revision (ICD-9) from 1987 to 1995. From 1996 the Tenth revision (ICD-10) was used. Since the NHDR is based on internationally

widely used ICD coding, this Finnish database offers an opportunity to produce statistics and studies which are comparable to other countries.

The data maintained in the NHDR are collected and updated on an annual basis by the National Research and Development Centre for Welfare and Health (Stakes) (Ailasmaa 2006). This register covers all the patients that have been hospitalised in Finland during the previous year. The annual update is based on patients' identity numbers (Ailasmaa 2006).

Being based on the ICD system is an important asset of the NHDR (International Statistical Classification ... 1992). In view of poisoning investigations, this system is somewhat limited due to the fact that many poisonings are coded as non-specified. The fairly high proportion of patients diagnosed with non-specified poisoning has been a fairly common feature of poisoning studies even internationally (McCaig and Burt 1999) and it is at least partly explained by the unclear circumstances in many poisoning cases. Another limitation of the NHDR is the underreporting of external causes (Mattila 2005), as in 10–20% of cases this information is missing. However, double coding used for poisonings (and other injuries) is obligatory: the primary poisoning code and the external cause code are both required. Although not all organisations execute this double coding, in the Tampere University Hospital Information System, this obligatory double coding is used. The fact that intoxications (or other hospitalisations due to injury) are coded with both a diagnosis and an external cause ensures that it is more unlikely that cases would be missed due to underreporting of external causes (Mattila et al. 2006).

Injury surveillance database and emergency department registers

Many developed countries have hospital register-based injury surveillance systems, but most developing countries have not (Mattila 2005). Computer-based injury surveillance databases have also been used in poisoning studies (Reith et al. 2001). Moreover, some countries have a specific injury surveillance system for children and adolescents (Cheng et al. 2006). Such systems may offer interesting and extensive databases for poisoning investigation. However, studies concerning the validity and coverage of these injury surveillance databases are scarce.

Few countries have specific registers to monitor injuries treated in ED. These ED injury surveillance systems offer data on less severe injuries (Walsh et al. 1996). In Finland, ED registers and studies based on ED registers are scarce. The oldest specific ED register is located at the Department of Orthopaedics and Traumatology at the Helsinki University Central Hospital (Honkanen and Michelsson 1980).

Cause-of-Death Statistics and death certificates

The data for poisoning deaths could be obtained from the cause-of-death statistics, which offer reliable information in many, mostly developed, countries. In Finland, the Official Cause-of-Death Statistics (OCDS) are an extensive, medico-legal death investigation system (Official Cause of Death Statistics 2005), which is computer-based since 1971 and annually updated and quality-controlled by the Cause-of-Death Bureau at the Statistics Finland, the central statistical office of the country. The 54-class death coding system has been the same since 1969, and it is not therefore vulnerable due to changes in the International Classification of Diseases (Official Cause of Death Statistics 2005, Official Statistics of Finland ... 2006).

The Finnish OCDS are in practice 100% complete, since each death, its certificate and the corresponding personal information in our computerised population register are crosschecked. The accuracy of the data is maximised in a 3-phase process, in which each death certificate and its codes are cross-examined (Kannus et al. 1999, Official Cause of Death Statistics 2005).

The strength of cause-of-death statistics is that they are complete and accurate in many developed countries and thus internationally comparable (Flanagan et al. 2005, Mattila 2005). Their specific limitations in poisoning studies are that only fatal poisoning cases are recorded and that no information on poisoning circumstances is registered.

The OCDS are based on death certificates, which constitute one data source that provides specific information about poisoning deaths in Finland. Death certificates have been collected by the Official Statistics of Finland since 1936 (Official Statistics of Finland ... 2006) and stored in electronic form since 1969. The determination of the cause of death is based on medical or forensic evidence. In poisoning cases the determination is always based on forensic autopsy in Finland. The accuracy of the death certificates and their cause-of-death codes are further verified by autopsies performed in 94% to 97% of these deaths (Kannus et al. 1999, Official Cause of Death Statistics 2005). The death certificates in Finland are classified according to ICD (International Statistical Classification ... 1992).

All deaths suspected to be due to poisoning are submitted to medico-legal cause-of-death determination in Finland (Lahti and Vuori 2003). This practice systematically includes a forensic toxicological examination. All post-mortem examinations are centralised to an authorised toxicological laboratory at the Department of Forensic Medicine at the Helsinki University (Lahti and Vuori 2003). Thus all chemical analyses performed after poisoning deaths are performed in the same laboratory. Limitations to the use of death certificates in poisoning

measurement include the fact that they also give information only of the fatal poisoning cases.

Statistics of Poison Information Centres

Information received by poison information or control centres (PIC) may be used in poisoning studies. In the United States, the Toxic Exposure Surveillance System (TESS) is compiled by the American Association of Poison Control Centers (AAPCC) (Watson et al. 2005). These data are used in poisoning prevention, direct training and in clinical research. The AAPCC data collection system covers 80% of the American population (Lovejoy et al. 1993).

The Finnish Poison Information Centre in Helsinki started its activities in 1961. The main reason for the establishment of the Centre was the high poisoning mortality among young children (Tallqvist and Korpela 1959, Visakorpi 1971). Today, the Finnish PIC receives altogether 40,000 phone calls annually (Myrkytystiedustelujen kuukausittainen jakauma 2006–2008 2008), mostly concerning paediatric poisonings with over half of the children being younger than six years (Hoppu 2006).

Statistics available from the PICs form an extensive database for paediatric poisoning studies. However, some shortcomings are associated with these databases. Since the patients are not treated at the PICs, the statistics of the centres may lack information about the poisoning outcome. The PICs invite the medical facilities attending to poisonings to send case histories to the centres, however, this request may not always be observed. Furthermore, the data at the PICs do not directly suffice to identify trends in the overall incidence in poisonings because the proportion of poisonings reported to the PICs is unknown (Watson et al. 2005). Thus, extrapolations from the number of reported poison exposures cannot be made from these data alone (Watson et al. 2005).

Other data sources

Various registers and databases may be used for epidemiological poisoning study. Some primary care centres keep individual electronic registers in Finland but extensive primary care registers do not exist in this country (Mattila 2005). Paediatric poisoning information given by primary care registers would not add much knowledge about serious paediatric poisonings, since in all of the paediatric

poisoning cases assumed to need professional medical services patients are transferred to hospital care (Hyvinvointipalvelut: Tietoa Tampereen kaupungin sosiaali- ja terveystalveluista 2007) and the information could be obtained from the NHDR. Nonetheless, primary care registers might provide a valuable database of poisoning occurrence in Finland.

Especially in developing countries, where national hospital discharge registers do not exist, surveys may elicit information on injuries (Mattila 2005). Surveys have also been used in poisoning studies. Hospital staff have been asked to complete ED patient record forms (McCaig and Burt 1999). Sometimes paediatric poisoning patients (or accompanying parent or adult) have been interviewed after attending to ED due to poisoning (Patel et al. 2006).

Surveys are, however, accompanied by substantial limitations for injury (and poisoning) research. One problem is the telescoping effect, which means a tendency to remember events in the past closer than they actually occurred. Moreover, it has been estimated that only 28–60% of the injuries are reported when using a 12-month recall period (Mock et al. 1999). Thus, recall periods between 1 to 3 months are recommended in injury surveys (Harel et al. 1994).

Telephone surveys have also been used in studies among patients (or their parents) calling to a PIC (Brayden et al. 1993, Ozanne-Smith et al. 2001). In Finland, where annually a huge amount of phone calls are received at the PIC (Hoppu 2006), phone interviews would offer one possible way to gather information on paediatric poisonings on a national level. However, the fact that the number of calls to PIC does not directly correspond to the trend in the overall incidence again needs to be taken into consideration (Watson et al. 2005).

REVIEW OF THE LITERATURE

Paediatric poisonings

Age groups in paediatric poisoning studies

The term paediatric poisoning is internationally widely used in reference to poisonings in children and adolescents (Liebelt and DeAngelis 1999, Michael and Sztajnkrzyer 2004, Greene et al. 2005, White and Liebelt 2006). Sometimes the term childhood poisoning is used with the same meaning (Mintegi et al. 2006).

Although paediatric poisoning most often refers to poisonings occurring among children and adolescents aged 0 to 18 years (Gauvin et al. 2001), there is inter-country variation, usually indicating differences between the healthcare systems. In France, the articles dealing with paediatric poisonings cover children and adolescents aged 0 to 17 years (Lamireau et al. 2002). In the United States and Canada, paediatric poisonings mostly refer to poisonings among 0 to 18-year-olds (Lacroix et al. 1989, Gauvin et al. 2001, Osterhoudt et al. 2004), but occasionally the upper age limit is 17 years (Lovejoy et al. 1993) and in some cases 19 years (McCaig and Burt 1999, Agran et al. 2001).

An even lower upper age limit is seen in studies from Australia (Reith et al. 2001), England and Scotland (Smith 1991, Patel et al. 2006), as well as the Nordic countries, e.g. Norway (Rajka et al. 2007), where the term paediatric poisoning is used to refer to children and adolescents up to 14 years. In Finland, the paediatricians treat mainly patients from 0 to 15 years of age (Toimintakertomus 2006 ... 2007). In this book, paediatric poisoning refers to poisoning cases in which the patients are not over 19 years of age. Most paediatric poisoning studies performed for this thesis included patients between 0 and 15 years old.

Features of paediatric poisonings

Poisonings in the paediatric age group have a bimodal distribution with the highest peak in young children and a continuous increase in adolescence (Greene et al. 2005). Most exposures among the youngest children are unintentional (Michael and Sztajnkrzyer 2004, Greene et al. 2005). As part of normal cognitive development, young children (under 5 years) may put almost anything into their mouths when discovering the environment while older children are assumed to have passed this oral development phase (Uziel et al. 2005). If the harmful agent is for example stored in a soft drink container, the youngest children may fail to recognise the suitability of the liquid and may consume ingredients before taste aversion leads to discontinuing the drink (Bryant and Singer 2003).

Intentional poisonings become more likely after the age of five (Bryant and Singer 2003). Children aged 5 to 9 years are less frequently involved in toxic exposures (Reith et al. 2001). Teenagers, on the other hand, are more often involved with poisonings related to substance abuse or suicidal behaviour (Cheng et al. 2006).

Boys have generally predominated the statistics of ED visits for acute poisoning among the youngest children in the previous reports (Marchi et al. 1998, Mintegi et al. 2006). However, the incidence rates among adolescents have been higher for girls than boys (Lamireau et al. 2002). Especially teenage girls constitute the high-risk group for suicide attempts by ingestion of toxic substances (Gauvin et al. 2001, Marbella et al. 2005).

In the previous paediatric poisoning studies, the poisoning substance has been of pharmaceutical origin in over half of the visits to paediatric emergency units (Lamireau et al. 2002, Mintegi et al. 2006). Ingestion has been the most common route of entry accounting for 77% of all and for 70% of fatal toxic exposures according to the AAPCC (Greene et al. 2008).

Basically, the clinical consequences of a specific poisoning agent in children and adult populations are similar (Lastentaudit 2000). Nonetheless, some impacts of intoxicants on children may be different. In paediatric patients airway resistance is greater and cardiac output is very dependent on the heart rate, and cardiovascular instability may be hidden by “normotensive” blood pressure readings (Bryant and Singer 2003). Furthermore e.g. young infants are very susceptible to thermoregulatory problems, such as hypothermia or hyperthermia, caused by poisoning agents (Bryant and Singer 2003).

Adults are often able to articulate abnormal sensations, such as difficulty in hearing, visual disturbances (e.g. hallucinations), headache, paresthesias, and dizziness. Most agents create a similar physiology in the child, but the clinical

expression may be more difficult to discern, especially in the youngest children (Bryant and Singer 2003). The importance of the clinicians being familiar with the basic pharmacological principles when treating paediatric poisoning patients cannot be underestimated (Goepp 1996).

Emergency department visits for paediatric poisonings

The annual number of poisonings among children younger than six years is more than one million in the United States (Liebelt and DeAngelis 1999). According to the Annual Report of the AAPCC Toxic Exposure Surveillance System, slightly over half (51.3%) of all poisonings occur in children younger than six years of age (Watson et al. 2005). In Finland, of the approximately 40,000 phone calls received annually by the PIC, over half concern children under six years of age (Hoppu 2006). Some of the phone calls result in ED visits. According to a Finnish study from 1980s, in 34% of the phone calls to the PIC concerning children, the poisoning case was considered sufficiently serious to warrant physician's attention (Eskola 1983).

French investigators have reported an incidence of 14.0 per 10,000 person-years for ED visits for poison exposures among 0 to 17 years old children and adolescents during 1989–1995 (Lamireau et al. 2002) (Table 2). Marchi et al reported the incidence of 35.2 per 10,000 person-years in Italy during the 1990s (Marchi et al. 1998). In a Norwegian study, the incidence of ED visits due to poisoning was 23.0 per 10,000 person-years in the 1980s among 0 to 14 year-old children and adolescents (Jacobsen et al. 1983). In 2003–2005, the corresponding figure in Norway was significantly lower (9.7 per 10,000 person-years) (Rajka et al. 2007).

In the United States, the average annual rate of poisoning-related ED visits during 1993–1996 was reported as 84.0 per 10,000 person-years among children under 5 years of age and among children and adolescents aged 5 to 19 years 29.0

TABLE 2. Incidence of ED visits for paediatric poisonings in previous studies.

Authors	Country	N	Age-group	Years	Incidence/10,000 person-years
Marchi et al.	Italy	1918	0–15	1990–94	35.2
Lamireau et al.	France	2988	0–17	1989–95	14.0
Rajka et al.	Norway	175	0–14	2003–05	9.7
Uziel et al.	Israel	502	1–15	5-year period	9.3*

*Includes unintentional poisonings only

per 10,000 person-years. (McCaig and Burt 1999). The probable reason for these markedly higher numbers from the United States compared to figures from other countries is the wide database, which included also primary health care.

High incidence figures were also reported in Finland in the 1980s. In one Finnish study, the incidence of poisoning cases needing medical treatment was 53.8 per 10,000 person-years among children and adolescents aged 0 to 15 years in Helsinki in the beginning of the 1980s (Eskola 1983). However, the incidence of poisonings treated in hospital was 15.1 per 10,000 person-years (Eskola 1983).

Hospital admissions for paediatric poisonings

Poisoning in children is a significant cause of morbidity (Patel et al. 2006). It is the second most common injury mechanism resulting in hospital admission among 0 to 4 years old children (Hippisley-Cox et al. 2002). The costs for hospital admission due to paediatric poisonings can be fairly high: 4968 dollars per patient per visit in 1995 as reported in the study performed in the United States (Woolf et al. 1997). However, studies investigating the epidemiology of poisoning hospitalisations are scarce (Gauvin et al. 2001).

In many countries, most of the paediatric poisoning patients are treated as outpatients and only 15–27% need hospitalisation (Lamireau et al. 2002, Mintegi et al. 2006, Patel et al. 2006). In some studies, up to 41–65% of the poisoning consultations in the ED lead to hospitalisation (Lacroix et al. 1989, Marchi et al. 1998).

In a study from Washington State, USA, the incidence of hospitalisations for intoxication was 45 per 100,000 person-years among children and adolescents aged 0 to 18 years (Gauvin et al. 2001) (Table 3). In a Norwegian study, the incidence of hospital admissions due to paediatric poisoning was 62 per 100,000 person-years among 0 to 14-year-olds (Rajka et al. 2007). In Australia, the admission rates to hospital for poisoning were reported as 144, 14 and 22 per 100,000 person-years among populations aged 0–4, 5–9 and 10–14 years, respectively (Reith et al. 2001). In Finland, children under six years of age have been reported to be hospitalised most frequently due to poisoning in the late 1980s, the incidence being 169 per 100,000 person-years (Lamminpää et al. 1993). This finding corresponds to the Australian figures (Reith et al. 2001).

TABLE 3. Incidence of hospital admissions for paediatric poisonings in previous studies.

Authors	Country	N	Age group	Years	Incidence/ 100,000 person-years
Gauvin et al.	United States	7322	0–18	1987–97	45
Rajka et al.	Norway	175	0–14	2003–05	62
Reith et al.	Australia	1516	0–14	2003–05	60
Lamminpää et al.	Finland	11592*	0–5	1987–88	169

*N includes all age groups

In the study performed in the United States, most (75%) of the hospitalisations for paediatric poisonings occurred among teenagers (12 to 18 years) (Gauvin et al. 2001). Instead, in the study from Scotland, up to 81% of children admitted to hospital for poisoning were 1 to 3 years old (Smith 1991). The figures are not, however, comparable since the Scottish study included only children under 15 years of age.

Hospitalisations for paediatric poisonings are usually short-term, with most of the patients being discharged within a few days. The median length of stay in hospital due to poisoning has been one day in previous studies (Smith 1991, Gauvin et al. 2001).

In the Scottish study, most of the admissions (61%) were due to consumption of medicines among 0 to 14 years old children (Smith 1991). In the study performed in the United States, pharmaceutical agents were identified as the cause of poisoning in most (80%) of the hospitalisations for paediatric intoxications (Gauvin et al. 2001). In a Finnish study patients under six years of age were hospitalised mostly due to non-drugs (59%) (Lamminpää et al. 1993). Multiple agents and self-inflicted intoxications have been more common in teenagers compared with younger children's hospitalisations (Gauvin et al. 2001).

Gauvin et al. found that teenage girls have a 2.5 times higher risk of hospital admission due to poisoning than teenage boys. Boys, in turn, have been more frequently involved in all younger age groups (Gauvin et al. 2001).

Poisoning deaths globally and locally

Poisonings cause considerable mortality worldwide. An estimated 5 million people worldwide died from injuries in 2000 – a mortality of 83.7 per 100,000 person-years

(The Injury Chart Book 2002). In these WHO statistics, unintentional poisonings comprise up to 315,000–350,000 deaths annually (The Injury Chart Book 2002, The World Health Report 2004). The worldwide incidence of unintentional poisoning deaths was 5.2 per 100,000 person-years in 2000 according to estimates of WHO (The Injury Chart Book 2002).

In addition, approximately 815,000 people commit suicide annually. The accurate proportion of intentional poisonings among all suicides is not known. In Finland, the proportion of self-poisoning of all suicides has been 15% in men and 39% in women (Partonen et al. 2003).

More than 94% of the unintentional fatal poisonings and 86% of all suicides occur in low- and middle-income countries (The Injury Chart Book 2002). Over 60% of the global unintentional poisoning mortality occurs among adolescents and adults aged between 15–59 years (The Injury Chart Book 2002). There are variations of age group distributions in poisoning deaths in different countries. In developed countries, most of the poisoning deaths occur among the adult population. In the United States, over half of all fatal poisonings occur in individuals aged 20 to 49 years (Watson et al. 2005). These age groups also account for the majority of unintentional poisoning deaths in the United States, whereas in Africa 0–4-year-old children constitute the majority of these deaths (The Injury Chart Book 2002).

All over the world, poisoning deaths occur more often in the male population. According to WHO report, in 64% of all fatal unintentional poisoning cases the victim is a male (The World Health Report 2004). In the United States, the male-female ratio of poisoning deaths has been 2.4 in the 1990s (Fingerhut and Cox 1998). This gender distribution is even more clearly seen in Europe, where the overall poisoning mortality rates among males are approximately three times higher than the rates in either sex in any other world region (The Injury Chart Book 2002). The highest poisoning mortality rates are found in the male populations of the low- and middle-income countries in Europe. In these male populations, especially in Eastern Europe, the poisoning mortality rate is over 30 per 100,000 person-years, whereas in most high-income countries, the incidence of poisoning deaths is clearly under 10 per 100,000 person-years (The Injury Chart Book 2002).

Most of the poisoning death figures from different countries are estimates, which are not based on an extensive medico-legal death investigation system. From this point of view, Finland is an exceptional country. Post-mortem forensic toxicology seems not to be centralised in any other country as thoroughly as at the Forensic Toxicology Division in Helsinki (Lahti and Vuori 2002). The lack of a centralised death investigation system is the most probable reason for the fact that studies investigating long-term trends in the incidence of poisoning deaths are

fairly scarce internationally. Some studies describing shorter periods in poisoning deaths, however, exist.

Poisoning mortality has been reported as declining in England and Wales during the 1980s and the early 1990s in both genders (Griffiths et al. 2006). On the other hand, studies from the United States have reported an increase in drug-induced deaths since 1990 (Paulozzi et al. 2006). A rise in prescriptions for certain drugs, such as opioid analgesics, is believed to have contributed to this development (Paulozzi et al. 2006).

Poisoning is a well-known suicide method around the world. Suicide figures in Finland have been among the highest in the world, especially for men (Official Statistics of Finland ... 2006). Toxic substances or agents have been identified as the cause of death in 27–30% of suicides in a Finnish study (Isometsä et al. 1997). Since 1990, a significant decline in suicides in Finland has occurred (Official Statistics of Finland ... 2006). The overall trend in injury deaths has also been decreasing in Finland during the last few decades (Kannus et al. 2001). The decline in suicides may be partly explained by the new antidepressants (selective serotonin reuptake inhibitors), which are safer and cause less poisoning deaths than older similar drugs (tricyclic antidepressants) (Frey et al. 2000, Vuori et al. 2006).

In Finland, drunkenness-oriented drinking is known to be common. Drinking spirits to intoxication has traditionally been common in the Finnish culture (Poikolainen et al. 2002). Several reasons have been offered to explain the rising trend of alcohol poisonings in Finland, including EU-membership and the increased general acceptance for women's use of alcohol – even in public places (Kannus et al. 2005). Due to the high figures in alcohol consumption and alcohol poisonings in Finland, alcohol poisoning deaths are often reported separately from other poisoning deaths (Vuori et al. 2006).

Paediatric poisoning deaths

In the 1950s, there were 834 deaths from intoxications among children younger than five years in the United States (Gauvin et al. 2001). Fortunately, paediatric poisoning deaths have declined markedly during the last few decades (Liebelt and DeAngelis 1999). In a British study, the incidence of childhood poisoning deaths among children aged 0 to 9 years decreased from 2.06 to 0.46 per 100,000 person-years during 1968–2000 (Flanagan et al. 2005). This positive trend is attributed to child-resistant closures, heightened parental awareness, intervention by poison information centres and specially trained healthcare professionals (Liebelt and

DeAngelis 1999, Rajka et al. 2007). However, poisoning still remains a frequent health problem causing some mortality among children (Lamireau et al. 2002). Differences in paediatric poisonings rates exist between societies. In a study conducted during 2001–2005, the age-specific average annual mortality in Estonia due to poisonings among 0–14-year-old children was relatively high, being 1.4 per 100,000 person-years (Väli et al. 2007). Even though the findings are not totally comparable due to different classification systems and unequal age groups it seems clear that paediatric poisoning death rates are higher in Estonia than in Great Britain (Flanagan et al. 2005).

The youngest children (under five years of age) are known to be involved in most of the paediatric poisonings due to a large number of accidental intoxications (Lamireau et al. 2002, Rajka et al. 2007). Although, in general, these poisonings among toddlers are more likely to be asymptomatic and require treatment and hospitalisation less often than in older children (Marchi et al. 1998), fatal poisonings do occur (Flanagan et al. 2005). Teenagers, on the other hand, have more intentional poisonings, which tend to be more severe and may even result in death (Gauvin et al. 2001, Rajka et al. 2007).

In Finland, the main reason for the establishment of the Poison Information Centre in 1961 was the high poisoning mortality in young children (Tallqvist and Korpela 1959, Visakorpi 1971). After the establishment of the PIC the average number of poisoning deaths among children under 5 years of age has dropped in Finland (Official Cause of Death Statistics 2005). While some reports claim that paediatric poisoning deaths have vanished from the country (Itkonen et al. 1996), others state that fatal poisonings still occur annually (Parkkari et al. 2000).

Risk factors and prevention

Studies concerning the risk factors for paediatric poisonings are fairly rare. A few decades ago many tablets were sugar-coated and hence small children might eat even dozens of tablets (Pharmaca Fennica 1985). Furthermore, in the past it was commonly believed that ingestion of small amounts of a toxic agent (e.g. one tablet of adult medicine) by a toddler is a benign act not expected to produce any significant harm. Nowadays it is, however, known that some drugs and other toxic agents have the potential to kill children even in low doses (Michael and Sztajnkrzyer 2004).

Brayden et al. studied behavioural antecedents of paediatric poisonings among 3–7-year-old children, and found that paediatric poisoning often occurs when a number of conditions coincide in one location at one time (Brayden et al. 1993).

Improper storage of poisoning agents, non-compliant behaviour, curiosity, misinterpretation of the substance, inadequate child monitoring and imitative behaviour were judged the most common antecedent of these ingestions (Brayden et al. 1993). In Brayden's study, lack of knowledge of poison prevention methods was rare. Nearly one third of children under six years of age who experience accidental poisoning will subsequently experience a second episode (Litovitz et al. 1989). Poisoning prevention education at the time of the first poisoning episode would be an important method of reducing the number of poisonings in children (Greene et al. 2005). Currently this prevention of further poisonings occurs only for a minority of paediatric poisoning cases (Demorest et al. 2004).

Socioeconomic factors and differences between social classes in paediatric poisonings were investigated in Finland in the 1980s. According to this study, poisonings among children from the highest social class were most often accidental and less serious, mostly caused by plants or tobacco, as compared to poisonings in lower social classes. The delay from the poisoning to the treatment was shortest in the the highest social group. (Eskola and Poikolainen 1983.)

A greater risk for childhood poisoning in rural areas has been recognised, but the reasons for the higher poisoning rates in these areas have not been fully investigated (Pearn et al. 1984). Increased availability of toxic chemicals and different attitudes toward them, defects in home design, and a lack of adequate medical care and information resources may be contributing factors (Reith et al. 2001).

In a British study, injuries (including poisonings) between different socioeconomic gradient wards were examined among 0–14-year-old children (Hippisley-Cox et al. 2002). In this study poisonings were three times more common among the most deprived wards compared to the least deprived wards (Hippisley-Cox et al. 2002). The authors highlighted the necessity to target intervention to most deprived areas.

In most of the paediatric poisoning cases the poisoning agent is obtained from home (Lamireau et al. 2002). According to an Australian study, up to 62% of the poisoned patients under 5 years old were alone in the room at the onset of the poisoning (Ozanne-Smith et al. 2001). Less vigorous parental supervision has been associated with an increased number of poisonings in children (Sinclair et al. 2008). The means of access is generally during periods of use of the agent (75%), including occasions when the agent was just purchased (Ozanne-Smith et al. 2001). In only 20% of the poisoning cases among 0–4-year-old children the agent was stored in its proper place (Ozanne-Smith et al. 2001). In most of the paediatric drug poisoning cases in the 0–5-year-old age group, the medication was prescribed to parents or grandparents (Lundén and Hoppu 1996).

In a Finnish study from the 1980s it was reported that the number calls to the PIC was lower during weekends than on weekdays and that the evening was the busiest time (Eskola 1983). An evening peak in exposures has been observed in other studies as well. Lovejoy et al found that exposure peaked from 4 pm to 10 pm (Lovejoy et al. 1993). In some studies exposures have been more frequent during meal times (Lamireau et al. 2002). In the Australian study most incidents among children under five years occurred between 9 am and 7 pm (Ozanne-Smith et al. 2001). In a French study, there was no difference in the exposures by the day of the week (Lamireau et al. 2002).

According to a report from the Finnish PIC, the peak months are those when people usually have holidays. During 2006–2007, the peak months in terms of number of calls received by the PIC were July and August (Myrkytystiedustelujen kuukausittainen jakauma 2006–2008 2008). In France, the frequency of children's exposures has been highest between April and July (Lamireau et al. 2002). In a study performed at Children's Hospital Boston, 55% of the accidents and 61% of the suicides in the paediatric population occurred between October and March (Fazen et al. 1986). In this study, racial backgrounds of the patients were also recorded but no significant difference between races were noted (Fazen et al. 1986).

Substance abuse and suicide attempts are more common in adolescents (children over 10 years of age) (Flanagan et al. 2005). The rates of suicides and accidental poisoning deaths are lower in 10–14-year-old adolescents compared with 15–19-year-olds (Shepherd and Klein-Schwartz 1998). Poisoning is a major cause of injury mortality among adolescents (Cheng et al. 2006). It is also a well-known method for suicide attempt in adolescents, especially in girls (Gauvin et al. 2001, Ramisetty-Mikler et al. 2005). Among adolescents a non-fatal suicide attempt is known to be the strongest predictor of eventual suicide (Marbella et al. 2005).

In a poisoning study conducted in Wisconsin, USA, among 12–17 years old adolescents, up to 60% of medication-related poisonings occurred in patients with a mental disorder diagnosis (Marbella et al. 2005). However, the risk factors for psychosocial dysfunction of adolescents who arrive to ED due to poisoning are inadequately assessed, documented and followed up (Woolfenden et al. 2002). According to previous studies deliberate self-poisoning in adolescence seems to be part of a complex and continuing network of problems for some young people, marked by high rates of psychopathology, comorbidity, with other disorders and high psychosocial adversity (Harrington et al. 2006).

In adolescent poisoning studies females had twice as many medication-related intoxications as males among 12–17 years old (Marbella et al. 2005). In some studies

the proportion of girls has been reported to be up to 75% among 10 to 17-year-olds (Ramisetty-Mikler et al. 2005).

Analgesics and psychotropic drugs have been the two most common drug groups used in adolescent poisonings (Marbella et al. 2005, Ramisetty-Mikler et al. 2005). Injury-prevention efforts such as management of depression, substance abuse education, and use of carbon monoxide detectors are believed to have a favourable influence on adolescent fatalities (Shepherd and Klein-Schwartz 1998).

In Finland, heavy and drunkenness-oriented drinking is common. Drinking spirits to intoxication has traditionally been popular among adults in our country (Poikolainen et al. 2002). Moreover, adolescent alcohol consumption has been considered a serious problem. Reports from the 1990s were alarming. Based on a Finnish study the age-adjusted monthly drunkenness rates among 14 to 18-year-olds rose from 13% to 27% among boys and from 6% to 22% among girls between 1981 and 1999 (Lintonen et al. 2000). Nonetheless, in the beginning of the 21st century, this drunkenness-oriented drinking has declined among adolescents (Rimpelä et al. 2007). In addition, the proportion of adolescents abstaining from alcohol has increased in the beginning of this century (Rimpelä et al. 2007). However, it is not known whether alcohol poisonings treated in EDs have simultaneously decreased.

In the 1990s, an increase in drug abuse and use of illicit drugs was reported in Finland (Poikolainen 1998). On the other hand, in the beginning of the 2000s, a declining trend in drugs offered to adolescents was reported (Rimpelä et al. 2007). However, this positive trend has ceased over the last few years (Rimpelä et al. 2007).

The decline noted in paediatric poisonings in many countries has been attributed to several factors, including product reformulations, child-resistant packaging, heightened parental awareness, and other protective measures, such as interventions by the PICs (Liebelt and DeAngelis 1999, Rajka et al. 2007). Advances in healthcare have also been noteworthy in reducing poisoning deaths (Liebelt and DeAngelis 1999).

Effective prevention is still the best form of treatment. It has been estimated that legislation for child-resistant packaging for oral prescription drugs (Poison Prevention Packaging Act) in the United States has reduced the child mortality rate by 1.4 deaths per 100,000 children younger than five years, even after controlling for changes in the consumption of oral prescription drugs and the overall decline in the unintentional injury rates for children (Liebelt and DeAngelis 1999). Adolescent occupational toxic exposures are considered an under-recognised hazard in some studies (Woolf et al. 2001). The experience accruing at the PICs has been suggested

to be capable of filling the gap in the surveillance of these poisonings (Woolf et al. 2001).

Advances in treatment

Basic guidelines

The decline in the number of poisoning deaths is attributed to multiple factors one of which has been suggested to be treatment advances (Liebelt and DeAngelis 1999). The basic principle in paediatric and other poisonings is symptomatic treatment (Tehohoito-opas 2002). In the case of a paediatric poisoning, the immediate acts include the minimisation of acute danger (mouth emptying, agent off from hands etc.) (Hoppu 2006). First aid assuring open airways, normal breathing and circulation is needed on the poisoning scene (Bryant and Singer 2003). Poisoning severity score (PSS) may be used to grade the severity of poisoning (Persson et al. 1998). Estimation of the amount of poisoning agent ingested by the child is often difficult yet important for planning the treatment (Lastentaudit 2000). The volume of a swallow is 0.27 ml/kg, or roughly 5 cubic centimetres (cc) for a 2-year-old and 20 cc for an adolescent (Bryant and Singer 2003).

Poisonings in children are often unclear events. Physicians should suspect poisoning if the paediatric patient admitted to hospital has weird symptoms such as tachycardia, drowsiness, unconsciousness, tachypnea or strange behaviour without a specific reason (Näntö-Salonen et al. 2005).

Activated charcoal

The most important and effective measure after first aid is gastrointestinal decontamination. Activated charcoal (AC) is the commonest form of gastrointestinal (GI) decontamination administered to potentially poisoned children (Osterhoudt et al. 2004). One of the pioneers in the studies providing important new information on the use of AC in poisonings has been P.J. Neuvonen, a physician from Finland (Neuvonen et al. 1983). The ability of AC to absorb toxin from the GI tract is best when AC is given as soon as possible after ingestion (Neuvonen et al. 1983, Greene et al. 2008). Studies have shown a mean reduction of 56–66% in the absorption of subtoxic doses of acetaminophen when AC was administered one hour after

ingestion compared to 22–23% when AC was administered two hours after ingestion (Yeates and Thomas 2000, Christophersen et al. 2002).

Administration of AC in the home is being recommended for potentially toxic ingestions in many countries (Liebelt and DeAngelis 1999). Despite such general guidelines, children treated in ED rarely have received AC within one hour of ingestion (Osterhoudt et al. 2004). Administration of AC includes also risks. Pulmonary aspiration of AC should be considered when assessing the risk of therapy (Osterhoudt et al. 2004). According to a recent review dealing with GI decontamination, the use of AC is contraindicated in patients with a dysfunctional GI tract or in patients with GI perforation (Greene et al. 2008). AC is also contraindicated in ingestions with high aspiration potential, such as hydrocarbons or patients who lack an intact or a protected airway, particularly if the poisoning is likely to produce central nervous system depression (Greene et al. 2008). Most substances are absorbed by AC but few, such as iron, cyanide, lithium and alcohols are not absorbed well (Neuvonen and Olkkola 1988). In these poisoning cases AC should not be administered (Greene et al. 2008).

Gastric lavage, ipecac syrup and whole-bowel irrigation

Poisoning treatments have changed substantially during the last few decades (Liebelt and DeAngelis 1999). Previous studies have shown that gastric lavage and administration of ipecac syrup have been fairly common treatments for poisonings in Europe, even in the 2000s (Mintegi et al. 2006). However, the utility of ipecac syrup has been questioned and its use is no longer recommended as standard care (Liebelt and DeAngelis 1999, Greene et al. 2008). There is no evidence that ipecac syrup improves the clinical outcome in poisoned patients, and in the worst case it may delay the administration of AC or other treatments (Liebelt and DeAngelis 1999). However, given within 30 minutes of an ingestion to patients with potential for significant toxicity in a location distant from hospital, ipecac syrup may be helpful (Greene et al. 2008).

Although gastric lavage was formerly a routine treatment procedure for paediatric poisonings (Tallqvist 1962), today it is not considered the standard care for intoxications. There is a lack of clinical evidence that gastric lavage would improve the outcome in poisoned patients (Liebelt and DeAngelis 1999). A situation in which gastric lavage could be of theoretical benefit is after recent ingestion of a very toxic substance (within 30 minutes) or in case that AC cannot be administered to the patient (Greene et al. 2008). In Finland, gastric lavage has been common

in paediatric ethanol poisoning care previously, but today, it is not recommended (Greene et al. 2008).

Whole-bowel irrigation with balanced polyethylene glycol solutions can be occasionally considered. This method has its greatest potential benefit for removing substances that are slowly absorbed from the GI tract or in cases when the amount of poisoning agent absorbed by AC is insufficient (Greene et al. 2008). Its use should be limited to cases such as ingestions of sustained-release or enteric-coated drugs and e.g. lithium poisonings (Liebelt and DeAngelis 1999).

Antidotes

Antidote administration may be helpful in the treatment of specific poisonings. They may, in certain circumstances, prevent or reverse toxicity (Bryant and Singer 2003). Some antidotes such as oxygen for carbon monoxide, naloxone for opiates and vitamin K preparations for oral anticoagulants displace an intoxicant from a site of action (Bryant and Singer 2003).

Acetaminophen poisonings are fairly common among paediatric poisonings (Rajka et al. 2007). These ingestions can lead to irreversible liver damage and death (White and Liebelt 2006). As acetaminophen is metabolised in the liver, toxic metabolites may be produced, e.g. N-acetyl-p-benzoquinoneimine, resulting in acute liver injury (White and Liebelt 2006). N-acetylcysteine (NAC) as an antidote could restore the function by repair or by bypassing the production of such toxic metabolites (Bryant and Singer 2003). The release of the intravenous form of NAC has changed the management of acetaminophen poisoning (White and Liebelt 2006).

The effectiveness of glucagon as an antidote has been demonstrated in beta-blocker and calcium channel blocker overdoses (Liebelt and DeAngelis 1999). Administration of fomepizole in ethylene glycol and methanol poisonings has been proven to be safe and efficient (White and Liebelt 2006). Flumazenil is recommended for children in severe benzodiazepine poisonings (Liebelt and DeAngelis 1999). Children are frequently exposed to iron-containing products, which have serious toxicity potential and activated charcoal is not capable of preventing iron absorption (Fine 2000). In iron poisonings deferoxamine therapy can be used with paediatric patients (Fine 2000).

AIMS OF THE STUDY

The general aim of this study was to describe the nature and occurrence of paediatric poisonings and poisoning deaths in Finland. The specific objectives of this study were the following:

- 1) To describe the incidence and nature of emergency department visits for acute paediatric poisoning among Finnish children.
- 2) To describe the trend in poisonings leading to hospitalisation among Finnish children and adolescents between 1971 and 2005.
- 3) To investigate the incidence and secular trend of poisoning deaths by age and gender in Finland and more specifically, among Finnish children describing the distribution of substances involved.

MATERIALS AND METHODS

This study was based on four data sets. The first data (I) were collected from the Tampere University Hospital Information System from 2002 to 2006. The second data (II) were extracted from the National Hospital Discharge Register from 1971 to 2005. The third data (III) were obtained from the Official Cause-of-Death Statistics Finland 1971–2005 and the fourth (IV) from the death certificates collected by the Official Statistics of Finland during 1969–2003.

Study populations and data sources

Populations

For computing the incidence rates of poisoning deaths, the annual mid-populations in Finland during 1971–2005 for all age groups and annual mid-populations for children (0 to 15 years) between 1969 and 2003 were obtained from the Official Statistics of Finland (Official Statistics of Finland ... 2006). In 1969, there were 1,249,606 children in the 0–15-year age group in Finland, and in 2003, the corresponding figure was 986,636. The annual mid-populations within the catchment area of the Pirkanmaa Hospital District for age groups 0 to 15 years during 2002–2006 were likewise obtained from the Official Statistics of Finland (Official Statistics of Finland ... 2006). In 2002, there were 83,159 children in the 0–15-year age group within the catchment area of the study hospital, and in 2006, the corresponding figure was 84,006.

Tampere University Hospital Information System

The Tampere University Hospital Information System is based on the hospital's discharge register and uses ICD-10 (International Statistical Classification ... 1992)

codes similarly for all diagnoses regardless whether the ED visit results in hospital admission or not. In addition, for poisoning cases, the system employs double coding: the primary poisoning code and the external cause code. The data are collected and the database maintained by the Pirkanmaa Hospital District with the purpose to record all hospital visits and hospitalisations at the Tampere University Hospital.

In order to investigate paediatric ED visits due to poisonings, all patients younger than 16 years admitted to the Tampere University Hospital's ED between 2002 and 2006 with a diagnosis of poisoning (codes T36–T65) were identified by a computer search from the Hospital Information System. Search was also performed according to external codes, but more patients were not found (due to double coding).

In this study information on the following parameters was obtained from the case records: age, gender, day of the week, number of previous ED visits due to injury, number of previous intoxications, and number of previous suicide attempts. We also collected data on time delays from ingestion to hospital admission, suspected agents, estimations of severity, origins of agent, routes of exposure, contacts to the PIC, deliberateness, and suicide attempts if recorded. Additionally, any mention on symptoms, administration of activated charcoal, ipecac syrup, or antidote, employment of gastric lavage, possible laboratory tests or imaging, admission to intensive care unit, and length of stay in hospital was noted.

National Hospital Discharge Register

The National Hospital Discharge Register (NHDR) contains basic hospitalisation data from all Finnish hospitals including the patient's age, time of hospitalisation, length of hospital stay and diagnosis (Ailasmaa 2006). The data are collected and maintained on an annual basis by the National Research and Development Centre for Welfare and Health (Stakes).

In order to determine the secular trend of hospitalisations due to poisoning in Finnish children and adolescents, all patients between 0 and 19 years hospitalised with a primary diagnosis of poisoning during 1971–2005 were identified from the NHDR by computer search using the appropriate ICD-codes.

The ICD Eighth revision was used from 1969 to 1987 (ICD-8) and the Ninth revision (ICD-9) from 1987 to 1995. In both ICD-8 and ICD-9 the codes 960–979 for intoxication by drugs, medicinals and biological substances, and codes 980–989 for effects of substances in chiefly non-medical use were used. From 1996 to 2005 the Tenth revision (ICD-10) was used with the corresponding codes being

T36–T65. Selection of intoxications was based on the primary diagnosis and not on the external causes of injury due to underreporting. For the purpose of this study the more specific ICD-10 codes were re-classified into the ICD-9 codes in order to maintain comparability between years. A conversion table was obtained from the National Research and Development Centre for Welfare and Health (Stakes) and the codes were verified by the investigators.

The figures of the hospitalised patients who had died due to poisoning were examined by comparing the identity numbers of the patients to the Official Cause-of-Death Statistics (OCDS). This data were obtained from the National Public Health Institute (KTL).

The Official Cause-of-Death Statistics

The data for poisoning deaths in Finland were obtained from the Official Cause-of-Death Statistics (OCDS) (Official Cause of Death Statistics 2005). Based on extensive medico-legal death certification in the country, this statutory register has been computer-based since 1971 and updated and quality-controlled by the Cause-of-Death Bureau at the Statistics Finland, the central statistical office of the country (Official Cause of Death Statistics 2005). The OCDS are based on death certificates and contain the following information on the patients: age, sex, marital status, place of residence, and place, cause and time of death for the deceased (Official Cause of Death Statistics 2005). The study population consisted of all Finnish people who had died from poisoning between 1971 and 2005.

The OCDS use the 54-class classification system which is maintained by Statistics of Finland (Official Cause of Death Statistics 2005, Official Statistics of Finland ... 2006). The coding system for poisoning deaths has been the same during the whole study period 1971–2005, and it is not therefore vulnerable due to changes in the ICD (Official Cause of Death Statistics 2005). The OCDS have two categories for poisoning deaths: alcohol poisonings and non-alcohol poisonings. In this study, the decision was made to examine deaths by alcohol separately from other poisonings since alcohol-induced deaths predominated in the fatal poisoning statistics. Furthermore, we covered the entire population of Finland since in this country practically all injury deaths are submitted to medico-legal cause-of-death determination.

Death certificates

The fourth (IV) data were collected from the children's death certificates. For the purpose of this study, copies of death certificates of all Finnish children aged 0–15 years who died from poisoning between 1969 and 2003 were obtained from Statistics Finland. The search was performed by Statistics Finland using the external cause ICD-codes for poisoning which during 1969–1986 (ICD-8) were E850–E877, E950–E952, E962 and E980–E982; during 1987–1995 (ICD-9) were E840–E859, E950–E952, E961 and E970–E971; and during 1996–2003 (ICD-10) were X40–X49, X60–X69, X85–X90 and Y10–Y19.

Death certificates have been stored by the Official Statistics of Finland since 1936, and they form the basis of the Finnish OCDS (Official Cause of Death Statistics 2005). Classified mortality statistics and death certificates have been available in electronic form since 1969 (Official Cause of Death Statistics 2005). The accuracy of the death certificates and their cause-of-death codes are further verified by autopsies performed in 94% to 97% of these deaths (Kannus et al. 1999).

In order to determine the secular trend and incidence of paediatric poisoning deaths in Finland the following parameters were collected from the death certificates: age, gender, place of intoxication, suspected agent(s), intent of poisoning (unintentional/intentionally inflicted by another person/intentionally inflicted by oneself/unknown). Possible medication errors, substance abuse and collateral suicides were recorded. Pharmaceutical agents were classified according to the Anatomical Therapeutic Chemical (ATC) Classification System (Guidelines for ATC classification and DDD assignment 2003).

Statistical methods

In the statistical analysis for computing the incidence rates of poisoning deaths, incidence was calculated by dividing the number of poisoning-related deaths by the annual mid-population number of persons in specific age-groups. The numbers and incidence rates of poisoning deaths were thus the true results concerning the entire population of Finland rather than cohort-based estimates.

The incidence and incidence rate ratios of poisonings leading to hospitalisation were based on annual mid-populations. In the statistical analysis for computing the incidence rates of hospitalisations due to poisoning, incidence was calculated by dividing the number of hospitalisations due to poisoning by the annual mid-

population number of persons in specific 5-year-age-groups. All incidence figures were event-based, not person-based.

In the statistical analysis for computing the incidence rates of ED visits due to poisoning, incidence was calculated by dividing the number of ED visits of the children living within the catchment area of the study hospital by the annual mid-population number of persons in a specific age group.

Gender distributions in the age groups were compared with use of the chi-square test. The level of statistical difference was set at 0.05. SPSS statistical software for Windows version 14.0 (SPSS Inc., Chicago, Illinois) was used to analyse the data. When comparing skewed hospitalisation time between genders, the Mann-Whitney U-test was used. Incidence rate ratios and 95% confidence intervals for incidence rates were calculated with Open Epi Programme. Mean values with range were used when reporting distribution of continuous variables (breath alcohol testing, blood ethanol, delay from exposure to admittance to hospital).

Reliability and validity of the data

The OCDS have been shown to have excellent coverage and high accuracy and they are thus well suited for epidemiological study (Parkkari et al. 2003). The accuracy of death certificates and their cause-of-death codes are further verified by autopsies performed on 94% to 97% of injury deaths in Finland (Official Cause of Death Statistics 2005). In addition, postmortem forensic toxicology is centralised in our country at the Forensic Toxicology Division in Helsinki (Lahti and Vuori 2002). Thus all chemical analyses done after poisoning deaths are performed in the same laboratory.

The validity of the NHDR has been investigated and found to be excellent: the accuracy rate of the diagnosis codes for poisonings was 96.0%, and 95.7% for all paediatric diagnoses (Aro et al. 1990). The Tampere University Hospital Information System is based on the hospital's discharge register and diagnoses are coded similarly, regardless whether the ED visit results in hospital admission or not. Thus it may be concluded that the reliability of the diagnostic codes used in the medical records of the study hospital is high.

Permissions and ethical aspects

Permission for the use of case records was granted by the Pirkanmaa Hospital District. The National Research and Development Centre for Welfare and Health (Stakes) granted permission for the use of the NHDR (Ref. 1383/900/2006). Permission for the use of death certificates was given by Statistics Finland (TK-53-245-07). The Ethics Committee of the Pirkanmaa Hospital District approved the study design (Code R07044).

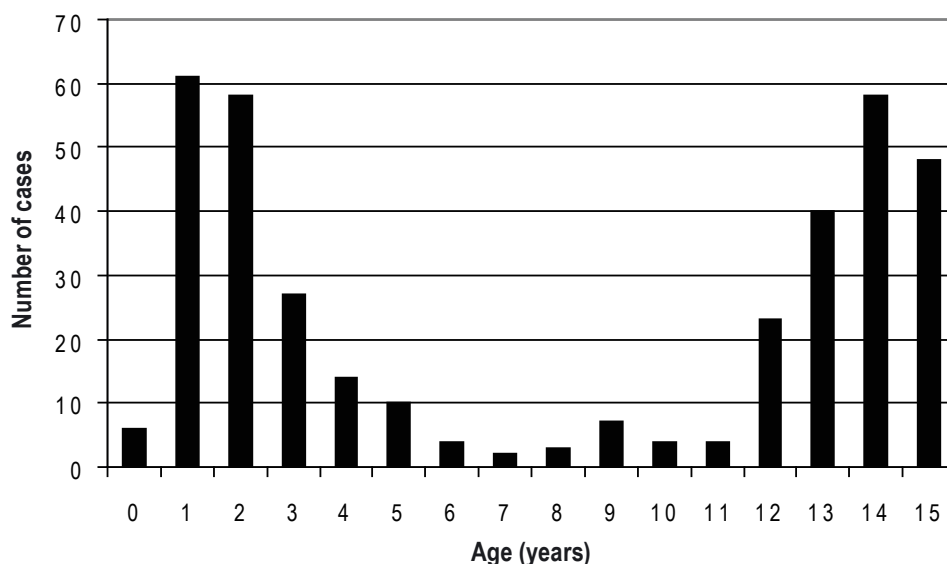
RESULTS

Poisonings leading to emergency department visits

Occurrence

During the study period 2002–2006, among 0 to 15 years old children, altogether 369 ED visits were diagnosed with poisoning codes T36–T65 at the Tampere University Hospital. The overall event-based incidence of emergency visits for paediatric poisoning in this age group was 8.1 per 10,000 person-years (95% CI 7.3–9.0) within the catchment area of this hospital. The age distribution of poisonings leading to ED visits was bimodal (Figure 1). Most of the acute paediatric poisonings concerned children aged 1 to 3 years and adolescents aged 12 to 15 years. Patients aged 0 to 4 years accounted for 45% of all poisoning visits. The incidence of ED visits for poisonings in this age group was 12.2 per 10,000 person-years (95% CI

FIGURE 1. Distribution of paediatric poisonings per age treated in Tampere University Hospital between 2002 and 2006.



10.2–14.1). Five to 15 years old children comprised 55% of the poisonings, the incidence of poisoning visits being 6.4 per 10,000 person-years (95% CI 5.5–7.3). Boys comprised slightly over half (55%) of the poisoning cases. The frequency of ED visits was highest on Fridays and on Saturdays when 19% and 20% of the intoxications occurred, respectively.

Agents

Of the ED visits involving acute paediatric poisoning non-pharmaceutical agents were suspected to be the causing agent in 60%, while pharmaceuticals were suspected in 31% (Table 4). Ethanol accounted for 31% of all poisoning cases. Among the 10 to 15 year-olds, ethanol poisonings accounted for up to 64% of all acute poisonings. Multiple agents were involved in 8% of the poisonings.

Nervous system drugs were the most common pharmaceuticals in ED visits due to paediatric poisoning accounting for 20% of all cases. Among 0 to 4 years old children the proportion of nervous system drugs was up to 30%. Two thirds of the nervous system drug poisonings were caused by psycholeptics (including hypnotics and drugs for psychosis and neurosis). Benzodiazepines accounted altogether for 26% of all drug poisonings. Temazepam and oxazepam were the most common individual agents each causing 12% of all drug poisonings.

Treatment

Up to 71% of the 0 to 4 year-old patients were asymptomatic when admitted to the ED. The proportion of symptomatic persons increased with age: among 5 to 9 year-olds, the proportion of asymptomatic children was 65%, whereas among adolescents aged 10 to 15 years only 24% were asymptomatic when admitted to the ED ($p < 0.001$).

Of the 309 patients with oral route of exposure to agent, 67% were treated with activated charcoal. Only three patients (1%) received ipecac syrup. Gastric lavage was performed on two patients (0.6%), both aged 2 years and diagnosed with iron poisoning. Twenty-one patients (6%) received specific antidotes. Three patients (1%) admitted to ED needed ventilator treatment. Up to 79% of the patients were admitted to hospital, while 21% of the patients were discharged without hospitalisation after ED visit. The Finnish Poison Information Centre was contacted for every third (33%) of the ED visits due to acute poisoning.

TABLE 4. Suspected agents involved in paediatric poisoning exposures treated in Tampere University Hospital between 2002 and 2006.

Agent	0–4 years		5–15 years		Total	
	N	(%)	N	(%)	N	(%)
Non-pharmaceutical agents	78	(47)	145	(71)	223	(60)
Ethanol	1	(0.6)	113	(56)	114	(31)
Bites and venoms	20	(12)	24	(12)	44	(12)
Domestic products	14	(8)	0	(0)	14	(4)
Fuels, lighter fluids, oils, solvents	11	(7)	0	(0)	11	(3)
Tobacco products	11	(7)	0	(0)	11	(3)
Carbon monoxide	5	(3)	5	(2)	10	(3)
Plants, berries, mushrooms	7	(4)	1	(0.5)	8	(2)
Other alcohols	6	(4)	1	(0.5)	7	(2)
Other non-pharmaceuticals	3	(2)	1	(0.5)	4	(1)
Pharmaceuticals	80	(48)	33	(16)	113	(31)
Nervous system	49	(30)	26	(13)	75	(20)
Psycholeptics	28	(17)	22	(11)	50	(14)
Analgesics	6	(4)	3	(1)	9	(2)
Psychoanaleptics	9	(5)	0	(0)	9	(2)
Antiepileptics	6	(4)	1	(0.5)	7	(2)
Cardiovascular system	8	(5)	0	(0)	8	(2)
Respiratory system	7	(4)	1	(0.5)	8	(2)
Blood and blood forming organs	6	(4)	0	(0)	6	(2)
Musculoskeletal system	3	(2)	3	(1)	6	(2)
Alimentary tract and metabolism	3	(2)	2	(1)	5	(1)
Anti-infectives for systemic use	2	(1)	0	(0)	2	(0.5)
Dermatologicals	1	(0.6)	0	(0)	1	(0.3)
Systemic hormonal preparations	1	(0.6)	0	(0)	1	(0.3)
Antineoplastic and immunomodulating agents	0	(0)	1	(0.5)	1	(0.3)
Multiple agents	7	(4)	24	(12)	31	(8)
Unknown	1	(0.6)	1	(0.5)	2	(0.5)
Total	166	(100)	203	(100)	369	(100)

Emergency department visits not leading to hospitalisation

Of those 78 patients discharged from ED without hospitalisation 55% were boys and 45% girls. Three quarters (76%) of these poisonings were unintentional. Most (71%) of the patients were 0 to 4 years old. In up to 60% of these poisoning cases not leading to hospitalisation the amount of poisoning agent was assessed insignificant. Most of the patients (76%) were asymptomatic when arriving to hospital.

Hospitalisations for paediatric poisonings

Occurrence

During the 35-year study period, 1971–2005, there were altogether 41,862 hospitalisations for poisoning among 38,582 children and adolescents aged 0 to 19 in Finland. The incidence rates of hospitalisation for poisonings among 0 to 19 years old Finnish children and adolescents declined during the period of 35 years. In 1971, there were 91.3 admissions per 100,000 person-years in boys and 105.2 per 100,000 person-years in girls. The peak year was 1986 when the number of admissions per 100,000 person-years was 121.4 in boys and 107.7 in girls. At the end of the study period in 2005, the corresponding figures were 64.8 in boys and 83.5 in girls. Incidence rate ratio between years 1986 and 2005 was 1.9 in boys (95% CI 1.6–2.1) and 1.3 in girls (95% CI 1.1–1.4).

Poisonings resulted in altogether 96,427 hospital bed days (incidence 208.6 days per 100,000 person-years) during the study period. The median length of hospital stay during the study period was one day (range, one to 938 days). In 64% of the cases, patients were hospitalised for 1 day and in 19% for 3 or more days. Up to 99% of the patients stayed under 2 weeks at hospital.

The median age at the time of hospitalisation was 6 years in boys and 13 years in girls ($p < 0.001$). The incidence ratio (male-female ratio) of poisonings leading to hospitalisation was 1.28 (95% CI 1.24 to 1.31) in the 0 to 4, 1.46 (95% CI 1.36 to 1.58) in the 5 to 9 and 0.96 (95% CI 0.92 to 1.01) in the 10 to 14 year age group. In the 15 to 19 year age group, girls predominated over boys in hospitalisations, the male-female-ratio being 0.62 (95% CI 0.59 to 0.64).

Most of the patients (92%) were hospitalised for poisoning only once during the study period, but 8% of the patients had two or more admissions. Re-hospitalisations were slightly more frequent among girls (9%) than among boys (7%) ($p < 0.001$).

The incidence of hospitalisations in the youngest age group (0 to 4 years) declined by 51% during the 35-year period. This dramatic decline was seen both in boys and girls (Figure 2), and was most obvious over the last two decades. The annual incidence of hospitalisations for paediatric poisonings was the lowest in the 5 to 9 year age group in both genders (10.4 to 46.8 per 100,000 person-years).

Among adolescents the changes were not so clear during the 35-year study period. Older girls (15 to 19 years of age) predominated over the other groups through the whole study period (Figure 3). The incidence of poisoning hospitalisations increased slightly among 10 to 14-year-old boys and girls. The decreasing trend in poisoning hospitalisations was seen in the 1970s among 15 to 19-year-olds. This

FIGURE 2. Incidence of poisonings (per 100,000 person-years) leading to hospital admission among 0 to 9-year-old Finnish children between 1971 and 2005.

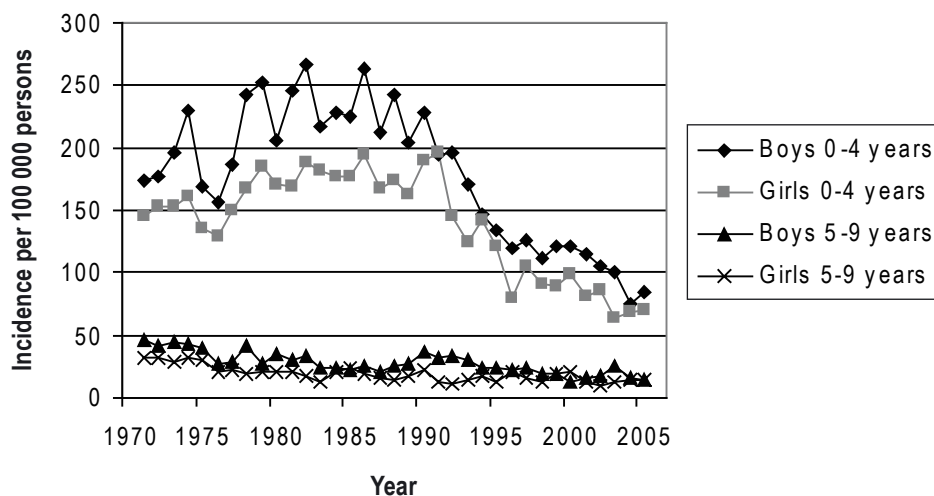
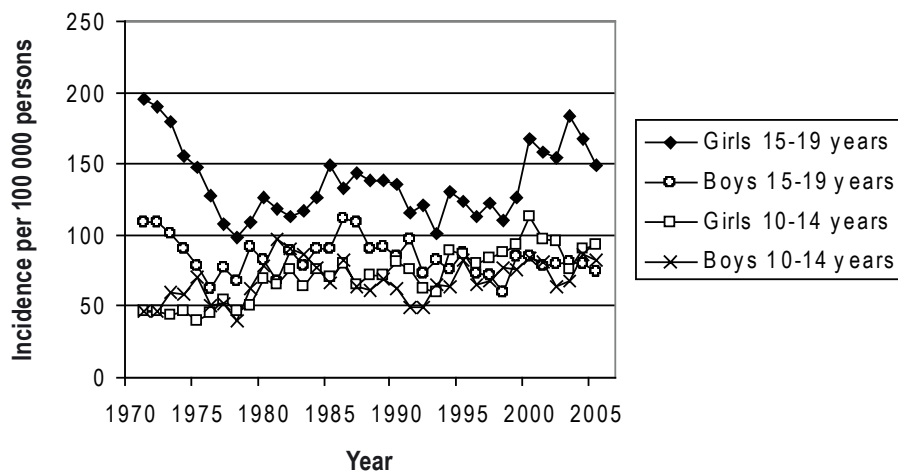


FIGURE 3. Incidence of poisonings (per 100,000 person-years) leading to hospital admission among 10 to 19-year-old Finnish adolescents between 1971 and 2005.



decrease was mainly due to a decrease in poisonings due to alcohol, central nervous system stimulants, sedatives and hypnotics.

Poisonings by drugs, medicinal and biological substances were the cause of hospitalisation in slightly over half (53%) of the 41,862 cases, while poisonings by toxic effects of substances chiefly non-medicinal accounted for the other half (Table 5). Pharmaceuticals accounted for half of the poisonings among 0–4-year-old children. Non-pharmaceuticals accounted for two thirds of hospitalisations for poisonings among 5 to 14 years old children. Among older adolescents (15–19 years old) pharmaceutical products comprised the majority (72%) of the hospitalisations for poisoning.

TABLE 5. Distribution of the causing agents in poisoning hospitalisations among Finnish children and adolescents between 1971 and 2005. The absolute number of hospital admissions is given in parentheses.

Age group	Drugs, medicinal and biological substances		Substances chiefly non-medicinal		Total	
0 to 4 years	50%	(8817)	50%	(8719)	100%	(17536)
5 to 9 years	34%	(915)	66%	(1785)	100%	(2700)
10 to 14 years	32%	(2572)	68%	(5549)	100%	(8121)
15 to 19 years	72%	(9762)	28%	(3743)	100%	(13505)
Total	53%	(22066)	47%	(19796)	100%	(41862)

The incidence of hospitalisations for alcohol poisoning increased during the study period, particularly among girls. In 1971, the incidence of hospital admissions for alcohol poisoning per 100,000 person-years was 15.8 in boys and 8.3 in girls, compared to 27.1 and 20.0 in 2005, respectively. Thus, the incidence of hospital admissions for alcohol-related poisoning increased 1.7 fold (95% CI 1.4 to 2.2) among boys and 2.4 fold (95% CI 1.8 to 3.3) among girls during this period of 35 years. Of all poisonings, 7,331 (18%) were alcohol-related.

Approximately half (53%) of the 10 to 14-year-old hospitalised patients had the primary diagnosis of alcohol poisoning. In the oldest age group (15 to 19 years), alcohol poisonings accounted for 19% of the hospitalisations.

Emergency department visits leading to hospitalisation in Tampere University Hospital

In a study conducted at Tampere University Hospital (Study I), most (291/369) of the paediatric patients (0 to 15 years old) were admitted to hospital after assessment in the ED. Four fifths of the patients were treated in the paediatric intensive care unit. Majority (62%) of the hospitalised patients were 5 to 15 years old. The proportion of boys was 55% and of girls 45%. Among those treated in the hospital, the median length of stay was one day (range, 1 to 43 days).

Slightly over half (51%) of paediatric poisonings leading to hospitalisation were intentional poisonings. Seven per cent of the patients had admitted to have attempted a suicide. The amount of agent was assessed to be potentially severe or severe in 93% of the hospitalised patients. Majority (59%) of the patients had had symptoms when arriving to ED.

Poisoning deaths

Poisoning deaths (all age groups)

During the study period 1971–2005, poisoning deaths increased in both genders (Figures 4 and 5). The overall incidence rates of both alcohol and non-alcohol poisoning deaths were substantially higher among men than women during the whole study period. However, from the beginning of the 1970s, when the rate of alcohol poisoning deaths was about ten times higher in men compared to women, the difference gradually decreased so that in the last few years men's incidence rate was about four times higher. In non-alcohol poisoning deaths the male-female ratio was 1.9 in 1971 and 2.1 in 2005.

Among Finnish children and adolescents (age groups 0–9 and 10–19 years), fatal poisoning rates were low during the whole 35-year period compared to adults. The incidence of poisoning deaths in these age groups varied from 0.0 to 2.7 per 100,000 person-years. There were no deaths caused by alcohol in children aged 0–9 years and 39 deaths in adolescents aged 10–19 years during the study period.

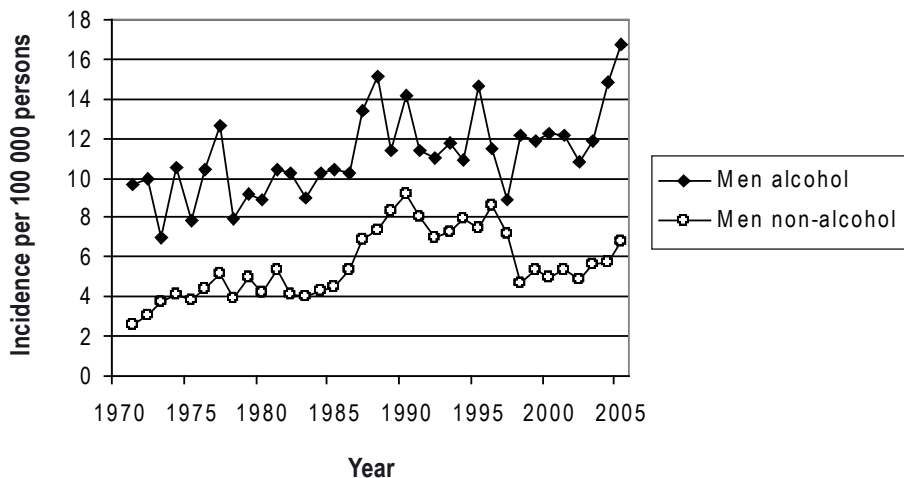
Men

During the 35-year study period, from 1971 to 2005, poisoning deaths increased in men (Figure 4). In 1971, the incidence of all poisoning deaths in men was 12.2 per 100,000 person-years (total number 273), while in 2005, the corresponding figure

was 23.6 per 100,000 person-years (total number 607). Both alcohol and non-alcohol poisoning deaths increased.

In 1971, the incidence of deaths attributable to alcohol was 9.6 per 100,000 person-years among men (total number 215) (Figure 4). In 2005, the corresponding figure was 16.8 per 100,000 person-years (total number 431). The age groups with the highest overall incidence rates in alcohol-attributable deaths consisted of 40–69-year-olds. The peak incidence, 41.8 deaths per 100,000 person-years (total 169), was seen among 50–59-year-old men in 2005.

FIGURE 4. Incidence of poisoning deaths in Finnish men between 1971 and 2005.

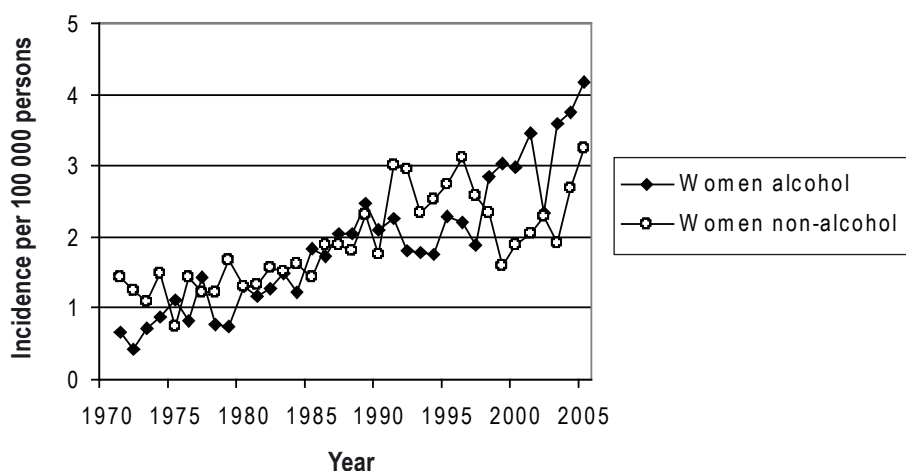


The incidence of non-alcohol poisoning deaths increased in men during the study period. In 1971, the incidence of poisoning deaths was 2.6 per 100,000 person-years in men (total number 58), while in 2005 the corresponding figure was 6.8 per 100,000 person-years (total 176). The highest annual incidence of fatal non-alcohol poisonings in men (9.2 per 100,000 person-years, total 223) was seen in 1990. In 2005, the highest incidence rate of non-alcohol poisoning deaths among males was seen in the age group of 40–49 years with 12.3 poisoning deaths per 100,000 person-years (total 47).

Women

During the study period of 35 years, poisoning deaths increased markedly in women, most clearly in alcohol deaths (Figure 5). The incidence of all poisoning deaths was 2.1 per 100,000 person-years among women (total number 50) in 1971.

FIGURE 5. Incidence of poisoning deaths in Finnish women between 1971 and 2005.



The corresponding figure in 2005 was 7.4 per 100,000 person-years (total number 199).

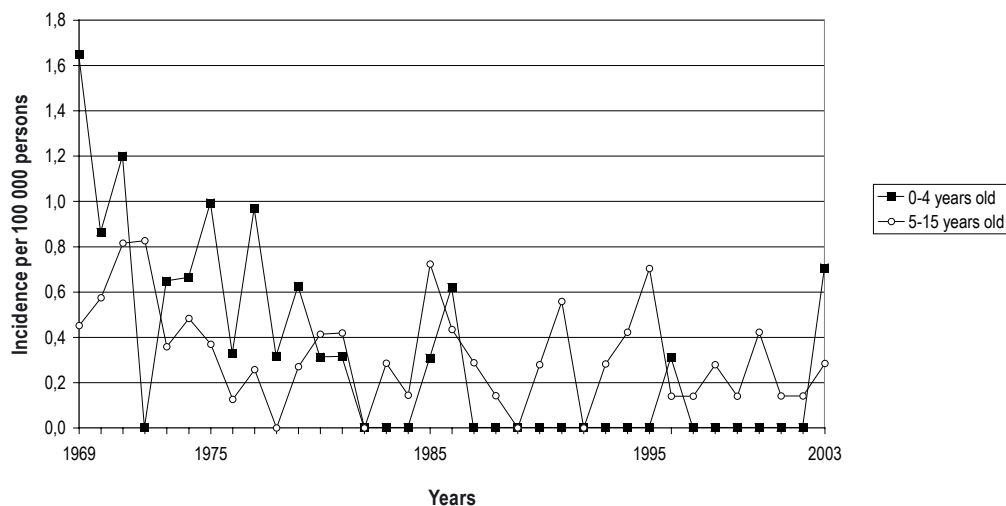
In 1971, the incidence of alcohol-attributable deaths was 0.7 per 100,000 person-years among women (total number 16). In 2005, the corresponding figure was 4.2 per 100,000 person-years (total number 112). The age group with the highest overall incidence rate was that consisting of 40–69-year-old women. The highest incidence of alcohol-attributable deaths among women, 12.8 per 100,000 person-years (total 52), was seen in 2005 among 50–59-year-old women.

The incidence of non-alcohol poisoning deaths among women was 1.4 per 100,000 person-years (total number 34) in 1971. In 2005, the corresponding figure was 3.2 per 100,000 person-years (total 87). In women, the peak year also in non-alcohol poisonings was 2005 (3.2 per 100,000 person-years, total 87). In that year, the highest incidence, 7.9 fatal poisonings per 100,000 person-years (total 32), was seen in the age group of 50–59 years women.

Paediatric poisoning deaths

During the study period 1969–2003 (in Study IV), altogether 121 children aged 0 to 15 years died from poisoning in Finland. The number and incidence of poisoning deaths among Finnish children showed a decreasing trend during this period from 10 deaths in 1969 (incidence being 0.8 per 100,000 person-years) to 4 in 2003 (incidence 0.4 per 100,000 person-years) (Figure 6).

FIGURE 6. Incidence of poisoning deaths among 0 to 15-year-old Finnish children in 1969–2003.



0 to 4 years old

Most (26/35) of the deaths among 0 to 4-year-old children were unintentional poisonings between 1969 and 2003. The total number of poisoning deaths among 0 to 4 years old children declined to practically zero by the beginning of the 1980s (Figure 7). The total number of intentional poisonings inflicted by another person (all collateral suicides) was 8 (23%) in this age group.

Slightly over a half (N=19; 54%) of the fatal poisonings occurred at home. Eight poisonings leading to death took place in car (or garage or caravan). Most of these (7/8) were carbon monoxide poisonings. Three poisonings took place at hospital (medication errors). Slightly more boys (N=22; 63%) than girls (N=13; 37%) died in this age group (0 to 4-year-olds). Six boys (27% of 22) and two girls (15% of 13) died in collateral suicides. None of these gender differences were statistically significant.

Pharmaceuticals caused 14 fatal paediatric poisonings (40%) among 0 to 4 years old children in Finland during 1969–2003 (Table 6). Nearly all (N=13; 93%) of the deaths caused by pharmaceuticals were unintentional. Deaths due to nervous system drugs accounted for the majority (57%) of these fatal drug intoxications. Psycholeptics were most often involved causing four (29%) of all drug poisoning deaths in this age group. Most (3/4) of these poisonings were caused by neuroleptics. Non-pharmaceuticals caused 18 poisoning deaths (51%) (Table 6). In most of these (N=10; 56%) the toxic agent was carbon monoxide among 0–4-year-old children.

FIGURE 7. Number of poisoning deaths among 0 to 4-year-old Finnish children in 1969–2003.

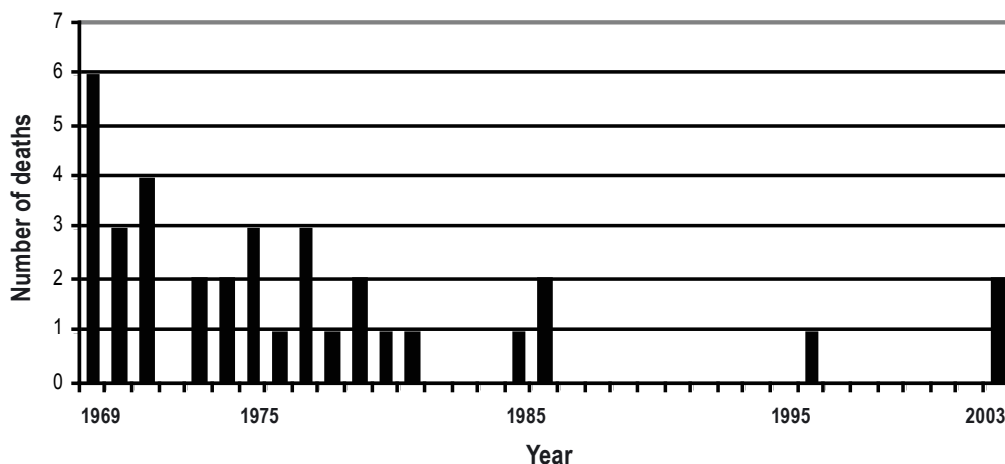


TABLE 6. Distribution of the causing agents and intent in paediatric poisoning deaths from 1969 to 2003 among 0 to 4-year-old Finnish children.

Agents	Number	(%)	Un-intentional %	Intentional by another person %	Unclear %
Pharmaceuticals	14	(40.0%)	92.9%	0.0%	7.1%
Nervous system	8	(22.9%)	100.0%	0.0%	0.0%
<i>Psycholeptics</i>	4	(11.4%)	100.0%	0.0%	0.0%
<i>Psychoanaleptics</i>	2	(5.7%)	100.0%	0.0%	0.0%
<i>Analgesics</i>	1	(7.1%)	100.0%	0.0%	0.0%
<i>Anesthetics</i>	1	(7.1%)	100.0%	0.0%	0.0%
Alimentary tract and metabolism	2	(5.7%)	100.0%	0.0%	0.0%
Cardiovascular system	2	(5.7%)	100.0%	0.0%	0.0%
Blood and blood forming organs	1	(2.9%)	100.0%	0.0%	0.0%
Respiratory system	1	(2.9%)	0.0%	0.0%	100.0%
Non-Pharmaceuticals	18	(51.4%)	66.7%	33.3%	0.0%
Carbon monoxide	10	(28.6%)	50.0%	50.0%	0.0%
Other industrial products	3	(8.6%)	66.7%	33.3%	0.0%
Insecticides	2	(5.7%)	100.0%	0.0%	0.0%
Domestic products	1	(2.9%)	100.0%	0.0%	0.0%
Ethanol	1	(2.9%)	100.0%	0.0%	0.0%
Fuels, lighter fluids and solvents	1	(2.9%)	100.0%	0.0%	0.0%
Multiple agents	3	(8.6%)	33.3%	66.7%	0.0%
Total	35	(100.0%)	74.3%	22.9%	2.9%

5 to 15 years old

Five to 15 years old children and adolescents accounted for 86 (71%) of all paediatric poisoning deaths in Finland during 1969–2003. The number and incidence of poisoning deaths varied during the study period (Figure 6).

Of the fatal poisonings, 41% occurred at home. The place of intoxication was unknown in up to 22% of the cases. Some 12% of the fatal poisonings occurred outdoors (e.g. forest) and 9% in a car or garage or caravan (all carbon monoxide poisonings).

Girls comprised 52% of the cases and boys 48%. Up to 66% of the poisonings were intentional self-poisonings and 37% of the cases were considered suicides among the 5 to 15 years old children. Among girls, up to 53% (24/45) of the deaths were classified as suicides while among boys the proportion of suicides was significantly lower (20%) ($p=0.017$). There were no significant changes in poisoning suicide rates during the study period.

Substance abuse was involved in 30% of the fatal poisonings and it was more common among boys (54%) than among girls (9%) ($p<0.001$). Substance abuse was involved in poisoning deaths in 10 cases in the 1970s, in eight cases in the 1980s and in four cases in the 1990s. Between 2000 and 2002, there were 3 fatal cases involving substance abuse, suggesting no decreasing trend of poisoning deaths due to substance abuse. Six of the poisoning deaths (7%) resulted from harm inflicted intentionally by another person. All these deaths were collateral suicides caused by carbon monoxide. Medication errors caused altogether three (9%) of the fatal drug poisonings among 5–15-year-old children.

Pharmaceuticals caused 37% of fatal poisonings in Finland during 1969–2003 among 5 to 15 years old children (Table 7). Deaths due to nervous system drugs accounted for the majority (64%) of these fatal intoxications. Dextropropoxiphen (analgesic) caused altogether eight deaths (24%) among 5 to 15 years old between 1979 and 2000 and represented the most common lethal medicine among Finnish children and adolescents during this 35-year period. The majority (5/8) of these deaths caused by dextropropoxiphen were suicides. Tricyclic antidepressants caused five poisoning deaths (15%).

Non-pharmaceuticals accounted for 48% of poisoning deaths in the 5–15-year-old age group (Table 7). Glues, fuels, lighter fluids and solvents accounted for altogether 17 fatal poisonings (20%) in this age group. Inhalation abuse deaths were slightly more common in the 1970s (5 cases) and the 1980s (7 cases) than in the 1990s (3 cases). None of the deaths from glue poisoning occurred after the 1980s, instead, all three latest sniffing deaths (1991–2001) were caused by butane. Inhalation abuse was also involved in one multi-agent poisoning death in 2000.

TABLE 7. Distribution of the causing agents and intent in paediatric poisoning deaths from 1969 to 2003 among 5 to 15-year-old Finnish children and adolescents.

Agents	Number	(%)	Substance abuse %	Intentionally inflicted by oneself %	Unintentional %	Intentionally inflicted by another person %	Unclear %
Pharmaceuticals	33	(37.2%)	15.2%	69.7%	12.1%	0.0%	18.2%
Nervous system	21	(24.4%)	23.8%	71.4%	0.0%	0.0%	28.6%
Analgesics	9	(10.5%)	22.2%	88.9%	0.0%	0.0%	11.1%
Psychoanaleptics	6	(7.0%)	0.0%	66.7%	0.0%	0.0%	33.3%
Antiepileptics	3	(3.5%)	0.0%	33.3%	0.0%	0.0%	66.7%
Psycholeptics	2	(2.3%)	100.0%	50.0%	0.0%	0.0%	50.0%
Other nervous system	1	(1.2%)	100.0%	100.0%	0.0%	0.0%	0.0%
Cardiovascular system	6	(7.0%)	0.0%	83.3%	16.7%	0.0%	0.0%
Antineoplastic & immuno-modulating agents	2	(2.3%)	0.0%	0.0%	100.0%	0.0%	0.0%
Musculoskeletal system	2	(2.3%)	0.0%	50.0%	50.0%	0.0%	100.0%
Antiparasitic products	1	(1.2%)	0.0%	100.0%	0.0%	0.0%	0.0%
Genitourinary system and sex hormones	1	(1.2%)	0.0%	100.0%	0.0%	0.0%	0.0%
Non-Pharmaceuticals	41	(47.7%)	45.2%	61.0%	17.1%	14.6%	7.3%
Carbon monoxide	10	(28.6%)	0.0%	27.8%	38.9%	33.3%	0.0%
Glues	9	(10.5%)	100.0%	100.0%	0.0%	0.0%	0.0%
Fuels, lighter fluids and solvents	8	(9.3%)	87.5%	87.5%	0.0%	0.0%	12.5%
Ethanol	2	(2.3%)	100.0%	50.0%	0.0%	0.0%	50.0%
Insecticides	2	(2.3%)	0.0%	100.0%	0.0%	0.0%	0.0%
Other alcohols	1	(1.2%)	0.0%	0.0%	0.0%	0.0%	100.0%
Unknown	1	(1.2%)	0.0%	100.0%	0.0%	0.0%	0.0%
Multiple agents	12	(14.0%)	16.7%	75.0%	0.0%	0.0%	25.0%
Total	86	(100.0%)	30.2%	66.3%	12.8%	7.0%	14.0%

Ethanol caused two (2%) poisoning deaths. Twelve poisoning deaths (14%) were caused by multiple agents. Ethanol was involved only in one of these fatal multi-agent poisonings. Illicit drugs did not cause any fatal poisonings among Finnish children during the study period.

Paediatric poisoning deaths in hospitalised patients

During the 35-year study period 1971–2005, altogether 41,862 hospital stays due to poisoning were recorded involving a total of 38,582 Finnish children and

adolescents aged 0 to 19 years. The number of hospitalised patients who had died from poisoning was investigated. Of all hospitalised patients 32 died during the initial hospitalisation. In addition there were 380 subsequent poisoning deaths of which nearly all (99.8%) occurred more than 30 days after the initial hospitalisation and before the end-point of the study in 2005.

Paediatric poisoning deaths in Tampere University Hospital

During 2002–2006, there were altogether 369 paediatric ED visits at the Tampere University Hospital due to poisoning among 0 to 15 year-old children. Of these, one 2-year-old boy died from ingesting grill lighter fluid. The overall mortality was 0.3%, and the incidence of poisoning deaths among children within the catchment area of the study hospital was 0.24 per 100,000 person-years (95% CI 0–0.71).

DISCUSSION

In this thesis the incidence and nature of paediatric poisonings and poisoning deaths were investigated in the Finnish population. The incidence figures of ED visits among 0–15-year-old children demonstrated that acute paediatric poisonings represent a relatively frequent problem in Finland. In poisoning hospitalisations a decreasing trend was most clearly seen in small children. Nonetheless, an increasing trend in hospital admissions due to alcohol poisoning was also noticed. At the same time, the overall trend in poisoning deaths in the country was ascending. While the number of paediatric poisoning deaths among the youngest children was decreasing, the incidence of fatal poisonings among 5–15 years old children varied during the last few decades.

In this study performed in Tampere University Hospital the mean annual incidence of ED visits for poisoning among children aged 0 to 15 years was 8 per 10,000 person-years. This incidence is clearly lower than that of 0 to 15 years old children treated in hospital in the beginning of the 1980s in Helsinki (15 per 10,000 person-years) (Eskola 1983).

The incidence of ED visits for paediatric poisoning was lower (8 per 10,000 person-years) than in studies from France (14 per 10,000 person-years) and Italy (35 per 10,000 person-years) (Marchi et al. 1998, Lamireau et al. 2002). On the other hand the incidence rates of childhood poisonings in Finland seem to be congruent with the latest report from Norway (Rajka et al. 2007). The differences of societies and healthcare systems in Finland compared to France and Italy may explain these margins. For example, in Italy the number of doctors per 1,000 citizens is clearly higher than in Finland and paediatricians are working in primary health care (Lääkäriksi ulkomaille Lääkäriliiton opassarja 2002). These factors may lower the threshold for contacting a doctor in poisoning cases. The Finnish culture and society is probably closer to that of Norway.

The Finnish PIC was contacted in every third poisoning case. Good practical skills among healthcare professionals in the most common poisoning cases may be one possible reason for the relatively low number of contacts to the PIC in

poisoning cases. However, the threshold for contacting may be too high. The fairly low proportion of contacts to the PIC in poisoning cases further suggests that the poisoning statistics of the PIC represent only a moderate part of all poisoning exposures occurring in homes and treated in primary health care and hospitals of this country.

During the study period, 1971–2005, there were altogether 41,862 hospitalisations for poisoning among 0 to 19 years old children and adolescents in Finland. The majority of these patients were 0–14 years old. Even though a decreasing trend was seen in hospitalisations, it may be concluded that poisonings resulted in nearly 1,000 hospitalisations among Finnish children and adolescents annually.

The declining trend seen between 1971 and 2005 in the incidence of hospital admissions due to paediatric poisonings in Finland was mostly due to the dramatic decrease of poisonings among 0 to 4-year-old children since the early 1990s. The median length of hospital stay was one day in the present study, which corresponds with the findings of the previous studies (Smith 1991, Gauvin et al. 2001).

In the study performed in the United States during 1987–1997, the median hospital charges were 2096 dollars per case (Gauvin et al. 2001). In another study from the United States, the charges per each paediatric patient visit hospitalised due to poisoning were 4968 dollars in 1995. It may be estimated that in Finland hospitalisations due to paediatric poisonings alone are responsible for costs amounting to at least two million euros annually.

Pharmaceutical agents have been encountered more often at emergency visits and hospital admissions related to acute paediatric poisonings as compared to non-pharmaceutical products (Gauvin et al. 2001, Mintegi et al. 2006, Patel et al. 2006). In this study, by contrast, non-pharmaceutical agents caused up to 60% of the poisonings leading to ED visits. A similar difference compared to other studies was also noticed with regard to hospital admissions for poisonings, as only half of all hospitalisations due to poisoning were caused by drugs and medicinal substances. Gauvin et al reported only 20% of paediatric hospitalisations due to poisoning being caused by non-pharmaceuticals (Gauvin et al. 2001).

In previous reports, poisonings from pharmaceuticals among the youngest children (under 5 years) have accounted for slightly over half of the ED visits and by paracetamol alone up to 20% (Mintegi et al. 2006, Patel et al. 2006). Findings in the present study were quite similar to these, as drugs comprised nearly half of the poisoning cases in this age group. On the other hand, the amount of poisonings caused by sedatives has been reported fairly low (2%) among children under 8 years of age in previous studies (Rajka et al. 2007). In the present study, however, analgesics

were the cause of poisoning in only a small number of cases, while psycholeptics were the most frequently encountered drugs among the youngest children.

The high amount of ethanol poisonings among Finnish children and adolescents may explain some differences between countries. The proportion of alcohol in ED visits due to paediatric poisonings has been under 10% in reports from many other countries (Marchi et al. 1998, Mintegi et al. 2006). In this study alcohol was involved in up to 31% of all poisoning-related ED visits. Among the 10 to 15 year-olds, ethanol poisonings accounted for 64% of all ED visits due to acute poisonings. In Norway, the proportion of ED visits due to alcohol poisoning among adolescents was recently reported to be 45% (Rajka et al. 2007). However, figures in Finland are even more striking.

The huge amount of alcohol poisonings in our country was also observable in paediatric hospitalisations due to poisoning. Up to 53% of the 10 to 14-year-old patients hospitalised for poisoning had the primary diagnosis of alcohol poisoning. For example, in the United States, hospital admissions due to alcohol poisonings have constituted only 6% of all poisoning cases (Gauvin et al. 2001). Moreover, the incidence of hospitalisations for alcohol poisoning among Finnish children and adolescent increased two-fold between 1971 and 2005, which indicates that the problem is not disappearing.

Hospitalisations for alcohol poisoning increased 1.7-fold among boys and 2.4-fold among girls during 1971–2005. An increase in hospital admissions in the 1990s due to alcohol poisoning among children and adolescents has been reported previously in Helsinki (Lamminpää 2004). This study, covering the whole country and a long time period, underlines this growing problem. Drunkenness-oriented drinking is known to be a serious problem in Finland. Intoxication due to alcohol has traditionally been common in our country (Poikolainen et al. 2002). Especially adolescent alcohol consumption has aroused concern among public health professionals (Lintonen et al. 2000).

Reports from the 1980s and 1990s have been alarming. Based on a Finnish study the age-adjusted monthly drunkenness rates among 14 to 18-year-olds rose from 13% to 27% among boys and from 6% to 22% among girls between 1981 and 1999 (Lintonen et al. 2000). An increase in hospital admissions due to alcohol poisonings was seen in this study as well, especially among girls. Incidences among boys during this period varied greatly and the increasing trend was not so clear in the 1980s and 1990s.

In the beginning of the 21st century, drunkenness-oriented drinking declined and the proportion of adolescents abstaining from alcohol has increased among Finnish adolescents (Rimpelä et al. 2007). In the present study some decrease was

seen in alcohol-related hospitalisations in both genders in 2000–2002, but then again there was a sharp rise in hospitalisations until 2005.

Various reasons have been offered to explain the rising trend of alcohol poisonings in Finland. Drinking has become more acceptable in public places. Furthermore, becoming a member of the EU may have increased alcohol consumption as well as the general acceptance for women's use of more alcohol (Kannus et al. 2005). The latest sharp increase in Finnish alcohol consumption and poisoning deaths is most probably due to the marked lowering of alcohol taxes in the beginning of 2004. Taxes have been raised after that, but the effect of this raise has not been seen yet.

However, alcohol poisoning deaths among the paediatric population (0 to 15 years old) have been uncommon during the last few decades. As a single agent ethanol caused three poisoning deaths and was involved in only one fatal multi-agent poisoning case in this paediatric population during 1969–2003. On the other hand, in the whole Finnish population, the incidence figures for alcohol poisoning deaths in Finland were high. Alcohol death rates increased clearly during 1971–2005 and this was most distinctly seen in women. In the early 1970s, the incidence rates of alcohol deaths were about ten times higher in men compared to women, while in the last few years of observation, men's incidence rate was about four times higher. This is probably due to increased alcohol consumption among women and the increased general acceptance for women's use of alcohol (Kannus et al. 2005).

Since alcohol poisoning deaths predominate in the fatal poisoning statistics in Finland, it was decided to study deaths by alcohol separately from other poisonings. Also the incidence of poisoning deaths from other than alcohol increased in the whole population during the study period of 35 years. Men had twice as many fatal poisonings compared to women. This concurs with gender distribution in poisoning deaths from other countries (The Injury Chart Book 2002).

When all poisoning deaths were counted together (alcohol and non-alcohol) and the incidence calculated, it was seen that poisoning deaths increased markedly in Finland during 1971–2005. In 1971, the incidence of all poisoning deaths was 12.2 per 100,000 person-years in men and 2.1 per 100,000 person-years in women. In 2005, the corresponding figures were 23.6 per 100,000 in men and 7.4 per 100,000 in women. These poisoning death incidence figures are clearly higher than fatal poisoning rates in other high-income countries of the European Region or any other continent (The Injury Chart Book 2002). Figures of same magnitude are reported among men in the low- and middle-income countries of the European Region. High alcohol abuse may explain the similar incidence figures in these countries.

In Finland the OCDS are based on the 54-class classification system, in which suicides constitute their own class apart from poisonings (Official Statistics of Finland ... 2006). In the present study the number and incidence of poisoning deaths were so high that many of the poisonings are likely to be intentional self-harm or actual suicides. Suicide figures in Finland have been among the highest in the world, especially for men (Official Statistics of Finland ... 2006). Poisoning is a well-known suicide method around the world and Finland is no exception (Isometsä et al. 1997). The decline in suicides since the 1990s has been explained partly by the new antidepressants which are safer and less toxic even in large amounts than older similar drugs (Öhberg et al. 1998, Frey et al. 2000). One possible reason for the increase in fatal poisoning deaths may be the growing drug abuse and use of illicit drugs (Poikolainen 1998).

Studies concerning the effectiveness of preventive alcohol interventions are somewhat contradictory. In some studies the overall efficacy of these interventions has been rather modest (Nilsen et al. 2006). On the other hand, some investigations have shown that for example a brief alcohol intervention can be effective (Seppä and Salaspuro 2003). Raising the alcohol tax rates has shown an effective and economical way to reduce alcohol consumption in developed countries (Alkoholipolitiikan kuluttajaopas 2004).

According to death certificates altogether 121 children aged 0 to 15 years died from poisoning in Finland during the study period 1969–2003. In the 1950s, there were annually 10–24 accidental poisoning deaths in Finland among 0–4-year-old children (excluding carbon monoxide poisonings) (Tallqvist and Korpela 1959). The main reason for the establishment of the Poison Information Centre (1961) was the high poisoning mortality in young children (Visakorpi 1971). In 1960–1968, the average number of poisoning deaths (excluding carbon monoxide poisonings) among children under 5 years of age was still 10 (Official Cause of Death Statistics 2005). A substantial decrease in poisoning deaths in the youngest children was seen in this study. Among 0–4-year-olds the incidence of poisoning deaths declined to practically zero by the beginning of the 1980s. This was probably mostly due to marked improvements in product reformulations, child-resistant closures, heightened parental awareness of toxic products and advances in health care (Liebelt and DeAngelis 1999).

Among 5–15-year-olds the incidence of poisoning deaths varied during the study period. While most of the deaths among 0–4 years old children were unintentional poisonings, a high proportion of poisonings were intentional in the 5–15-year age group. Gender differences were also seen. Although the distribution of fatal poisonings per gender was almost equal among the 5 to 15-year-olds in this

study, suicides were more common in girls and substance abuse in boys, which emphasises the difference between genders in adolescent intentional poisonings. Collateral suicides occurred in all ages and both genders.

When two of the databases (III and IV) describing figures of poisoning deaths among 0–14-year-old children during 1971–2003 were compared, it was observed that the figures were different (41 cases vs. 69 cases). This suggests that the OCDS does not include all poisoning deaths. The most probable reason for this difference is the fact that in the OCDS data (III) evident suicides are reported in their own class even if the death was registered as being caused by an intoxicant.

Internationally, studies concerning the trend of paediatric poisoning deaths have been scarce. In a previous British study Flanagan et al reported that the incidence of childhood poisoning deaths in children aged 0 to 9 years decreased from 2.06 to 0.46 per 100,000 person-years during 1968–2000 (Flanagan et al. 2005). In this study, the incidence rates were somewhat lower in Finnish children of this age group during the corresponding period, but showed a similar decreasing trend. In a study conducted in Estonia during 2001–2005 the age-specific average annual mortality due to poisonings among 0 to 14-year-old children was 1.4 per 100,000 person-years (Väli et al. 2007). The present study showed that in Finland the incidence of poisoning deaths among 0 to 15-year-old children was 0.4 per 100,000 person-years in 2003.

In the present study nervous system drugs accounted for slightly over a half of the paediatric drug poisoning deaths. The findings were similar to the study performed in England and Wales during 1968–2000. Flanagan et al reported that antidepressants, barbiturates, opiates and salicylates accounted for 50% of all fatalities due to childhood drug poisonings (Flanagan et al. 2005). However, the findings are not totally comparable due to the different classification systems of agents and the unequal age groups.

The present study also revealed that about 38,000 Finnish children and adolescents were hospitalised due to poisoning and up to 380 died in subsequent poisonings more than 30 days after the initial hospitalisation and before the end of year 2005. This suggests that hospitalisation due to poisoning may be a significant risk factor for experiencing fatal poisoning later in life.

Strengths and limitations of the study

The strengths of this study include the availability of the exact annual mid-populations for each age group and the use of an internationally recognised

classification system (ATC) on pharmaceutical agents. The incidence rates of ED visits due to poisoning, hospital admissions and poisoning deaths were based on the annual mid-populations in Finland. These were obtained from the Official Statistics of Finland, which offers a reliable computer-based national population register (Official Statistics of Finland ... 2006).

The rates of paediatric ED visits due to poisoning in Tampere University Hospital were identified by a computer search from the Hospital Information System using the International Classification of Diseases Tenth revision (International Statistical Classification ... 1992). In this hospital information system, double coding is used for poisonings: the primary poisoning code and the external cause code. The fact that poisonings were identified with both diagnosis and external causes ensures that no cases were missed due to underreporting of external causes. Naturally, poisoning cases in which the physician has recorded a completely wrong diagnosis may have been missed in this search. However, the validity of hospital discharge codes has been studied in Finland. Since an accuracy of 96% in the diagnosis codes for poisonings and 96% in the paediatric diagnosis codes have been shown in these studies (Aro et al. 1990), it may be concluded that the validity of this search is reliable.

Investigation of the secular trend of hospitalisations due to poisoning in Finnish children and adolescents was performed with the computer search from the NHDR. The strengths of this register are that it covers the entire population and that it is based on the ICD classification. A limitation in the use of the NHDR is the underreporting of external causes (Mattila et al. 2006). Thus, the search was based only on the primary diagnosis and not the external causes of poisoning. A further limitation in the present search was the fact that a fairly high proportion of patients admitted to hospital due to poisoning were diagnosed with a non-specified poisoning code (McCaig and Burt 1999). However, the distribution of agents to drugs and non-drugs seems to be clear. In addition, the validity of the Finnish NHDR has been investigated and found to be excellent (Aro et al. 1990).

Reporting ED visits for childhood poisonings has been more common than reporting incidence rates of hospital admissions for childhood and adolescent poisonings. A notable strength in describing the poisoning hospitalisations among children and adolescents was the long study duration (35 years). Corresponding secular trends of hospitalisations due to poisonings have not been previously reported in international publications. Previous studies have covered shorter periods of time and have been conducted within one hospital catchment area or within one province (Smith 1991, Mintegi et al. 2006). A further strength of this

study was that the hospitalisation data were obtained from all Finnish hospitals and thus covered the entire country.

To report poisoning deaths in Finland the data were obtained from the OCDS, an extensive, medico-legal death investigation system in the country (Official Cause of Death Statistics 2005). The OCDS are based on death certificates that have been collected by Statistics Finland since 1936. The accuracy of the data of OCDS of Finland is maximised in a 3-phase process: first by the local authority, second by the forensic officer and finally by Statistics Finland. Since the codes are further verified by autopsies performed in 94% to 97% of the injury (including poisoning) deaths, it may be concluded that accuracy of these statistics is excellent (Kannus et al. 1999, Official Cause of Death Statistics 2005). In addition, all chemical analyses performed after a poisoning death are performed in the same laboratory (Lahti and Vuori 2002, 2003). This further enhances the reliability of death certificates in poisoning cases. A limitation of death certificates is that information on the circumstances surrounding the poisoning deaths obtained from certificates is usually somewhat limited.

The length of the study period, 35 years, is a major strength in the reporting of poisoning deaths in Finland. Other strengths in describing poisoning deaths were that this study covered the entire population of Finland and that in this country practically all poisoning deaths are submitted to medico-legal cause-of-death determination (Lahti and Vuori 2003). This medico-legal practise includes information on the medical and other history of the deceased, circumstances of the death, and autopsy and toxicological findings so that a forensic examiner can form a justified, evidence-based opinion about the manner and cause(s) of death (Lahti and Vuori 2003).

Secular trends in fatal poisonings in whole populations or among children and adolescents have been little investigated (Flanagan et al. 2005). The present study profiled both.

The present study has several limitations. Any poisoning – especially paediatric poisoning – is often an unclear event. Serious poisoning events may not always have any witness, and the amount of poisoning substance is frequently obscure (Bryant and Singer 2003). A limitation of the reporting of ED visits was that we analysed only the acute paediatric poisonings treated in one main university hospital. Consequently, we did not have the figures of less severe poisonings treated in health centres within the hospital district. However, we may assume that in paediatric poisoning cases patients are often referred to the central or university hospital and are rarely treated in primary health care. Nonetheless, the figures of the paediatric or any other poisonings treated outside of the study hospital are not known. In

addition, the exact figures and distribution of paediatric poisoning patients treated in detoxification centres were not investigated. Within the study hospital catchment area, there is a community centre staffed by social workers, which houses a room for under-aged adolescents to stay if they are drunk. In paediatric poisoning cases assumed to need professional medical services, the persons are, however, always transferred to hospital care.

In describing the hospitalisations due to paediatric poisonings the more specific ICD-10 codes were re-classified into the ICD-9 codes in order to maintain comparability between years. In the process of recoding ICD-10 to ICD-9 some information might have been lost as the ICD-10 codes are more accurate. The data may also include some cases in which the patient had been treated in more than one hospital due to a single poisoning. In addition, due to underreporting of external causes there is a lack of sufficient evidence to determine whether the poisoning was intentional or unintentional. Furthermore, since the data was based on ICD-codes and hospitalisation statistics instead of clinical data, the management and outcome of the patients, specific agents causing the poisonings or co-ingestions could not be reported. However, it is notable that the validity of the Finnish National Hospital Discharge Register has been investigated and found to be excellent: the accuracy rate of the diagnosis codes for poisonings was 96% (Aro et al. 1990).

A limitation in reporting the poisoning deaths in Finland was that, owing to international statistics regulations, some poisonings can be classified as diseases rather than poisonings in the Finnish mortality statistics (Lahti and Vuori 2002, Vuori et al. 2006). However, we used the same classification system for the entire study period and thus our results are comparable throughout 1971–2005. Comparability between years in the 54-class classification system is a notable strength of the OCDS in Finland. A limitation is that this database does not include information on the single agents that caused the poisonings except alcohol. A further limitation is that this database does not include evidence that would enable to determine whether the poisoning death was unintentional or intentional. In addition, obvious suicides are reported in their own category in the 54-class classification system and they are not included in this data. Finally, the OCDS do not include information on the chronicity of the intoxications. However, we may assume that most of them were acute events (McGuigan 2003).

Prevention of poisonings

This study showed that poisonings in the paediatric population continue to represent a frequent problem in Finland. High, and growing, incidence figures of poisoning deaths among Finnish adults are also a cause for concern. The growing number of alcohol poisoning deaths among women is particularly disturbing. The substantial lowering of alcohol taxes in Finland in 2004 received criticism from health care professionals (Hillbom 2005). A subsequent raise of the taxes was decided by the Finnish Parliament in November 2007 and put into effect in the beginning of 2008. It is too early yet to assess the impact of this change, but it is possible that the raise was not sufficient to induce changes in drinking behaviour.

The large number of ED visits and hospitalisations due to alcohol poisoning is a cause of concern. Although positive changes have been reported in terms of reduced drunkenness-oriented drinking and increase of abstinence among adolescents (Rimpelä et al. 2007), this study highlights the need to develop more effective primary prevention programmes to reduce alcohol consumption in adolescence. The influence of parents and families plays still the most important role. More liberal drinking habits and permissive thinking towards drinking in adolescence is alarming. An increase in total consumption of alcohol in Finland in the last few years has been reported (Huttunen 2006). A decrease in alcohol consumption and alcohol-related problems in children and adolescents may be achieved by changes in the attitudes of the adult population and through increased adult supervision. The elevation of alcohol taxes by only a few per cents in mild alcohols is not likely to have a marked effect on drinking in adolescence. In addition, stricter legislation in shops that sell spirits to under-aged adolescents is needed. Reports have shown that about half of the under-aged adolescents managed to buy alcohol from retail sale stores (Holmila et al. 2005). This also suggests that punishments for selling alcohol to minors have been too lenient. In Sweden the lowering of the alcohol percentage of medium strength beer succeeded to reduce the total consumption of alcohol in the country (Huttunen 2006). This solution has been proposed also by Finnish healthcare professionals.

Prevention measures such as child-resistant packaging, heightened parental awareness of toxic substances, other protective measures such as interventions by the PIC and rapid advances in health care have contributed to the reduction of paediatric poisonings and poisoning deaths among children during the last few decades (Liebelt and DeAngelis 1999). The decline in deaths from accidental poisoning among the youngest children to practically zero may give an illusion that the danger has disappeared in our country. The poisoning death of a 2-year-

old boy in 2003 after unintentionally ingesting grill lighter fluid reminds us that the danger of fatal poisoning among the youngest children continues to exist.

A few decades ago many tablets were sugar-coated and, since small children might eat several tablets without taste aversion, irreversible outcomes resulted (Pharmaca Fennica 1985). This fatal history should not be forgotten. Nowadays pharmaceutical industry is once again developing more flavoursome drugs (Suzuki et al. 2004). This development may have some serious disadvantages. The most threatening and dangerous risk in such drug development is the possibility that the flavouring of pharmaceuticals is extended to drugs meant for adults, without concern for potential consequences in children. Ingestion of only one tablet may be fatally toxic for a small child (Michael and Sztajnkrzyer 2004). Regarding the risks of drug poisonings in the future the pharmaceutical industry thus plays a very important role, and it should take more responsibility for actions promoting poisoning prevention.

Child-resistant packaging is known to reduce child mortality from the unintentional ingestion of oral prescription drugs (Rodgers 1996). Legislation and directives concerning child-resistant packaging have been efficient in many countries in reducing severe paediatric poisonings (Aalto 1988). Becoming a member of the EU in 1995 may have had some effect on the recent decline in hospital admissions due to poisoning among the youngest children in Finland. The EU directives include fairly clear guidelines and regulations for child-resistant packaging (Council Directive ... 1967).

There is a paucity of research studies in the literature which investigate the effectiveness of childhood poisoning prevention programmes (Nixon et al. 2004). Home safety education and the provision of safety equipment improve poison-prevention practices (Kendrick et al. 2008). Home safety interventions increase the safe storage of medicines and cleaning products, and an easy access to PIC numbers, but there is a lack of evidence on poisoning rates (Kendrick et al. 2008). There is a clear need to increase studies aimed at developing effective poisoning prevention campaigns.

Injury prevention programmes in primary health care have traditionally given some information regarding poisonings to the Finnish population at large (Aalto 1988). Newsletters concerning toxic agents and first aid in poisoning events have been aimed at helping families with small children (Pyötsiä et al. 1988, Kinon et al. 1992, Hoppu et al. 2002). Child-resistant closures have been widely used in Finland in the last decades (Aalto 1988). Warnings concerning child-safe storing are often printed on containers that include agents which may be toxic for children. It is, nonetheless, possible that people have become dulled for these warnings.

Probably new more thought-provoking campaigns against poisoning in children are needed.

Most paediatric poisonings occur in the home and the poisoning agent is often obtained from home. Moreover, poisonings often occur in families with several children or in families where parents use drugs regularly. Risks are markedly higher if parents use nervous system drugs. Children may learn a pill-taking culture from their parents and tend to imitate their parents' acts such as taking a pill from the container if one is available. Primary prevention should be focused on these risk families with social problems to prevent unnecessary poisonings. Many of the poisoning accidents among the youngest children occur at the time when the agent is being used or if it is stored improperly. Thus, the use of locked cabinets when storing pharmaceuticals or toxic household products should be highlighted in these programmes (Koskenvuo 2003).

Another risk group that should be included in primary prevention programmes is adolescents over 10 years old. Along with alcohol as an independent agent abused, prevention should target children and adolescents who are at risk to commit suicide or to experiment with substance abuse. Psychiatric prevention with early diagnosing and treatment of depression and other mental disorders is needed. Gender distribution should be taken into account when prevention programmes are being planned. When medications are prescribed to treat mental disorders in adolescents, the toxicity of the prescribed dose should be considered along with assessing the risk of suicidal behaviour or substance abuse of the patient. Queues for psychiatric care for children and adolescents must be dissolved. Several months of waiting to receive the appropriate care is excessive and may result in suicidal events or careless substance abuse. Physicians treating paediatric poisoning patients should also be familiar with the fact that patients visiting ED due to poisoning are at risk of subsequent poisoning which may be even more dangerous than the first one. In addition, youngsters admitted to hospital due to poisoning are much more likely to suffer from mental disorders than their peers, another fact to be acknowledged by the physician after giving first aid in poisoning events. Consultation of psychiatrists specialised in paediatric patients should be a routine procedure rather than a measure reserved for the most difficult cases. Organising appropriate care for these patients includes educating more specialists and making this field of medicine more attractive for doctors.

Chemical assaults represent one form of child abuse (Hurme et al. 2008). Sometimes chemical assault may lead to homicide by poisoning agents. The present study also showed that collateral suicides by poisoning occur in Finland. Desperate parents should be identified in the primary health care and the symptoms of parental

mental illness should be recognised and treated earlier. Careful attention to child's welfare by social workers could save lives too. Collateral suicides and chemical assaults may be prevented through more effective social prevention methods.

Scientific challenges in the future

Poisoning research in Finland has many challenges in the future. The general trend in injury deaths has been decreasing in Finland during the last few decades. However, a corresponding decline in poisoning deaths in general was not seen in the present study. The reason for the rise in the number and incidence of poisoning deaths is not known, and the topic deserves further study.

Treatment for poisonings seems mostly to follow the latest guidelines. The number of hospital admissions due to poisoning is decreasing, but still nearly a thousand children and adolescents are hospitalised annually. In addition to subjective suffering, attention is drawn to the high costs of these hospitalisations. The total burden of costs of paediatric poisoning injuries in the country is not known and merits further research. Moreover, the reasons for the high proportion of ED visits leading to hospital admission of paediatric poisoning cases must be studied in the future. The costs of paediatric poisonings in Finland may be reduced by reducing unnecessary hospitalisations. However, this cannot be executed at the expense of children's safety.

Clear downward changes in adolescent poisoning death trends due to suicide or substance abuse were not seen in this study. This highlights the urgent need for promotion of the well-being of families and for health programmes against teenage alcohol and substance abuse. Since the risk factors for paediatric poisonings are not known in Finland, studies are needed to investigate factors predicting paediatric poisonings. Campaigns and studies focusing on child safety should be encouraged. Development of even more child-resistant closures to avoid exposures to toxic agents in homes is also important in the future. Follow-up studies are necessary to determine whether the new flavoured drugs are increasing the number of paediatric poisonings. Collaboration with pharmaceutical industry is particularly important in this type of investigation.

In epidemiological poisoning studies the most important factor in reporting the incidences of exposures are reliable databases. Databases used in this study offered solid grounds to report the secular trends of poisonings in Finland. The incidence of less severe exposures is not known. Although the Finnish PIC is contacted frequently in poisoning cases, many exposures are not entered into statistical

databases. The national primary care register might be used as a database with more knowledge of less severe but common poisoning exposures in the country.

Paediatric poisonings still present a frequent problem in Finland. Even though most of the poisonings are asymptomatic and do not need long hospitalisations, danger has not disappeared and fatal poisonings do occur. Continuous research and intervention efforts are needed to better control the burden of paediatric poisoning injuries in our society.

CONCLUSIONS

In this study the incidence and nature of paediatric poisonings and poisoning deaths were investigated in the Finnish population. The main findings of the study were the following:

- 1) The incidence figures of emergency department (ED) visits among 0–15-year-old children indicated that acute paediatric poisonings represent a relatively frequent problem in Finland.
- 2) In poisoning hospitalisations a decreasing trend was most clearly seen in small children. Nonetheless, an increasing trend in hospital admissions due to alcohol poisoning was noted.
- 3) An increasing trend in poisoning deaths in the whole Finnish population was reported. However, a decrease in the number of paediatric poisoning deaths among the youngest children was observed while the incidence of fatal poisonings among 5–15-year-old children varied during the last few decades.

Non-pharmaceutical agents caused up to 60% of the poisonings leading to ED visits, mostly due to multiple alcohol poisonings. A remarkable number of hospital admissions due to alcohol poisoning were identified in our country. Of the 10 to 14-year-old patients hospitalised for poisoning, 53% had the primary diagnosis of alcohol poisoning.

Bimodal distribution was seen in ED visits due to poisoning, with the youngest children (1–3 years) and adolescents (12–15 years) representing the majority. Boys predominated in the younger age groups, while girls had more ED visits and hospitalisations among adolescents. Most of the poisonings among the youngest children were unintentional. Intentional poisonings occurred more frequently among adolescents. Suicides were more common in girls and substance abuse in boys, which emphasises the difference between genders in adolescent intentional poisonings. Collateral suicides occurred in all ages and both genders.

Prevention measures such as child-resistant packaging and heightened parental awareness of toxic substances have reduced paediatric poisonings and poisoning deaths among children during the last few decades in Finland. Moreover, rapid advances in health care and interventions by the Poison Information Centre have improved the outcome of paediatric poisoning exposures. Nonetheless, poisonings remain a life-threatening problem in Finland among children and adolescents.

Continuous research and intervention efforts are needed to reduce paediatric poisonings in our society. Prevention programmes should be focused on families with an increased risk of paediatric poisoning. Mental illnesses among children, adolescents and their parents should be diagnosed and treated earlier to avoid unnecessary unintentional poisonings, substance abuse, suicidal behaviour, chemical assault and collateral suicides.

As a single agent, alcohol poses the strongest threat for the future. The high and growing numbers of alcohol poisonings among adolescents and alcohol poisoning deaths among adults highlight the need to intensify primary prevention activities against alcohol abuse in Finland.

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ORIGINAL PUBLICATIONS

Paediatric poisonings treated in one Finnish main university hospital between 2002 and 2006

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Abstract

Aim: Acute poisonings are a major cause of morbidity among children. This study aims to describe the incidence and nature of emergency visits for acute paediatric poisoning among Finnish children.

Methods: All patients younger than 16 years admitted to the Tampere University Hospital's emergency department with a diagnosis of poisoning during 2002–2006 were identified from the Hospital Information System using the International Classification of Diseases (ICD-10).

Results: Altogether 369 emergency visits were diagnosed with poisoning, the overall incidence being 8.1 per 10 000 person-years (95% CI 7.3–9.0). A majority of patients were adolescents aged 10–15 years (48%) and children under 5 years (45%). Boys represented 55% of the cases.

Nonpharmaceutical agents were suspected to be the cause in 60.4% and pharmaceuticals in 30.6% of the intoxications. Multiple agents were involved in 8.4% of the cases. Ethanol was the agent in 30.9% of the poisonings. Most patients (78.9%) were hospitalized (median length of stay 1 day). Overall mortality was 0.3%.

Conclusion: Acute paediatric poisonings represent a relatively frequent problem in Finland, and remain a life-threatening problem. The high proportion of alcohol poisonings highlights the necessity to develop more effective primary prevention programs.

INTRODUCTION

Acute poisonings are a major cause of injury-related morbidity among children in many countries (1,2). More than one million children younger than 6 years experience intoxication annually in the United States (1). Fortunately, childhood poisoning deaths have declined markedly during the last few decades (1,3). This favourable development has been attributed to factors such as child-resistant packaging, intervention by poison information centres and advances in health care (1). In a recent Norwegian study, the rate of childhood poisonings in the city of Oslo decreased from 230 to 97 per 100 000 during 1980 and 2003–2005 (3). Moreover, at the time of emergency department admission, most of the children suspected of poisoning are asymptomatic (4,5). However, intoxication in children can still lead to life-threatening complications, and even death (6,7).

Previous studies conducted in paediatric emergency departments have shown that most of the acute poisoning-related emergency visits involve children under 5 years of age (4,5). Distribution according to age has shown a predominance of young infants, children beginning to walk and discover the environment (4). In the younger age groups, boys have been more frequently involved in emergency visits and hospital admissions due to intoxication, while girls have predominated among teenagers (4,6,8). Girls' predominance in

adolescence has been explained by a higher incidence of intentional self-intoxications among teenage girls (6).

In the previous European studies, the poisoning substance has been of pharmaceutical origin in over half of the visits to paediatric emergency units (4,5). Pharmaceutical agents have also been identified in most of the acute paediatric intoxications leading to hospital admission in the United States (6). Analgesic agents (especially paracetamol), antidepressants and benzodiazepines have been the drugs most frequently found in paediatric drug poisonings (4,6). Among nonpharmaceutical intoxications, household products, alcohol, illicit drugs and fumes have been the most common agents (4,6).

The management of poisoning emergencies in the paediatric emergency care units has changed over the last few decades. For example, ipecac syrup, which was widely routinely administered in the past, is rarely used today (1). Similarly, gastrointestinal lavage is no longer considered the standard care for paediatric poisonings (1), but administration of activated charcoal has remained a common practice (9). New antidotes have substantially improved the care of patients with significant poisonings (10).

Although some reports of emergency visits for paediatric poisonings exist internationally (3–5), studies investigating acute paediatric poisonings in Finland are lacking. The aim of this study was, therefore, to describe the incidence and

nature of emergency department visits for acute paediatric poisoning in one main university hospital district in Finland.

MATERIALS AND METHODS

For this study, all patients younger than 16 years admitted to the Tampere University Hospital's emergency department (ED) from 2002 to 2006 with a diagnosis of poisoning were identified by a computer search from the Hospital Information System using the International Classification of Diseases Tenth revision (ICD-10) codes T36–T65 (11). Information on the following parameters was obtained: age, gender, day of the week, number of previous ED visits due to injury, number of previous intoxications and number of previous suicide attempts. We also recorded time delays from ingestion to hospital admission, suspected agents, estimations of severity, origins of agent, routes of exposure, contacts to Poisoning Information Center, deliberateness and suicide attempts recorded. Symptoms, administration of activated charcoal, ipecac syrup, or antidote, employment of gastric lavage, possible laboratory tests or imaging, admission to intensive care unit and length of stay in hospital were also recorded.

In order to compute the incidence rates of intoxications leading to ED visits, the annual mid-populations for each age group (0 to 15 years) were obtained from the Official Statistics of Finland (12). In 2002, there were 83 159 children in the 0- to 15-year age group within the catchment area of the study hospital, and in 2006, the corresponding figure was 84 006. SPSS statistical software for Windows version 14.0 (SPSS Inc., Chicago, IL) was used to analyze the data. Open Epi Program was used to calculate 95% confidence intervals, which were used to calculate incidence rates. Mean values with range were used when reporting distribution of continuous variables (breath alcohol testing, blood ethanol, delay from exposure to admittance to hospital). Pharmaceutical agents were classified according to the Anatomical Therapeutic Chemical (ATC) Classification System, widely used for the classification of WHO Collaborating Centre for Drug Statistics Methodology (13). The Ethics Committee of the Pirkanmaa Hospital District approved the study (Code R07044).

RESULTS

During 2002–2006, there were altogether 369 paediatric ED visits diagnosed with poisoning codes T36–T65 at the Tampere University Hospital. Patients' ages ranged from 0 to 15 years. The overall incidence of emergency visits for paediatric poisoning within the catchment area of this hospital was 8.1 per 10 000 person-years (95% CI 7.3–9.0).

Of all the patients, 45.0% were under 5 years. The incidence of ED visits for poisonings was 12.2 per 10 000 person-years in the youngest age group (0 to 4 years) (95% CI 10.2–14.1). Children aged 5 to 9 years represented only in 7.0% of the poisonings, and the incidence of ED visits for poisoning was 1.9 per 10 000 person-years in this age-group (95% CI 1.1–2.6). Adolescents aged 10 to 15 years comprised

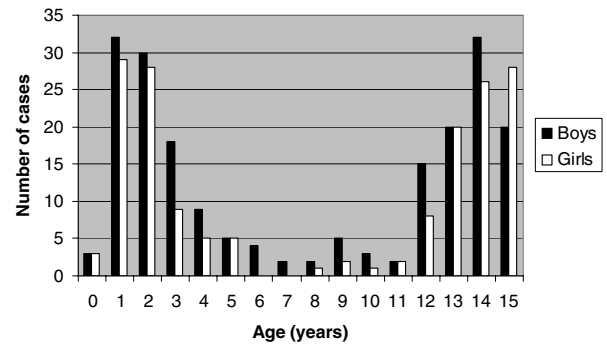


Figure 1 Number and age distribution of paediatric poisonings treated in Tampere University Hospital between 2002 and 2006.

48.0% of all visits, and the incidence of ED visits for poisoning was 10.0 per 10 000 person-years (95% CI 8.4–11.5). Most of the acute paediatric poisonings concerned children aged 1 to 2 years and adolescents aged 14 to 15 years. (Fig. 1)

Slightly more than half of the cases (54.7%) of poisoning in the ED were boys. When all patients were analyzed by age, it was seen that boys predominated slightly in the younger age groups, while girls had more ED visits only among the 15-year-olds. (Fig. 1) These differences were not, however, statistically significant ($p = 0.536$). One-fifth (18.2%) of the patients had a history of one or several previous visits to ED due to injury, including 7.3% who had been admitted to ED due to intoxication. Sixteen patients had had two ED visits for poisoning during the 5-year period 2002–2006, and 2.2% of the patients had previously attempted to commit a suicide.

Most (78.9%) of the patients were admitted to hospital. Among those treated in the hospital, the median length of stay was 1 day (range, 1 to 43 days) and four-fifths of patients were treated in the paediatric intensive care unit. Three out of 369 (0.8%) patients needed ventilator treatment, and one 2-year-old boy died from ingesting grill lighter fluid. The overall mortality was 0.3%, and the incidence of poisoning deaths among children was 0.24 per 100 000 person-years (95% CI 0–0.71).

Nonpharmaceutical agents were suspected to be the cause of poisoning in 60.4% and pharmaceuticals in 30.6% of the ED visits for acute poisoning. (Table 1) Multiple agents were involved in 8.4% of the poisonings. Ethanol was the cause of poisoning in 30.9% of the cases. Nearly all (113/114) of ethanol poisonings occurred among 10- to 15-year-old adolescents, boys constituting a small majority. (Fig. 2) Among the 10 to 15 year-olds, ethanol poisonings accounted for 63.8% of all acute poisonings. The mean value of breath alcohol testing among these patients was 1.41 parts per thousand (ppt) of alcohol (range, 0.05 to 3.45 ppt; standard deviation [SD] 0.70), and the mean value of blood ethanol was 38.0 mmol/L (range, 0.0 to 93.4 mmol/L; SD 14.8). Bites and venoms accounted for 11.9% of acute poisonings. (Table 1) Household products, fuels, lighter fluids, oils and solvents and tobacco products were also fairly common poisoning agents.

Table 1 Suspected agents involved in poisoning exposures in different age groups

Agent	0-4 years n (%)	5-9 years n (%)	10-15 years n (%)	Total n (%)
Nonpharmaceutical agents	78 (47.0)	21 (80.8)	124 (70.1)	223 (60.4)
Ethanol	1 (0.6)	0 (0.0)	113 (63.8)	114 (30.9)
Bites and venoms	20 (12.0)	16 (61.5)	8 (4.5)	44 (11.9)
Domestic products	14 (8.4)	0 (0.0)	0 (0.0)	14 (3.8)
Fuels, lighter fluids, oils, solvents	11 (6.6)	0 (0.0)	0 (0.0)	11 (3.0)
Tobacco products	11 (6.6)	0 (0.0)	0 (0.0)	11 (3.0)
Carbon monoxide	5 (3.0)	5 (19.2)	0 (0.0)	10 (2.7)
Plants, berries, mushrooms	7 (4.2)	0 (0.0)	1 (0.6)	8 (2.2)
Other alcohols	6 (3.6)	0 (0.0)	1 (0.6)	7 (1.9)
Other nonpharmaceutical products	3 (1.8)	0 (0.0)	1 (0.6)	4 (1.1)
Pharmaceuticals	80 (48.2)	5 (19.2)	28 (15.8)	113 (30.6)
Nervous system	49 (29.5)	3 (11.5)	23 (13.0)	75 (20.3)
Psycholeptics	28 (16.9)	3 (11.5)	19 (10.7)	50 (13.6)
Analgesics	6 (3.6)	0 (0.0)	3 (1.7)	9 (2.4)
Psychoanaleptics	9 (5.4)	0 (0.0)	0 (0.0)	9 (2.4)
Anti-epileptics	6 (3.6)	0 (0.0)	1 (0.6)	7 (1.9)
Cardiovascular system	8 (4.8)	0 (0.0)	0 (0.0)	8 (2.2)
Respiratory system	7 (4.2)	1 (3.8)	0 (0.0)	8 (2.2)
Blood and blood forming organs	6 (3.6)	0 (0.0)	0 (0.0)	6 (1.6)
Musculoskeletal system	3 (1.8)	0 (0.0)	3 (1.7)	6 (1.6)
Alimentary tract and metabolism	3 (1.8)	0 (0.0)	2 (1.1)	5 (1.4)
Anti-infectives for systemic use	2 (1.2)	0 (0.0)	0 (0.0)	2 (0.5)
Dermatologicals	1 (0.6)	0 (0.0)	0 (0.0)	1 (0.3)
Systemic hormonal preparations	1 (0.6)	0 (0.0)	0 (0.0)	1 (0.3)
Antineoplastic and immunomodulating agents	0 (0.0)	1 (3.8)	0 (0.0)	1 (0.3)
Multiagents	7 (4.2)	0 (0.0)	24 (13.6)	31 (8.4)
Unknown	1 (0.6)	0 (0.0)	1 (0.6)	2 (0.5)
Total	166 (100.0)	26 (100.0)	177 (100.0)	369 (100.0)

Nervous system drugs caused intoxication in 20.3% of the patients. (Table 1) Most of these poisonings (50/75) were caused by psycholeptics (including hypnotics and drugs for psychosis and neurosis). Analgesics and psychoanaleptics (including anti-depressants) each caused 2.4% of all poi-

sonings. All anti-depressant poisonings (8) were caused by tricyclic anti-depressants. Selective serotonin reuptake inhibitors were involved only in a small number of multiple-agent intoxications. Temazepam and oxazepam were the most common individual agents causing 3.8% and 3.5% of all poisonings, respectively. Benzodiazepines accounted altogether for 25.7% of all drug poisonings.

In children aged 0 to 9 years, nearly all (97.9%) poisonings were classified as unintentional, whereas among older children and adolescents (aged 10 to 15 years), 92.0% of the poisonings were intentional. Altogether 23 patients had admitted to have attempted a suicide (6.2% of the cases). In four cases (1.1%), the agent had been given intentionally by another person. The frequency was highest on Fridays and on Saturdays when 19.2% and 19.8% of the intoxications occurred, respectively. In 42.0% of the acute poisonings, the agent was obtained from home, whereas on 13.3% of occasions, the agent was received from a friend. The poison was derived from nature in 14.1% of occasions (mostly bites and venoms). The route of exposure was oral in 83.7% of the patients, dermal in 11.4% (bites and venoms mainly) and inhalation in 3.3% of the patients.

Nearly half (48.2%) of the patients were asymptomatic when admitted to the ED. In the 0- to 4-year-olds, the

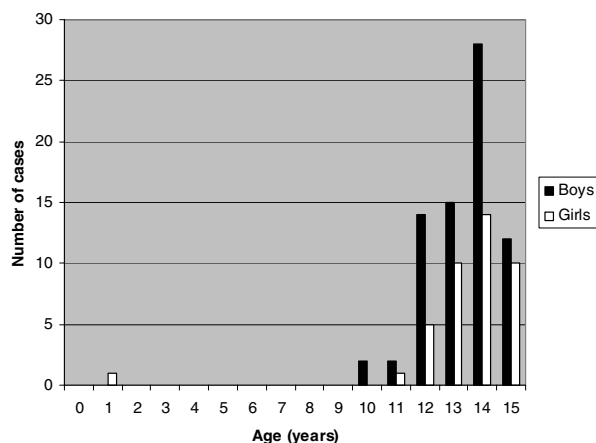


Figure 2 Number and age distribution of paediatric ethanol poisonings treated in Tampere University Hospital between 2002 and 2006.

proportion of asymptomatic children was 71.1%, in the 5- to 9-year-olds 65.4%, while among adolescents aged 10 to 15 years, only 24.3% were asymptomatic ($p < 0.001$). In most patients (75.3%), the physician assessed the amount of agent to be potentially severe, and in 6.5% of the cases severe. The amount of poisoning agent was assumed to be insignificant only in 17.6% of visits.

The Finnish Poison Information Center was contacted for every third (32.8%) of the ED visits due to acute poisoning. Of the 309 patients with oral route of exposure to agent, 67% were treated with activated charcoal. Only three patients (1.0%) received ipecac syrup. Gastric lavage was performed on two patients (0.6%), both aged 2 years and diagnosed with iron poisoning. Twenty-one patients (5.7%) received specific antidotes.

The mean delay from exposure to admittance to Tampere University Hospital was 3 h 11 min (range, 15 min to 24 h; SD 3 h 56 min). Laboratory tests were performed in 78.0% of the intoxications, and radiological imaging was needed for 4.9% of the patients.

DISCUSSION

This study investigated the incidence and nature of emergency visits for acute paediatric poisonings between 2002 and 2006 in one main university hospital district in Finland. The mean annual incidence of emergency visits for poisoning among children aged 0 to 15 years was 8.1 per 10 000 person-years. Most of the patients were children under 5 years or adolescents aged 10–14 years. Boys represented 55% of the emergency visits. Of all ED visits, three-fourths led to hospital admission. Although the overall mortality (0.3%) was low, our study shows that intoxication in children still remains a life-threatening problem. Involvement of non-pharmaceutical agents was suspected in 60% of the poisonings, particularly ethanol, which was involved in up to 31% of all poisoning-related emergency visits.

In most of the previous studies, the data provide information from the 1970s to 1990s (4,14). In this study, the incidence of emergency visits for childhood poisoning was lower than in studies from France and Italy (4,14). Differences between societies and health care systems may explain these margins. However, the incidence rates of childhood poisonings in Finland seem to be congruent with the latest report from Norway (3).

Although boys have generally predominated the statistics of emergency visits for acute poisoning in the previous reports (5,14), the incidence rates among adolescents have been higher for girls than boys (4). Our findings according to sex and age were similar to these reports. Higher poisoning figures among teenage girls are assumed to be due to the higher number of intentional intoxications (15).

Pharmaceutical agents have been encountered more often at emergency visits and hospital admissions related to acute paediatric poisonings as compared to nonpharmaceutical products (2,5,6). In our study, nonpharmaceutical agents caused up to 60% of the poisonings. The high amount of ethanol intoxications among Finnish children and adoles-

cents may explain this difference. Considering that the proportion of alcohol in paediatric poisonings has been under 10% in reports from many other countries (5,14), alcohol use seems to be more popular among Finnish children and adolescents. In Norway, the proportion of alcohol poisonings among adolescents was recently reported to be fairly high (3), but in Finland, adolescent alcohol consumption seems to be an even more serious problem. According to a Finnish study, the age-adjusted monthly drunkenness among 14- to 18-year-old Finnish adolescents was 27% among boys and 22% among girls in 1999 (16).

In previous reports, poisonings from medication products among the youngest children (under 5 years) accounted for slightly over a half of the ED visits (2,5), and by paracetamol alone up to 20% (5). Our findings were quite similar, as pharmaceuticals comprised nearly half of the poisoning cases in this age group. At the same time, the amount of poisonings caused by sedatives has been reported fairly low (2%) among children under 8 years of age (3). In this study, however, analgesics were the cause of poisoning in only a small number of cases, while psycholeptics were the most frequently encountered drugs among the youngest children.

Reports from other countries have shown that most of the children visiting paediatric emergency units due to acute poisoning are discharged home soon after admission to emergency care unit (4,5,14). In this study, however, most of the patients were hospitalized. Most of the younger children (under 5 years) were asymptomatic at the time of admission to hospital, whereas a majority of children over 10 years had symptoms. These findings are congruent with previous reports (4,5,14). Poisoning patients, although asymptomatic on arrival to ED, frequently need observation and hospitalization due to delayed toxicity, which may gradually develop to produce even serious poisoning (17). Previous studies have shown that gastric lavage and administration of ipecac syrup have been fairly common treatments for poisonings in Europe, even in the 2000s (5). According to the present findings, these treatments are rare in Finland today. Instead, up to 67% of patients with oral exposure to toxic agent were administered activated charcoal. Thus, it seems that the latest guidelines are mostly followed in the treatment of paediatric poisonings in Finland (1).

In this study, we identified all acute paediatric poisonings diagnosed with ICD-codes T36–65 within the hospital catchment area during 2000–2006. A notable strength of this paper is that, in this hospital's information system, double coding is used for poisonings: the primary poisoning code and the external cause code. The fact that intoxications were identified with both diagnosis and external causes ensures that no cases were missed due to under-reporting of external causes (18). The validity of hospital discharge codes has been studied in Finland, showing an accuracy of 96.0% in the diagnosis codes for violence and poisonings and 95.7% in the paediatric diagnosis codes. Tampere University Hospital Information System is based on hospital discharge register and diagnoses are coded similarly, regardless whether the ED visit results in hospital admission or not. Thus the

authors conclude that the reliability of the diagnostic codes used in the medical records of the study hospital is high (19). Other strengths include the availability of the exact annual mid-populations for each age group from the Official Statistics of Finland and the use of an internationally recognized classification system (ATC) on pharmaceutical agents (13).

A limitation of the study is that we analyzed only the acute poisonings treated in one main university hospital. Consequently, we did not have the figures of less-severe poisonings treated in health centres within the hospital district. However, even in cases of slight suspicion of poisoning, paediatric patients are often referred to the university hospital. Within the study hospital catchment area, there is a community centre staffed by social workers, which houses a room for under-aged adolescents to stay if they are drunk. In paediatric poisoning cases assumed to need professional medical services, the persons are, however, always transferred to hospital care (20).

In conclusion, acute paediatric poisonings represent a relatively frequent problem in Finland. In spite of child-resistant packaging, heightened parental awareness and other protective measures, such as interventions by the Finnish Poison Information Center and specially trained health care professionals, paediatric poisonings remain a life-threatening problem. With this information about paediatric poisonings, this study may enhance awareness of childhood intoxications today. Especially the high proportion of alcohol poisonings among Finnish children highlights the necessity to develop more effective primary prevention programs. Increased adult supervision would also probably help decrease children's alcohol consumption and risks of alcohol-related intoxication.

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Secular Trends in Poisonings Leading to Hospital Admission among Finnish Children and Adolescents between 1971 and 2005

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Objective To investigate the secular trends in childhood poisonings leading to hospitalization in Finland.

Study design All children and adolescents age 0 to 19 years hospitalized in Finland with the primary diagnosis of poisoning between 1971 and 2005 were identified using the International Classification of Diseases.

Results During the study period, there were 41 862 hospitalizations with 96 427 hospital bed days for poisoning in 38 582 children and adolescents. The incidence of hospitalization declined from 91.3 admissions per 100 000 person-years in boys and 105.2 per person-years in girls in 1971 to 64.8 in boys and 83.5 in girls in 2005. In the 0- to 4-year age group, admissions declined by 51%. Hospitalizations for alcohol poisoning increased 1.7-fold (95% confidence interval = 1.4 to 2.2) in boys and 2.4-fold (95% confidence interval = 1.8 to 3.3) in girls. Alcohol poisoning was the primary diagnosis in 53% of those in the 10- to 14-year age group.

Conclusions Poisoning remains an important cause of morbidity in Finnish children and adolescents despite the decreased overall incidence of poisonings leading to hospitalization between 1971 and 2005. The increasing trend of hospital admissions for alcohol poisoning, especially in 10- to 14-year-olds, is noteworthy. Effective primary prevention programs and adult supervision should be targeted at reducing alcohol consumption and alcohol-related poisonings in youth. (*J Pediatr* 2008;153:820-4)

Poisoning in children and adolescents may lead to serious complications, hospitalization, and sometimes even death.¹ Poisoning in these age groups has been extensively studied in the United States, and there are a few reports from developing countries.² In other countries, however, research in this area is lacking. In the United States, an estimated more than 1 million children under age 6 years experience toxic exposures annually.³ Poisoning is also an important cause of injury and mortality in adolescents.⁴ Children under age 5 years dominate the statistics on emergency room visits for poisoning;⁵⁻⁷ however, children in this age group are often asymptomatic and may not require hospital admission.⁸

Studies on the causes of hospitalization due to poisoning are scarce. In a study from Washington state, 75% of the hospitalizations for pediatric poisoning occurred in teenagers, and the incidence of hospitalizations for intoxication was 45 per 100 000 in children age 0 to 19 years.¹ Boys are more likely than girls to be hospitalized for poisonings under age 13 years;⁹ however, this sex distribution reverses during the teenage years. For example, Gauvin et al¹ found that teenage girls have a 2.5-fold higher risk of hospital admission due to poisoning than teenage boys.

The causes of poisoning leading to hospitalization vary by age. Pharmaceutical agents are involved in most pediatric hospitalizations for poisoning in the United States;¹ analgesic agents (most commonly acetaminophen) are involved in 1/3 of cases. Alcohol is the most common nonpharmaceutical agent involved, accounting for 6% of all hospitalizations for poisoning in 0- to 18-year-old children and adolescents.¹ Pharmaceutical agents predominate in teenagers, whereas nonpharmaceutical agents are more common in children under age 12.¹ In Finland, children under age 6 years are more commonly hospitalized for nondrug poisoning.¹⁰

International studies investigating the secular trend in hospitalization for pediatric poisoning are lacking, and only few nationwide reports exist.^{1,11} The present study examined the trend in poisoning leading to hospitalization in Finnish children and adolescents between 1971 and 2005.

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METHODS

For this study, we used the database of Finland's National Hospital Discharge Register, which contains basic hospitalization data from all Finnish hospitals, including patient age, time of hospitalization, length of hospital stay, and diagnosis.¹⁰ The data are collected and updated annually by the National Research and Development Center for Welfare and Health. The Ethics Committee approved the study design (National Research and Development Center for Welfare and Health, number: 1383/900/2006).

A computer search identified all patients between age 0 and 19 years who were hospitalized with a primary diagnosis of poisoning between 1971 and 2005. The International Classification of Diseases (ICD), eighth revision (ICD-8), was used from 1971 to 1986, and the ninth revision (ICD-9) was used from 1987 to 1995. In both ICD-8 and ICD-9, the codes 960-979 for intoxication by drugs, medicinals, and biological substances and codes 980-989 for effects of substances in chiefly nonmedical use were used. From 1996 to 2005, the tenth revision (ICD-10) was used, with corresponding codes T36-T65. The identification of intoxicants was based on the primary diagnosis and not on the external causes of injury, due to underreporting.¹² For the purpose of this study, the more specific ICD-10 codes were reclassified into the ICD-9 codes to ensure comparability among years.

To compute the incidence and incidence rate ratios of intoxications leading to hospitalization, the annual mid-populations were obtained from the Official Statistics of Finland,¹³ a computer-based national population register. The number of children and adolescents age 0 to 19 years was 1 517 738 in 1971 and 1 227 846 in 2005. Thus, the numbers and incidence rates of hospitalization due to poisoning were true results reflecting the actual child and adolescent population in Finland during the study period, rather than cohort-based estimates.¹³ SPSS 14.0 for Windows software (SPSS Inc, Chicago, Illinois) was used to analyze the data. When comparing skewed hospitalization time between sexes, the Mann-Whitney U-test was used. Incidence rate ratios and 95% confidence intervals for incidence rates were calculated using the OpenEpi program.

RESULTS

During the study period of 1971 to 2005, a total of 41 862 hospitalizations for poisoning were recorded in 38 582 children and adolescents age 0 to 19 in Finland. The incidence rate declined during this 35-year period. In 1971, the rate was 91.3 admissions per 100 000 person-years in boys and 105.2 per 100 000 person-years in girls. The peak year was 1986, with 121.4 admissions per 100 000 person-years in boys and 107.7 per 100 000 person-years in girls. At the end of the study period in 2005, the corresponding figures were 64.8 in boys and 83.5 in girls. During the entire study period, 32 patients died of poisoning during the initial hospitalization and 380 died later, nearly all (99.8%) more than 30 days after initial hospitalization.

Poisonings accounted for a total of 96 427 hospital-bed days (incidence, 208.6 days per 100 000 person-years) during

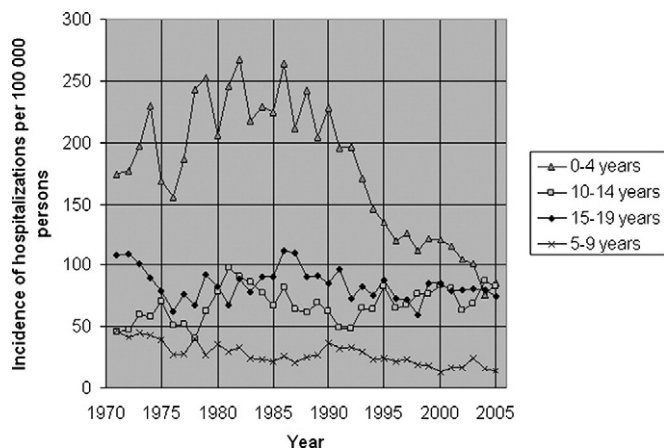


Figure 1. Incidence of poisoning (per 100 000 person-years) leading to hospital admission in Finnish boys between 1971 and 2005.

the study period. The median length of hospital stay during the study period was 1 day (range, 1 to 938 days). Patients were hospitalized for 1 day in 64% of the cases and for 3 or more days in 19% of the cases. In 98.9% of the patients, the hospital stay was < 2 weeks, and in 99.7% it was < 30 days. Most of the patients (92%) were hospitalized for poisoning only once during the study period, but 8% of the patients had 2 or more admissions. Rehospitalization was slightly more frequent in girls than in boys (9% vs 7%; $P < .001$).

The median age at the time of hospitalization was 6 years in boys and 13 years in girls ($P < .001$). The male:female incidence ratio of poisoning leading to hospitalization was 1.3 in the 0- to 4-year age group, 1.5 in the 5- to 9-year age group, 1.0 in the 10- to 14-year age group, and 0.6 in the 15- to 19-year age group.

The incidence of hospitalization declined by 51% in the youngest age group (0 to 4 years) over the 35-year study period. This downward trend was most obvious in the last 2 decades. The annual incidence of hospitalization for pediatric poisoning was the lowest in the 5- to 9-year age group in both sexes, except for the year 1971 in boys (10.4 to 46.8 per 100 000 children) (Figures 1 and 2). In 1971, the highest incidence of poisoning hospitalization occurred in the 0- to 4-year age group in boys (174.0 per 100 000 boys) and in the 15- to 19-year age group in girls (195.0 per 100 000 girls). In 2005, boys age 0 to 4 years still had the highest incidence of hospitalization in males, but the incidence of 85.2 per 100 000 persons was only marginally higher than that of the 10- to 14-year (82.5) and 15- to 19-year (74.9) age groups.

The most dramatic decline in the incidence rates in both boys and girls was seen in the 0- to 4-year age group. This decrease started in the early 1990s. In other age groups, the changes were not so clear during the 35-year study period. The incidence of poisoning hospitalization increased slightly in the 10- to 14-year-olds and showed a decreasing trend in the 5- to 9-year-olds. The trend toward decreasing poisonings also was seen in the 1970s in the 15- to 19-year-olds.

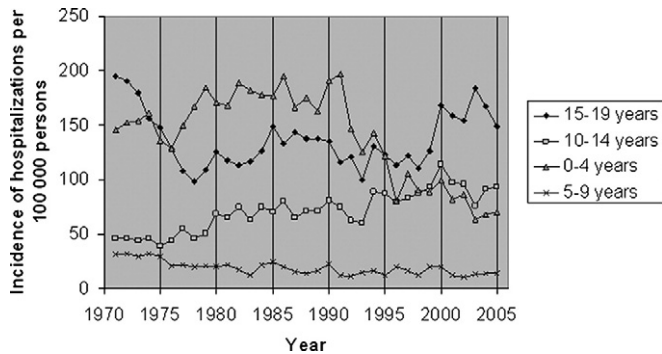


Figure 2. Incidence of poisoning (per 100 000 person-years) leading to hospital admission in Finnish girls between 1971 and 2005.

Poisoning Diagnoses

Poisonings by drugs and medicinal and biological substances (ICD codes 960-979) were the cause of hospitalization in 53% of the 41 826 cases, with poisonings by toxic effects of chiefly nonmedicinal substances (ICD codes 980-989) accounting for the remainder. In the 0 to 4-year age group, unspecified drugs and medicinal substances accounted for 11% and unspecified nonmedicinal substances accounted for 24% of all hospitalizations. Some 7% of hospitalizations for poisoning were due to corrosive aromatics, acids, or caustic alkalis. In 6% of the cases, the primary source of intoxication was a noxious substance eaten as food (Table; available at www.jpeds.com). In the 5- to 9-year-olds, the most common sources were unspecified nonmedicinal substances (accounting for 38% of the cases), followed by alcohol poisoning (8%).

Approximately half (53%) of the 10- to 14-year-olds hospitalized for poisoning had a primary diagnosis of alcohol poisoning. Of these cases, 62% were boys. In the oldest age group (15 to 19 years), alcohol poisoning accounted for 19% of the hospitalizations; unspecified drugs and medicinal substances were the second leading cause, accounting for 18% of the hospitalizations. The decreased rate of hospitalization in the 15 to 19-year-olds in the 1970s was due mainly to decreased poisoning from alcohol, central nervous system stimulants, sedatives, and hypnotics.

Of the 41 826 total poisonings recorded during the study period, 7 331 (18%) were alcohol-related. The great majority of the specified alcohol poisoning diagnoses involved ethanol poisoning; the total proportion of methanol, isopropanol, or any other specified alcohol type was only about 1% of these cases. The incidence of hospitalization for alcohol poisoning increased during the study period, particularly in girls (Figure 3). The incidence of hospital admission for alcohol poisoning per 100 000 person-years was 15.8 in boys and 8.3 in girls in 1971, compared with 27.1 and 20.0, respectively, in 2005. This represents a 1.7-fold (95% confidence interval = 1.4 to 2.2) increase in the incidence of hospitalization for alcohol-related poisoning in boys and a 2.4-fold (95% confidence interval = 1.8 to 3.3) increase in girls during the 35-year study period.

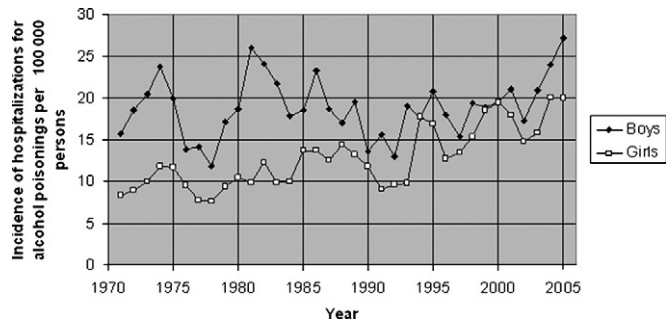


Figure 3. Incidence of alcohol poisoning (per 100 000 person-years) leading to hospital admission in Finnish boys and girls age 0 to 19 years between 1971 and 2005.

DISCUSSION

During the 35-year study period from 1971 to 2005, the overall incidence of poisoning leading to hospital admission declined in Finnish children and adolescents age 0 to 19 years. This decline was due mainly to the dramatic decrease in poisoning in 0- to 4-year-old children since the early 1990s. However, the incidence of hospitalizations for alcohol poisoning increased 2-fold during the study period. Approximately 50% of all hospitalizations for poisoning in 10- to 14-year-olds were caused by alcohol, with a gradually increasing trend seen throughout the study period. Boys predominated over girls in the hospitalization statistics in the younger age groups, while girls constituted most of the admissions in the 15- to 19-year age group.

The present study is unique in that it describes the trend in poisoning hospitalizations in children and adolescents in a well-defined population over a 35-year period. Most previous studies covered shorter periods and were conducted within a single hospital catchment area or within a single province.^{6,11} Emergency room visits for childhood poisonings have been reported, but only a few countries have reported rates of hospital admissions for childhood and adolescent poisoning.^{1,5,7} Another strength of this study is that the hospitalization data were obtained from all Finnish hospitals.

The study also has some limitations. First, in the process of recoding ICD-10 to ICD-9 (and ICD-8), some information may have been lost, because the ICD-10 codes are more accurate. The data also may include some cases in which the patient had been treated for a single incidence of poisoning in more than one hospital. Moreover, due to underreporting of external causes, we lacked sufficient evidence to determine whether a poisoning was intentional or unintentional. Because the data were based on ICD codes and hospitalization statistics instead of on clinical data, we had no information on patient management and outcome, specific agents causing the poisonings, or co-ingestions.

A reasonable suspicion of poisoning in a pediatric patient frequently leads to a diagnosis of poisoning. This decision is appropriate, because even severe poisonings may present with minimal symptoms in the beginning and cause delayed-onset toxicity.¹⁴ The fairly high proportion of pa-

tients diagnosed with a nonspecified poisoning is a fairly common limitation of previous poisoning studies.⁵ Regardless, however, the distribution of pharmaceutical agents and nonpharmaceutical agents seems clear. In addition, the validity of the Finnish National Hospital Discharge Register has been found to be excellent, with accuracy rates of 96.0% for the diagnostic codes for poisonings and 95.7% for all pediatric diagnostic codes.¹⁵

Over the 35-year study period, the incidence of poisoning leading to hospital admission declined notably in the 0- to 4-year-old children. The last few decades have brought marked improvements in product formulations and child-resistant packaging, heightened parental awareness of toxic agents, improved interventions by poison information centers, and increased availability of specially trained health care professionals.³ The combined impact of these various factors may explain the decline in the incidence of hospitalization for pediatric poisoning in the 0- to 4-year-olds noted in the present study. Finland's entry into the European Union in 1995 may have had an effect on the recent decline in poisoning admissions, because European Union directives include guidelines and regulations for child-resistant packaging.¹⁶ In addition, improved monitoring systems, new antidotes, and the increased ability to accurately measure blood serum levels of many drugs may allow more liberal discharge of patients today,^{3,17} and today's poison information centers may be better prepared to provide parents with adequate home care instructions for milder poisonings.

Previous studies found a median length of hospital stay of 1 day,^{1,11} which corresponds with the findings of the present study. Nearly all (99.7%) patients were discharged before 30 days. The few cases involving hundreds of hospital bed-days are likely related to some serious consequences of poisoning (eg, disability). In earlier studies, ingestion of pharmaceutical agents was the most common cause of hospitalization for pediatric intoxication.^{1,11} In our study, however, only about 1/2 of all poisonings were caused by drugs and medicinal substances. The most likely explanation for this difference is the high proportion of hospitalizations due to alcohol ingestion in Finland. In view of the thousands of ethanol poisoning codes, compared with only a few dozen other alcohol poisoning codes, we can assume that nearly all of the nonspecified alcohol poisonings were actually caused by ethanol.

A possibly reason for the decreased incidence of poisonings in 15- to 19-year-olds in the 1970s in Finland may be the public health campaigns against alcohol misuse launched at the beginning of that decade.¹⁸ During the 1980s and 1990s, alcohol use among Finnish adolescents increased, and the drinking patterns became more drunkenness-oriented.¹⁹ In the present study, hospital admissions due to alcohol poisoning were most common in adolescents age 10 to 14 years. Based on a previous Finnish report, the age-adjusted monthly drunkenness rate in 14- to 18-year-olds rose from 13% to 27% in boys and from 6% to 22% in girls between 1981 and 1999.¹⁹ In the present study, the incidence of

hospitalization for alcohol poisoning increased in girls during this period, whereas in boys the sharpest rise was seen over the last few years of the study. This recent increase may be related to the significant decrease in alcohol taxes in Finland, which took effect on March 1, 2004.

Our findings are in agreement with previous research demonstrating higher hospitalization rates in teenage girls than boys¹ but the reverse in younger age groups.^{1,11} Intoxication is a well-known suicide method in adolescent girls.²⁰ Even though we could not determine whether a poisoning was intentional or unintentional, it seems likely that the relatively high incidence of poisoning hospitalizations in 15- to 19-year-old girls can be linked to suicide attempts by intoxication. This supposition is supported by the high number of cases involving poisoning by psychotropic agents, central nervous system stimulants, and analgesics in the 15- to 19-year-old girls in the present study.

In conclusion, poisonings continue to be an important cause of morbidity in Finnish children and adolescents despite a decline in the overall incidence of poisoning leading to hospitalization between 1971 and 2005. This decline was due mainly to the dramatic decrease in poisonings in 0- to 4-year-old children after the early 1990s. This favorable trend is attributable primarily to improvements in product formulations, child-resistant packaging, and information dissemination by poison information centers, as well as to advances in health care. But life-threatening poisonings still occur. Research and intervention efforts aimed at preventing pediatric poisoning should continue. More effective public education campaigns focusing on child safety are needed. Poisoning prevention should include the development of even-safer child-resistant packaging and childproof closure devices, along with more effective parental education. Storage of pharmaceuticals and toxic household products in locked cabinets should be promoted.

It is noteworthy that the incidence of hospital admissions for alcohol poisoning shows an increasing trend over the 35-year study period. This trend is especially evident in the poisoning hospitalizations in 10- to 14-year-olds, of which approximately 50% were attributed to alcohol ingestion. This increase in hospital admissions for alcohol poisoning is alarming. Effective primary prevention programs, more intensive adolescent supervision by adults, and an increase in Finland's alcohol tax probably will be needed to reduce adolescent alcohol consumption and alcohol-related poisonings.

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Table. Distribution of diagnoses of hospitalizations for poisoning in Finnish children and adolescents, 1971 to 2005, % (n)

ICD code	Diagnosis	0 to 4 years	5 to 9 years	10 to 14 years	15 to 19 years	Total
960	Antibiotics	1.8% (308)	4.1% (112)	1.9% (151)	2.9% (388)	2.3% (959)
961	Other anti-infectives	0.7% (131)	3.6% (96)	0.8% (68)	1.5% (207)	1.2% (502)
962	Hormones and synthetic substitutes	0.7% (122)	1.2% (32)	0.6% (50)	0.5% (74)	0.7% (278)
963	Primarily systemic agents	3.6% (639)	1.5% (41)	0.8% (69)	1.0% (131)	2.1% (880)
964	Agents primarily affecting blood constituents	4.1% (720)	1.3% (35)	0.4% (33)	0.4% (60)	2.0% (848)
965	Analgesics, antipyretics, and anti-rheumatics	3.7% (654)	2.4% (65)	4.5% (365)	9.4% (1267)	5.6% (2351)
966	Anticonvulsants and anti-Parkinsonism drugs	1.1% (194)	1.9% (52)	1.6% (132)	2.6% (352)	1.7% (730)
967	Sedatives and hypnotics	2.3% (400)	1.5% (40)	2.0% (163)	6.7% (901)	3.6% (1504)
968	Other central nervous system depressants and anesthetics	0.1% (15)	0.1% (4)	0.1% (6)	0.1% (18)	0.1% (43)
969	Psychotropic agents	3.4% (596)	1.5% (40)	3.5% (281)	9.5% (1278)	5.2% (2195)
970	Central nervous system stimulants	3.4% (601)	3.4% (91)	1.9% (155)	7.6% (1029)	4.5% (1876)
971	Drugs primarily affecting the autonomic nervous system	0.9% (166)	0.4% (11)	0.3% (25)	0.5% (63)	0.6% (265)
972	Agents primarily affecting the cardiovascular system	3.4% (589)	1.1% (29)	0.5% (43)	1.2% (159)	2.0% (820)
973	Agents primarily affecting the gastrointestinal system	3.7% (654)	1.2% (33)	0.7% (57)	2.0% (270)	2.4% (1014)
974	Water, mineral, and uric acid metabolism drugs	0.6% (111)	0.4% (10)	0.3% (22)	0.2% (27)	0.4% (170)
975	Agents primarily acting on the smooth and skeletal muscles and respiratory system	2.0% (353)	0.8% (21)	0.4% (35)	0.5% (67)	1.1% (476)
976	Agents primarily affecting skin and mucous membrane, ophthalmologic, otorhinolaryngologic, dental drugs	0.7% (120)	0.3% (9)	0.2% (17)	0.3% (36)	0.4% (182)
977	Other and unspecified drugs and medicinal substances	11.3% (1976)	5.3% (143)	8.6% (695)	17.7% (2391)	12.4% (5205)
978	Bacterial vaccines	2.5% (439)	1.6% (43)	1.9% (153)	3.6% (480)	2.7% (1115)
979	Other vaccines and biological substances	0.2% (29)	0.3% (8)	0.6% (52)	4.2% (564)	1.6% (653)
980	Alcohols	1.6% (278)	8.0% (217)	53.1% (4315)	18.7% (2521)	17.5% (7331)
981	Petroleum products	4.8% (838)	3.9% (105)	0.9% (72)	0.6% (80)	2.6% (1095)
982	Solvents other than petroleum based	4.4% (775)	2.3% (63)	1.2% (99)	1.0% (131)	2.6% (1068)
983	Corrosive aromatics, acids, and caustic alkalis	7.2% (1266)	4.2% (114)	0.8% (67)	1.0% (131)	3.8% (1578)
984	Lead and its compounds	0.1% (16)	0.6% (15)	0.0% (3)	0.0% (5)	0.1% (39)
985	Other metals	0.7% (123)	0.6% (16)	0.2% (15)	0.2% (25)	0.4% (179)
986	Carbon monoxide	0.7% (118)	3.3% (89)	1.2% (98)	0.8% (111)	1.0% (416)
987	Other gases, fumes, or vapors	0.3% (51)	1.0% (28)	0.6% (50)	0.9% (121)	0.6% (250)
988	Noxious substances eaten as food	6.3% (1103)	4.5% (122)	0.7% (60)	0.5% (74)	3.2% (1359)
989	Other substances, chiefly nonmedicinal as to source	23.7% (4151)	37.6% (1016)	9.5% (770)	4.0% (544)	15.5% (6481)
Total		100.0% (17536)	100.0% (2700)	100.0% (8121)	100.0% (13505)	100.0% (41862)

Incidence of poisoning deaths in Finland in 1971–2005

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Poisonings cause considerable morbidity and mortality worldwide. However, only few countries have published nationwide statistics on poisoning deaths. Based on the Official Cause-of-Death Statistics of Finland, we investigated the incidence and secular trend of poisoning deaths in Finland in 1971–2005. Alcohol poisoning deaths and other poisoning deaths were analyzed separately. During the 35-year study period, other poisoning deaths (non-alcohol) increased from 2.6/100,000 in men and 1.4/100,000 in women in 1971 to 6.8/100,000 and 3.2/100,000 in 2005, respectively. Alcohol poisoning death rates also increased from 9.6/100,000 in men and 0.7/100,000 in women in 1971 to 16.8/100,000 and 4.2/100,000 in 2005, respectively. In the early 1970s, the

incidence rates of alcohol deaths were about 10 times higher in men compared with women, whereas in the last few years of observation, men's incidence rate was only about four times higher. Our study showed that alcohol and other poisoning deaths increased in Finland between 1971 and 2005. Men's risk was markedly higher than women's risk, but in the later years, women's risk was increasing. Poisoning death rates among children and adolescents were low throughout the period.

Key words: death; incidence; mortality; poisoning; trend

Introduction

Poisoning has been defined as taking a substance that is injurious to health or can cause death.¹ The majority of poisonings are considered acute rather than chronic events.² Poisonings cause considerable morbidity and mortality worldwide.³ According to the estimates from the World Health Organization, approximately 350,000 people die yearly due to poisoning.³ Poisonings have been mainly studied in the United States, and only few countries have published nationwide statistics on poisoning deaths.⁴

In England and Wales, poisoning mortality has declined among both men and women during the 1980s and the early 1990s.⁵ In contrast, studies across numerous jurisdictions in the United States have reported an increase in drug-induced deaths since 1990.⁶ The authors believe that a rise in pre-

scriptions for opioid analgesics may have contributed to this development.⁶ In the United States, 56% of fatal poisonings occurred in individuals aged 20–49 years.⁷

Fatal poisonings among children are rare. Although children younger than 6 years dominate less severe poisoning statistics, they comprise just 2.3% of the fatalities.⁷ Since 1950s, pediatric poisoning deaths have declined significantly in the United States.⁸ Poisoning deaths among Finnish children have been rare in the last few decades.⁹ The positive progress has been thought to be mainly due to product reformulations, child-resistant packaging, heightened parental awareness of toxic effects of many substances, and preventive interventions and poisoning information provided by poison information centers and specially trained health professionals.^{8,10}

The aim of this study was to investigate the incidence and secular trend of poisoning deaths (alcohol and non-alcohol) per age and gender in Finland in 1971–2005.

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Methods

The data for poisoning deaths in Finland were obtained from the Official Cause-of-Death Statistics, which is an extensive, medico-legal death investigation system in the country.¹¹ This register has been computer based since 1971 and is annually brought up to date and quality controlled by the Cause-of-Death Bureau at the Statistics Finland, the central statistical office of the country. The coding is based on the Finnish medico-legal death investigation system. Regarding poisoning deaths, the codes (41 for alcohol and 48 for non-alcohol poisoning) were the same during the whole study period of 1971–2005 and were therefore not affected by possible changes in the International Classification of Diseases.^{11,12} The study population consisted of all Finnish people who had died from poisoning between 1971 and 2005.

There are two categories for poisoning deaths in the Official Cause-of-Death Statistics of Finland: alcohol poisonings and non-alcohol poisonings.¹¹ Because alcohol-induced deaths predominated in the fatal poisoning statistics, it was decided to study deaths by alcohol separately from other poisonings.

The Finnish Official Cause-of-Death Statistics are in practice 100% complete because each death, its certificate, and the corresponding personal information in our computerized population register are cross-checked. The accuracy of the data is maximized in a 3-phase process, in which each death certificate and its codes are cross-examined.^{11,13} In these official statistics, poisoning deaths are coded as part of the injury-related death category, for which the accuracy of the death certificates and their cause-of-death codes are further verified by autopsies performed in 94–97% of these deaths.^{11,13}

For computing the incidence rates of poisoning deaths, the annual mid-populations were obtained from the Official Statistics of Finland,¹² a computer-based national population register. The numbers and incidence rates of poisoning deaths were thus the true results concerning the entire population of Finland rather than cohort-based estimates.

Results

All poisoning deaths

During the study period of 35 years, from 1971 to 2005, an overall rise was seen in the incidence of all poisoning deaths (non-alcohol and alcohol). In 1971, the incidence of all poisoning deaths was

12.2/100,000 in men (total number: 273) and 2.1/100,000 in women (total number: 50) and in 2005, 23.6/100,000 in men (total number: 607) and 7.4/100,000 in women (total number: 199), respectively.

Non-alcohol poisoning deaths

The incidence of non-alcohol poisoning deaths increased during the study period. In 1971, the incidence of poisoning deaths was 2.6/100,000 in men (total number: 58) and 1.4/100,000 in women (total number: 34). In 2005, the corresponding figures were 6.8/100,000 in men (total: 176) and 3.2/100,000 in women (total: 87; Tables 1 and 2 and Figure 1).

The highest annual incidence of fatal non-alcohol poisonings in men (9.2/100,000, total: 223) was seen in 1990 (Table 1). In women, the peak year was 2005 (3.2/100,000, total: 87; Table 2). In general, men had substantially higher incidence rates of non-alcohol poisoning death than women (Tables 1 and 2 and Figure 1). The male-female ratio of non-alcohol poisoning deaths was 1.9 in 1971 and 2.1 in 2005.

In 2005, the highest incidence rate among men was seen in the age group of 40–49 years with 12.3 non-alcohol poisoning deaths per 100,000 men (total: 47; Table 1). In women, the highest incidence in 2005, 7.9 fatal non-alcohol poisonings per 100,000 women (total: 32), was seen in the age group of 50–59 years (Table 2).

Among children and adolescents (age range, 0–19 years), fatal non-alcohol poisoning rates were low during the whole 35-year period. These findings were similar in boys and girls (Tables 1 and 2). Fatal non-alcohol poisonings in the age groups of 0–4, 5–9, and 10–14 years were uncommon, only few cases occurred per year (41 cases in all age groups combined) during the study period. Although non-alcohol poisoning deaths increased with age so that more fatal cases were seen among adolescents aged 15–19 years, the total number of deaths was less than 10 per gender per year during the whole 35-year period.

Alcohol poisoning deaths

During our study period, 1971–2005, alcohol poisoning deaths increased. In 1971, the incidence of deaths by alcohol poisoning was 9.6/100,000 in men (total number: 215) and 0.7/100,000 in women (total number: 16). In 2005, the corresponding figures were 16.8/100,000 in men (total number: 431) and 4.2/100,000 in women (total number: 112; Tables 3 and 4 and Figure 1).

Table 1 Age-specific incidence (per 100,000 persons) of poisoning deaths (excluding alcohol deaths) in men in Finland between 1971 and 2005

Year	Age group									Total
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+	
1971	0.3	1.0	2.5	4.1	3.9	5.6	3.4	2.7	0.0	2.6
1972	0.3	1.0	2.8	4.1	6.7	4.2	2.8	7.8	6.0	3.1
1973	0.0	1.5	2.5	5.0	7.5	6.5	4.4	10.1	11.6	3.8
1974	0.0	0.7	3.3	4.9	10.0	6.9	6.6	6.1	5.6	4.1
1975	0.9	1.3	3.4	5.0	3.6	10.3	6.1	4.7	5.3	3.9
1976	0.6	1.5	4.1	6.2	10.0	6.6	3.4	5.7	0.0	4.4
1977	0.9	0.8	4.0	7.1	10.4	9.4	6.8	6.5	4.9	5.1
1978	0.0	0.0	3.8	6.0	7.1	7.5	6.9	2.1	4.6	4.0
1979	0.3	0.0	4.4	6.5	10.7	8.4	8.8	3.0	8.7	5.0
1980	0.0	0.8	4.2	4.5	9.4	7.9	5.9	3.0	0.0	4.2
1981	0.0	1.4	4.3	7.2	9.1	11.3	8.8	2.9	3.9	5.5
1982	0.0	0.3	4.0	4.7	9.1	6.2	7.6	3.7	0.0	4.1
1983	0.0	0.6	1.8	3.5	9.0	11.3	5.2	4.6	7.1	4.0
1984	0.0	0.6	4.1	5.3	7.1	8.2	7.9	3.6	3.3	4.3
1985	0.3	0.6	3.1	7.3	8.1	10.1	2.8	1.8	9.7	4.5
1986	0.3	0.9	4.9	9.5	9.2	6.2	7.5	2.7	3.1	5.4
1987	0.0	1.2	4.2	11.1	12.5	11.2	7.8	7.3	8.7	6.9
1988	0.0	0.6	2.1	14.5	13.9	10.8	10.6	4.6	5.6	7.3
1989	0.0	0.6	4.8	12.5	15.8	13.8	11.7	6.6	10.5	8.3
1990	0.0	1.2	6.0	14.6	16.9	16.2	9.1	6.5	10.2	9.2
1991	0.0	1.5	5.2	12.0	15.7	10.4	10.8	6.4	12.2	8.1
1992	0.0	0.6	4.0	9.8	13.3	13.9	6.9	4.5	11.8	7.0
1993	0.0	1.8	2.6	10.1	15.4	13.6	8.3	4.4	0.0	7.3
1994	0.0	0.3	3.6	9.1	20.1	14.0	6.9	5.1	6.8	8.0
1995	0.0	2.4	5.1	9.7	14.7	12.7	5.9	7.4	4.4	7.5
1996	0.0	0.6	6.1	8.8	19.4	12.6	12.7	7.9	2.2	8.6
1997	0.0	1.5	5.2	7.8	14.7	12.3	9.0	5.3	2.2	7.2
1998	0.0	1.2	3.1	7.1	7.9	5.6	5.8	4.4	12.9	4.7
1999	0.0	1.5	6.2	7.4	7.0	10.2	5.3	2.8	6.5	5.4
2000	0.0	2.1	9.6	4.6	6.8	6.8	4.4	4.8	4.1	5.0
2001	0.0	2.4	7.4	5.5	8.9	6.1	7.6	2.6	6.0	5.3
2002	0.0	2.1	5.7	8.7	5.7	6.1	6.4	3.2	3.8	4.9
2003	0.3	2.7	7.1	7.0	8.0	7.0	5.8	5.1	7.3	5.6
2004	0.0	2.4	11.2	7.7	6.0	6.2	6.9	2.5	8.6	5.7
2005	0.0	1.5	7.4	11.0	12.3	9.4	6.6	3.7	1.6	6.8

Among men, the age groups with the highest overall incidence rates consisted of the 40- to 69-year-olds. The peak incidence, 41.8 deaths per 100,000 men (total: 169), was seen among 50- to 59-year-old men in 2005 (Table 3). In women, the highest incidence of alcohol poisoning deaths, 12.8 deaths per 100,000 women (total: 52), was seen in the same year and age group as in men (50 to 59-year-old women in 2005; Table 4).

The overall incidence rates of alcohol poisoning deaths were substantially higher among men than women during the study period (Tables 3 and 4 and Figure 1). From the beginning of the 1970s, when these rates were about 10 times higher in men compared with women, the difference has gradually decreased so that in the last few years men's incidence rate was about four times higher (Tables 3 and 4 and Figure 1).

The incidence of alcohol poisoning deaths in children and adolescents (0- to 19-year-old) was very

low during the entire period of 35 years. There were no poisoning deaths caused by alcohol in children aged 0-9 years and only few deaths in adolescents aged 10-19 years (Tables 3 and 4). None of these occurred among 10- to 14-year-olds.

Discussion

The incidence of all poisoning deaths grew in Finland from the early 1970s until the 1990s when it leveled off before starting to rise again in the last few years. The incidence of alcohol poisoning deaths increased similarly until the late 1980s then declined somewhat but began to rise sharply during the last few years of observation. The incidence of all poisoning deaths in Finnish children and adolescents was low during the entire 35-year study period. The incidence of fatal poisonings (alcohol and non-alcohol) was clearly higher in men than in

Table 2 Age-specific incidence (per 100,000 persons) of poisoning deaths (excluding alcohol deaths) in women in Finland between 1971 and 2005

Year	Age group									Total
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+	
1971	0.3	0.7	0.8	0.7	1.0	3.7	2.9	2.4	5.5	1.4
1972	0.0	0.8	0.8	1.7	3.4	0.4	1.2	1.5	7.9	1.3
1973	0.6	0.5	0.2	1.1	1.4	2.6	1.2	1.5	5.1	1.1
1974	0.9	0.5	0.5	0.7	3.5	3.7	2.0	1.4	0.0	1.5
1975	0.3	0.5	0.2	1.4	1.4	1.1	0.4	1.4	0.0	0.7
1976	0.0	1.0	1.2	2.3	1.4	1.8	2.4	2.0	2.2	1.4
1977	0.0	0.0	1.9	1.2	1.4	2.2	2.0	1.3	2.1	1.2
1978	0.3	0.0	2.2	1.2	2.2	2.1	0.8	0.0	3.9	1.2
1979	0.3	0.3	0.5	1.1	4.3	3.2	2.8	1.7	3.6	1.7
1980	0.0	0.6	0.8	2.5	1.4	1.7	2.0	1.7	1.7	1.3
1981	0.7	0.0	0.8	0.5	2.9	2.8	2.4	1.1	3.2	1.3
1982	0.0	0.3	0.5	1.3	3.9	1.4	3.2	1.6	7.5	1.6
1983	0.0	0.0	1.1	1.0	1.4	1.1	3.6	5.7	4.2	1.5
1984	0.0	0.0	1.6	1.5	3.5	2.5	0.8	3.0	5.4	1.6
1985	0.0	0.9	1.1	1.7	2.8	1.8	1.2	2.0	2.5	1.4
1986	0.0	0.0	1.1	2.4	4.3	3.7	2.4	1.5	2.4	1.9
1987	0.0	0.0	1.1	1.5	3.5	2.9	1.9	5.5	3.4	1.9
1988	0.0	0.6	0.5	2.0	1.8	5.2	1.9	2.5	4.4	1.8
1989	0.0	0.3	1.1	3.3	4.6	3.7	3.1	2.0	3.1	2.3
1990	0.0	0.3	0.6	1.3	1.7	5.5	3.7	2.5	1.0	1.8
1991	0.3	0.3	1.4	3.6	5.1	5.2	5.6	1.5	4.8	3.0
1992	0.0	0.6	1.2	2.6	5.0	6.5	4.5	3.0	4.6	2.9
1993	0.0	0.0	1.2	2.6	5.6	4.0	3.0	1.5	2.7	2.3
1994	0.0	0.6	0.9	0.8	4.4	6.1	3.8	3.9	4.4	2.5
1995	0.0	0.3	1.2	1.6	4.6	6.3	6.9	1.0	3.4	2.8
1996	0.0	0.3	0.0	4.5	4.8	5.1	5.8	5.2	2.5	3.1
1997	0.0	0.0	1.0	2.2	4.6	7.7	2.0	2.8	2.5	2.6
1998	0.0	0.6	0.6	3.0	3.0	3.1	3.5	5.1	4.1	2.4
1999	0.0	0.9	0.6	0.5	3.0	2.3	2.7	2.7	1.6	1.6
2000	0.0	1.3	2.3	1.1	1.5	4.8	1.9	2.2	1.6	1.9
2001	0.0	0.3	1.0	1.1	2.3	4.9	2.3	4.0	3.1	2.0
2002	0.0	0.9	0.6	0.9	4.2	3.2	4.2	2.2	6.8	2.3
2003	0.0	0.0	0.9	0.6	3.7	4.0	1.9	2.7	3.6	1.9
2004	0.0	0.3	1.5	0.9	3.5	8.2	3.7	2.7	0.7	2.7
2005	0.0	0.6	1.2	1.2	4.5	7.9	5.3	1.8	6.0	3.2

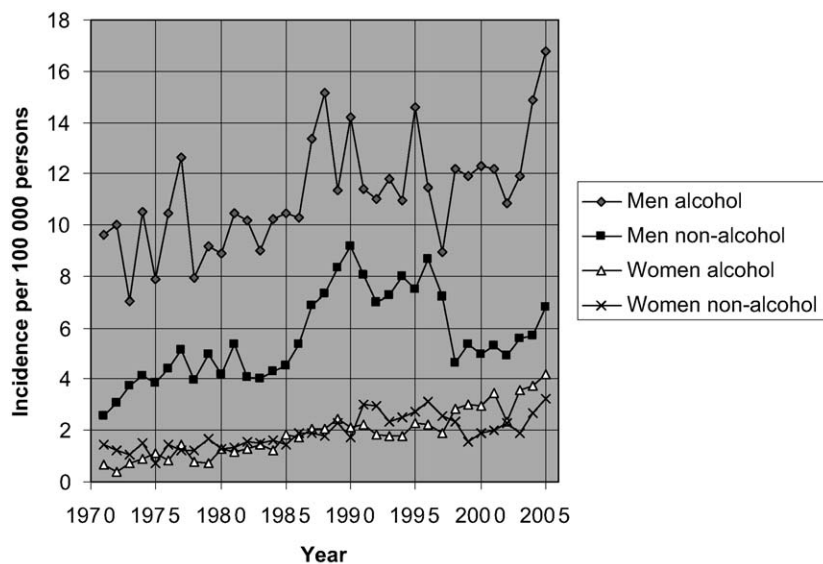


Figure 1 Incidence of poisoning deaths in Finland 1971–2005.

Table 3 Age-specific incidence (per 100,000 persons) of alcohol deaths in men in Finland between 1971 and 2005

Year	Age group									Total
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+	
1971	0.0	0.0	2.2	13.3	31.1	21.9	15.4	4.1	18.4	9.6
1972	0.0	1.0	3.7	14.7	28.3	22.4	16.8	5.2	0.0	10.0
1973	0.0	0.7	2.7	9.4	15.6	18.5	16.1	3.8	0.0	7.0
1974	0.0	0.0	6.5	11.7	23.9	29.8	18.2	10.9	0.0	10.5
1975	0.0	0.5	4.3	9.7	19.6	18.8	14.4	5.9	0.0	7.9
1976	0.0	0.3	4.6	9.8	31.9	24.9	16.8	9.1	5.1	10.5
1977	0.0	0.5	4.4	17.2	29.4	30.7	26.0	7.6	4.9	12.6
1978	0.0	0.8	2.6	12.2	14.3	23.3	11.4	7.4	0.0	7.9
1979	0.0	0.0	3.7	12.0	23.5	20.5	14.1	9.1	0.0	9.1
1980	0.0	1.1	5.0	11.0	19.4	19.4	15.8	7.9	0.0	8.9
1981	0.0	0.3	4.5	11.2	24.4	30.1	15.8	4.8	0.0	10.4
1982	0.0	0.0	2.8	12.8	20.4	30.6	16.4	8.4	0.0	10.2
1983	0.0	0.0	4.1	9.1	17.9	23.7	17.2	12.9	0.0	9.0
1984	0.0	0.0	3.8	13.9	20.2	24.9	18.1	8.2	6.7	10.3
1985	0.0	0.6	2.8	15.3	19.7	26.8	17.1	6.4	3.2	10.5
1986	0.0	0.0	2.6	12.3	19.9	28.4	16.6	11.0	3.1	10.3
1987	0.0	0.0	4.5	16.7	26.4	29.5	28.1	8.2	5.8	13.4
1988	0.0	0.3	3.4	14.0	35.5	41.2	25.3	6.4	0.0	15.2
1989	0.0	0.3	2.9	14.2	21.9	25.2	23.8	6.6	0.0	11.4
1990	0.0	0.0	2.4	18.4	26.1	37.8	22.0	12.9	2.5	14.2
1991	0.0	0.3	1.9	17.2	20.2	29.8	16.4	5.5	2.4	11.4
1992	0.0	0.6	2.0	11.3	24.0	24.4	18.1	9.9	7.1	11.0
1993	0.0	0.3	2.3	10.6	26.6	26.1	19.4	10.5	7.0	11.8
1994	0.0	0.0	1.8	8.6	23.1	23.0	28.0	5.1	4.5	11.0
1995	0.0	0.6	2.1	14.1	29.0	35.3	26.0	11.5	4.4	14.6
1996	0.0	0.0	1.8	12.4	21.5	23.3	24.1	11.9	4.4	11.5
1997	0.0	0.0	1.5	6.5	17.8	17.8	22.5	9.1	0.0	8.9
1998	0.0	0.0	2.2	10.5	24.5	28.8	21.8	9.5	0.0	12.2
1999	0.0	0.0	3.4	11.2	24.2	24.8	22.0	8.4	0.0	11.9
2000	0.0	0.0	2.8	11.1	27.3	27.3	19.4	5.4	0.0	12.3
2001	0.0	0.3	2.8	8.6	28.0	26.7	20.4	6.6	0.0	12.2
2002	0.0	0.0	4.5	9.9	23.9	22.0	15.3	6.5	1.9	10.8
2003	0.0	0.0	4.7	8.7	22.7	26.8	22.0	5.1	3.7	11.9
2004	0.0	0.3	1.5	11.8	27.7	36.0	23.5	14.5	1.7	14.9
2005	0.0	0.3	3.5	14.3	27.7	41.8	29.4	11.1	1.6	16.8

women in 1971–2005. Finally, the incidence of alcohol poisoning deaths was highest in 2005; the secular rise being sharpest among women.

Our study is unique because it describes the trend of alcohol and non-alcohol poisoning deaths in a well-defined population over a period of 35 years. Internationally, corresponding studies are lacking and no long-term trends in the incidence of poisoning deaths have been published. Most studies have been conducted within one hospital catchment area or within one province, or they have covered only a short-time period.⁴

The length of the study period, 35 years, is a major strength of this paper. Other strengths of this study are that we covered the entire population of Finland and that in this country practically all injury deaths are submitted to medico-legal cause-of-death determination.¹⁴ This medico-legal practice includes information on the medical and other history of the deceased, circumstances of the death, and autopsy and toxicological findings so that a forensic exam-

iner can form a justified, evidence-based opinion about the manner and cause(s) of death.¹⁴ Although death certificates do not include information on the chronicity of the intoxications, we may nonetheless assume that most of them were acute events.²

In Finland, the death certification process seems to provide an appropriate contribution to the mortality statistics.¹⁵ Death certificates have been collected by the Official Statistics of Finland since 1936. Classified mortality statistics have been available since 1969.¹²

A limitation in our study is that, owing to international statistics regulations,^{16–18} some poisonings can be classified as diseases rather than poisonings in the Finnish mortality statistics.^{17,18} However, we used the same international classification system for the entire study period and thus our results are comparable throughout 1971–2005 and with other countries. A further limitation was that our database did not include information on the agents that caused the poisonings except alcohol. Furthermore, we

Table 4 Age-specific incidence (per 100,000 persons) of alcohol deaths in women in Finland between 1971 and 2005

Year	Age group									Total
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+	
1971	0.0	0.0	0.3	0.4	1.0	1.5	2.9	0.0	0.0	0.7
1972	0.0	0.0	0.0	1.0	1.4	0.4	0.4	0.8	0.0	0.4
1973	0.0	0.0	0.2	0.7	2.1	1.1	2.0	0.0	0.0	0.7
1974	0.0	0.0	0.5	2.4	1.7	0.7	2.0	0.0	0.0	0.9
1975	0.0	0.0	0.0	1.4	3.2	2.6	2.0	1.4	0.0	1.1
1976	0.0	0.0	0.2	2.0	1.8	1.8	0.8	0.7	0.0	0.8
1977	0.0	0.3	0.0	1.5	3.2	3.2	3.2	1.9	0.0	1.4
1978	0.0	0.0	0.2	0.9	1.4	2.5	1.2	0.6	0.0	0.8
1979	0.0	0.3	0.3	1.1	1.4	2.1	0.8	0.0	0.0	0.7
1980	0.0	0.0	1.0	2.2	3.6	2.1	1.2	0.6	0.0	1.3
1981	0.0	0.0	0.8	1.3	2.9	3.5	0.4	1.1	0.0	1.2
1982	0.0	0.0	0.3	1.6	3.5	4.6	0.4	0.5	0.0	1.3
1983	0.0	0.0	0.0	2.0	3.2	4.6	2.0	1.0	0.0	1.5
1984	0.0	0.0	0.5	1.2	2.5	2.5	2.4	2.0	0.0	1.2
1985	0.0	0.0	0.8	1.2	5.2	6.5	1.6	0.5	0.0	1.8
1986	0.0	0.0	0.0	1.5	4.3	4.4	3.9	1.5	0.0	1.7
1987	0.0	0.0	1.1	1.2	1.9	7.0	6.2	0.5	1.1	2.0
1988	0.0	0.0	0.8	1.5	4.8	5.9	3.1	1.0	1.1	2.0
1989	0.0	0.0	0.0	2.0	5.7	8.1	4.2	1.0	0.0	2.5
1990	0.0	0.0	0.0	3.3	3.9	4.0	5.2	1.0	0.0	2.1
1991	0.0	0.0	0.3	2.6	4.8	6.3	4.1	0.5	0.0	2.3
1992	0.0	0.0	0.0	2.1	5.8	3.3	1.9	1.0	0.9	1.8
1993	0.0	0.3	0.0	1.6	4.3	3.6	4.5	0.0	0.0	1.8
1994	0.0	0.0	0.6	1.6	3.2	5.0	3.4	1.0	0.0	1.8
1995	0.0	0.0	0.9	2.7	6.5	3.5	3.5	0.5	0.0	2.3
1996	0.0	0.0	0.0	1.6	5.1	5.4	4.3	1.4	0.8	2.2
1997	0.0	0.0	0.0	1.3	4.4	5.5	2.3	1.9	0.0	1.9
1998	0.0	0.0	0.6	2.2	6.5	7.0	5.5	0.9	0.0	2.8
1999	0.0	0.3	0.3	0.3	6.8	7.9	3.9	0.9	0.0	3.0
2000	0.0	0.0	0.6	1.7	7.9	5.9	5.4	2.2	0.0	3.0
2001	0.0	0.0	1.0	2.2	4.7	9.8	7.4	3.1	0.8	3.5
2002	0.0	0.3	0.3	1.7	5.2	5.1	4.2	0.9	1.5	2.3
2003	0.0	0.3	0.9	1.2	6.3	10.1	5.6	4.0	0.0	3.6
2004	0.0	0.0	0.0	2.5	5.3	11.6	8.5	0.9	0.0	3.7
2005	0.0	0.0	0.3	2.5	6.4	12.8	8.2	1.3	0.7	4.2

lacked sufficient evidence to determine whether the death was a suicide, homicide, or unintentional.

Poisoning mortality rates among children have been fairly low in the last few decades. However, in the beginning of the study period, the incidence was slightly higher and showed a decreasing trend when coming to the 1990s. A similar decreasing trend has been noted in other countries as well.^{7,8,19-24} According to the World Health Report, in 64% of all fatal poisoning cases, the victim was a male.³ In the United States, the male-female ratio on poisoning deaths was 2.4 in 1995.⁴ The present study shows that in Finland, the incidence of poisoning deaths is clearly higher in men compared with women, a result which concurs with previous literature.⁴

Suicide figures in Finland have been among the highest in the world, especially for men.¹² Various toxic substances or agents have been the cause of poisoning death in 27-30% of suicides.²⁵ Since 1990, a significant decline in suicides has occurred.¹² Previous research has suggested that

this decline may be partly explained by the new antidepressants (selective serotonin reuptake inhibitors), which are safer and cause less poisoning deaths than older similar drugs (tricyclic antidepressant).¹⁷ In addition, based on previous findings, the general trend in injury deaths has been decreasing in Finland during the last few decades.²⁶ However, contrary to our expectations, a corresponding decline in poisoning deaths in general was not seen in the present study. The reason for the rise in the number and incidence of poisoning deaths is not known, and the topic deserves further study. One possible reason for the increase in poisoning deaths may be the growing drug abuse and use of illicit drugs.²⁷

Various reasons have been offered to explain the rising trend of alcohol poisonings in Finland, including our European Union-membership and the increased general acceptance for women's use of alcohol - even in public places.²⁸ The incidence of alcohol poisoning deaths increased further after the year 2004. The most probable explanation for

this was the substantial lowering of alcohol taxes in Finland on March 1, 2004 followed by a quick and sharp increase in alcohol consumption. This political decision has later been criticized by public health groups, and a raise in alcohol taxes has been proposed.

To sum up, both non-alcohol and alcohol poisoning deaths among adult Finns increased during 1971–2005. Men had a higher risk of poisoning death compared with women. The incidence of poisoning deaths in children and adolescents remained low during the entire 35-year study period. Further research is warranted to investigate why deaths by poisoning are increasing in Finland although the overall injury death and suicide rates are declining.

Special attention should be paid to the increase in adults' alcohol poisoning deaths during 1971–2005, with a leap seen after alcohol taxes were lowered in Finland in 2004. A rapid increase in the alcohol tax levels would probably be needed to decrease alcohol-related morbidity and mortality in this country.

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