

SALMA EL-TAYEB EL-AMIN

# Use and Determinants of Various Types of Tobacco Products

Study Among Finnish and Sudanese  
Adolescents and Young Adults



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ACADEMIC DISSERTATION

To be presented, with the permission of  
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of Tampere University,

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<i>Responsible supervisor and Custos</i>	Professor Arja Rimpelä Tampere University Finland	
<i>Pre-examiners</i>	Emeritus Professor Lasse Kannas University of Jyväskylä Finland	Professor Connie Evashwick George Washington University USA
<i>Opponent</i>	Docent Tellervo Korhonen University of Helsinki Finland	

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*Dedicated to you ...*

*To Sudan that has been bitterly divided over conflicts. We deeply apologise for changing your history.*

*To my beautiful city Juba.*

*To my teachers.*

*To the ones who ignite my life, my mother Aamna, my children M. Al Akram, Rama and Muhab.*



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*Salma El Tayeb El Amin*



# ABSTRACT

Tobacco use remains one of the most serious health hazards worldwide. As developed nations take measures to reduce tobacco use, the populations of developing nations are at increased risk of targeting by tobacco companies. Youth are a highly vulnerable target audience and are susceptible to being attracted to a variety of tobacco-containing products. Extensive research has focused on understanding the causes, health impacts, and remedies related to the smoking of cigarettes by young people. Much less attention has been given to other types of tobacco products. The main aim of this study was to investigate the determinants and the use of five different kinds of tobacco products among adolescents and university age students. The study, comprised of four discrete research sub-studies, examined young people from the Sudan and Finland at various points in time. The framework applied to examine the influences on individual behaviour regarding tobacco use is organized from the perspective of family factors to community norms to societal policies. Three data sets were used in the four research sub-studies: the first two Sudanese data sets were drawn from the Sudanese Youth Tobacco Survey (SYTS) and the Sudanese Health Professional Student Survey (SHPSS). The third Finnish data set was drawn from the Adolescent Health and Lifestyle Survey (AHLS) and the Finnish registration system. Basic and advanced analyses were performed, including logistic regression models, Mediation and multi-level analyses using different methodologies and software.

The main findings highlight the importance of the influences of tobacco use by parents, maternal and paternal grandparents, friends, and teachers on the use of cigarettes, water-pipe, tombak, snus, and electronic cigarettes by adolescents. This study revealed that parents' smoking and their use of tombak and snus were strong influences on the adolescents' tobacco use, with a higher risk of smoking initiation among both the Sudanese and Finnish adolescents. The conclusions emerging from this study are that parents' tobacco use is a key factor on youth smoking, and that the likelihood of youth smoking is significantly increased when both parents smoke, with more effect of the mother. In addition, the Finnish grandparents' smoking was found to be transmitted directly and indirectly to their grandchildren and influences them to smoke and to use other kinds of tobacco products as well as vaping. This

study also highlights the effects of exposure to residential smoking and school smoking policies on the tobacco use by young adult university-level students. The findings point to the pivotal role of the school environment, including the role of teachers' use of tobacco on students' tobacco use in general together with smoking on school premises.

From contextual evidence and findings, the results of the study provide information for decision-makers and health providers to create effective policies and programs and to adapt prevention strategies for different kinds of tobacco products, particularly those targeted at youth and adolescents. More effective interventions at home and at school, with stricter policy actions and enforcement, are needed, to stop youth use of cigarettes and e-cigarettes, as well as to prevent or stop use of snus and tombak dipping, in order to reach the objective of a society free of tobacco and its harmful health effects.

# TIIVISTELMÄ

Tupakointi on edelleen yksi maailman suurimmista terveysriskeistä. Samalla kun kehittyneet maat aktiivisesti toimivat tupakoinnin vähentämiseksi, kehittyvien maiden väestö on yhä suuremmassa riskissä joutua tupakkayhtiöiden markkinoinnin kohteeksi. Nuoriso on erityisen haavoittuva ryhmä, jota erityyppiset tupakkaa sisältävät tuotteet houkuttavat. Nuorten tupakoinnin syitä, terveysvaikutuksia ja ehkäisytöimiä koskeva tutkimus on ollut laajaa. Muita tupakkatuotteita kuin savukkeiden polttamista ja niiden vaikutuksia on tutkittu vähemmän. Tämän työn ensisijainen tarkoitus oli tutkia tekijöitä, jotka selittävät viiden eri tupakkatuotteen käyttöä nuorten ja yliopisto-opiskelijoiden keskuudessa. Tutkimus koostuu neljästä tieteellisestä artikkelista, joissa tutkittiin suomalaisia ja sudanilaisia nuoria. Tutkimuksessa käytetty viitekehys, jolla tutkittiin yksilöiden tupakointikäyttäytymistä, rakentui kolmen tekijän ympärille: perhetekijät, yhteisön normit ja yhteiskunnan toimet. Tutkimuksessa käytettiin kolmea eri aineistoa, joista kaksi oli Sudanista: Sudanese Youth Tobacco Survey (SYTS) ja Sudanese Health Professional Student Survey (SHPSS). Kolmas aineisto oli suomalainen, Nuorten terveystapatutkimus (NTTT). Aineistojen analysoinnissa käytettiin sekä tilastollisia perusmenetelmiä että kehittyneempiä menetelmiä kuten logistista regressiota ja monitasomallinnusta.

Tutkimuksen tuloksissa korostuu vanhempien, isovanhempien, ystävien ja opettajien tupakoinnin vaikutus nuorten tupakkatuotteiden käyttöön (savukkeet, nuuska, vesipiippu, sähkösavukkeet ja tombak). Tutkimus osoitti, että vanhempien tupakointi ja tombakin/nuuskan käyttö lisäsivät nuorten tupakointiriskiä ja erityisesti tupakoinnin aloittamisen riskiä sekä Sudanissa että Suomessa. Tämän tutkimuksen perusteella voidaan todeta, että vanhempien tupakointi on avaintekijä nuorten tupakoinnin aloittamisessa ja että tupakoinnin todennäköisyys kasvaa, jos molemmat vanhemmat tupakoivat. Äidin vaikutus on kuitenkin isän vaikutusta suurempi. Lisäksi suomalaisten isovanhempien tupakoinnin todettiin lisäävän lastenlasten tupakointia ja muiden tupakkatuotteiden ja sähkösavukkeiden käyttöä. Vaikutus oli sekä suora että epäsuora vanhempien tupakoinnin kautta. Nuorten yliopisto-opiskelijoiden tupakointiriskiä lisäävänä tekijänä Sudanissa nousi esiin tupakoinnille altistuminen asuintoloissa sekä koulun tupakkapolitiikan vaikutukset.

Tutkimustulokset osoittavat kouluympäristön, mukaan lukien opettajien tupakointi, olevan keskeinen nuorten tupakointiin vaikuttava tekijä sekä tupakoinnissa yleensä että erityisesti koulun alueella tupakoinnissa. Väitöskirjatutkimuksen tulokset tuovat uutta tietoa päättäjille ja terveydenhuoltoalan ammattilaisille. Tämä tieto auttaa kehittämään nuorille aiempaa tehokkaampia toimenpiteitä ja ohjelmia sekä ehkäisystrategioita, jotka kattavat myös muut tupakkatuotteet ja tupakankaltaiset tuotteet kuin perinteiset savukkeet. Nuorten savukkeiden polton, sähkösavukkeiden, nuuskan ja tombakin käytön lopettamiseksi tarvitaan aikaisempaa tehokkaampia interventioita kotona ja koulussa liitettynä tehokkaaseen tupakkapolitiikkaan ja sen toimeenpanoon. Näin voidaan saavuttaa tupakkavapaa yhteiskunta, josta tupakkatuotteiden terveyshaitat puuttuvat.

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# ABBREVIATIONS

AHLS	Adolescents Health and Lifestyle Survey
A-OR	Adjusted Odds Ratio
CDC	Centres for Diseases Control and Prevention
CI	Confidence Interval
CPHA	Canadian Public Health Association
DALYs	Disability-Adjusted Life Years
GHPSS	Global Health Professional Student Survey
GYTS	Global Youth Tobacco Survey
EC	E-cigarette
ETS	Environmental Tobacco smoke
FCTC	Framework Convention on Tobacco Control
IARC	International Agency for Research on Cancer
LRA	Logistic regression analysis
M RTP	Modified Risk of Tobacco Products
NCDs	Non-Communicable Diseases
NNK	N-nitrosoanatabine (sample based on dry weight)
NNN	N-nitrosornicotine
OR	Odds Ratio
PH	Power of Hydrogen
SBT	Social Behavioural Theory
SCT	Social Cognitive Theory
SES	Socioeconomic Status
SLT	Smokeless Tobacco
SMOH	Sudan Ministry of Health
SHPSS	Sudanese Health Professional Student Survey
SYTS	Sudanese Youth Tobacco Survey
TSNA	Tobacco-specific N-nitrosamines
TPB	The theory of planned behaviour
TTI	Theory of Triadic Influence
WHO	World Health Organization





# FUNDAMENTAL AND GLOSSARY

**Adolescents:** Refers to persons in their teenage years (between age 12 and 18).

**Bias:** Any deviation of results or inferences from the truth, or processes leading to such deviation. Any trend in the data collection; analysis; interpretation; publication, or review of data that can lead to false conclusions that are systematically different from the truth.

**Chewing tobacco:** Tobacco product placed in the gingivo-buccal area of the oral cavity, including loose-leaf (scrap), plug (press), twist (roll), and fine-cut tobacco

**Confidence interval (CI):** The 95 percent CI, is used to estimate the precision of odds ratio, the range of values in which it is 95 per cent certain that the true value lies for the whole population. For example, 95 per cent, that the true value of a variable such as a mean, proportion, or rate is contained within the interval.

**Confounder:** A third variable that indirectly distorts the relationship between two other variables because it is independently associated with each of the variables. A confounder can be controlled by stratification, adjustment or by multivariate technique when analysing, the control of which introduces rather than eliminates bias.

**Confounding:** A situation in which the measure of the effect of an exposure on risk is distorted because of the association of exposure with another factor, a third factor (an “extra” variable that did not account for).

**Cross-sectional study:** It is an observational descriptive study that examines or measures the relationship between health-related characteristics (exposure) and other variables of interest (outcomes) as they exist in a defined population and in a given area at one particular time.

**Descriptive study:** A study concerned with and designed only to describe the existing distribution of variables, without regard to causal or other hypotheses.

**Dual tobacco users:** Refers to having a smokeless tobacco habit concurrently with a smoking habit, usually of cigarettes. Recently, this term can also be used when smokeless use combined with e-cigarette use.

**Generalisability:** Applicability of the results beyond the study setting and the particular people studied to another group or population. Generalisability describes the extent to which research findings can be applied to settings other than that in which they were originally tested.

**Mediation:** Refers to the transmission of the effect of an independent variable on a dependent variable through one or more other variables. Statistically, mediation corresponds to an indirect effect of an independent variable on a dependent variable

that passes through one or more mediator variables, either partial (direct, indirect effects) or complete (total effects).

*Direct effect:* That part of the exposure effect, which is not mediated or explained by a given set of potential mediators (deal with an impact of an individual/people on another when not mediated or transmitted through a third individual/people “mediators”).

*Indirect effect:* That part of the exposure effect, which is mediated or explained by those same mediators. It is calculated by multiplying the paths that constitute the effect.

*Total effect:* With complete mediation, the entire (or total) effect of an independent variable on a dependent variable is transmitted through one or more mediator variables. Thus, the independent variable has no direct effect on the dependent variable; rather, its entire effect is indirect. The proportion of the total effect is usually obtained by the ratio of the unadjusted (direct effect) to the adjusted (indirect effect).

**Modified smokeless tobacco products:** Non-combustible tobacco-containing products which have reduced toxicants.

**Odds ratio (OR):** A measure of the degree or strength of an association between an exposure and outcome. In a cross-sectional study, it is measured as the ratio of the odds of exposure among the cases.

**P-value:** Calculated probability, obtained from a statistical test, in other words, it is the probability of finding the observed, or results when the null hypothesis of the research question is true.

**Recall bias:** Systematic bias due to differences in accuracy or completeness of recall or memory of past events or experiences, such as exposure to tobacco, or the time of the first cigarette.

**Reliability:** The degree of stability that exists when a measurement is repeatedly made under different conditions, or by different observers, and the thing being measured is assumed not to have changed and gives the results each time when used.

**School premises:** Means closed indoor premises in schools with ceiling, floor, and walls, staying places; as waiting space or for working or meetings, halls and open yards.

**Self-efficacy:** Estimation of the degree to which a person has confidence to perform a particular behaviour or chain of specific behaviour to manage the situation.

**Selection bias:** Error due to systematic differences in characteristics between those who are selected for inclusion in a study and those who are not, or between those compared within a study and those who are not, or too small to represent the target population. Persons who are less likely to enter the study will be under-represented and those who are more likely to enter the study will be over-represented relative to others in the general population.

**Significant others:** For scientific and short use in this study, significant others is defined as a person who is important to one's well-being with strong influence on the adolescent and young adult's life under study (examples from the current study:

mother, father, maternal mother, maternal father, paternal mother, paternal father, close friends, peers at school).

**Smoking area:** Means a separate room placed on indoor premises that has been approved by the building inspection authority.

**Smoke-free area:** Means indoor premises or part there of where smoking is prohibited.

**Tobacco products:** Means products that can be consumed and consist, wholly or even partly, of tobacco, whether genetically modified or not and intended for smoking, sniffing, sucking, or chewing.

**Tobacco use:** Using tobacco, include use of cigarettes, water-pipe “shisha”, smokeless tobacco, cigars, and electronic-cigarettes.

**Validity:** Means the appropriateness of the tools, processes, and data.

**Young people:** Are used interchangeably in the present work to refer generally to persons aged 17 years and older.



# ORIGINAL PUBLICATIONS

This doctoral dissertation is based on the following four original publications. These studies are referred to in this summary by Roman numerals as Study I, II, III and IV respectively as presented below (regardless of publication year).

- I. El-Amin, S. E. T., Nwaru, B. I., Ginawi, I., Pisani, P., & Hakama, M. (2011). The role of parents, friends and teachers in adolescents' cigarette smoking and tombak dipping in Sudan. *Tobacco Control*, 20(2), 94-99.
- II. El Amin, S. E. T. (2019). School smoking policies and health science students' use of cigarettes, shisha and dipping tombak in Sudan. *Frontiers in public health*, 7, 290.
- III. Kinnunen, J. M., Ollila, H., El-Amin, S. E. T., Pere, L. A., Lindfors, P. L., & Rimpelä, A. H. (2015). Awareness and determinants of electronic cigarette use among Finnish adolescents in 2013: a population-based study. *Tobacco control*, 24(e4), e264-e270.
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# 1 INTRODUCTION

Tobacco remains the largest preventable and the most serious health hazard of non-communicable diseases globally, contributing more to morbidity and mortality than all other health risk factors combined (Boutayeb & Boutayeb 2005; Magnusson 2019; WHO 2018; WHO 2019). The impact of smoked tobacco is devastating and results in high costs, including high disability adjusted life years (DALYs), along with the social and emotional costs associated with suffering, disability, and premature death (Peacock et al. 2018; Makate et al. 2020). Smoked tobacco imposes a massive economic burden, including ill health costs and loss of productive capacity by disability, and death imposes a massive economic burden on society and on individuals and families (Thomeer et al. 2019). Although smoking cigarettes is the largest avoidable health risk on earth that has been extensively documented (WHO 2019; IARC 2004), and despite the hazards, people of all ages choose to ignore warnings; thousands continue to initiate using tobacco and tobacco-related products every day (Thomeer et al. 2019). Up to half of the users die prematurely in middle age, with an average loss of 20 years of life expectancy (Thompson et al. 2018). Around 1.2 million of those deaths are the result of non-smokers being exposed to smoking (Peto & Lopez 2004; DiFranza 2004). There is increasing evidence that all forms of smokeless tobacco, including the Swedish snus and Sudanese tombak, contain nicotine, addictive substance and carcinogenic nitrosamines at differing levels and cause various kinds of ill health as well as increased risk of fatal myocardial infarction and cancer among regular users (Idris et al. 1995; Boffetta et al. 2008; Piano et al. 2010; Lee 2011; Thompson et al. 2018). Furthermore, shisha “water-pipe” is a major public health concern, and accounts for a significant and growing use of tobacco products globally. Earlier, water-pipe was associated with older males of low socioeconomic class. Now it is widely used, and its popularity has increased among adolescents and young adults and is becoming more common in the developed world and among women (Barnett et al. 2013). Likewise, with increasing popularity of electronic cigarettes vaping as one alternative to tobacco, as perceived by most adults to be less addictive than combustible cigarettes overall, younger adults indicate higher addictive qualities (Otero et.al. 2019; Harvey 2016; Barrington-Trimis

et al. 2016). However, recent studies showed that e-cigarette use was found to be associated with lung injury (Blount et al. 2020; Christiani 2020).

Although tobacco rates recently have declined in developed world countries, the picture is not so positive for other countries around the world (Plotnikova et al. 2019). Smoking remains highest among populations that already suffer from poorer health and other disadvantages (Ciapponi & World Health Organization 2014; Mikhailovich & Morrison 2008). With the reduction of tobacco use in high income countries, the targets for the tobacco industry's predatory marketing are creating new challenges and preying especially upon poor families everywhere, with inevitable effects on the adolescents (Brown-Johnson et al. 2014; Jha & Chaloupka 2000; Pampel 2008; Hosseinpoor et al. 2011; Mbulo et al. 2019; Ciapponi & World Health Organization 2014). Tobacco use has so far received inadequate attention in the African countries, which present the greatest risk for tobacco use expansion. Limited evidence indicates that most countries in Africa are in the early stages of the tobacco epidemic and that tobacco consumption has increased faster than in the developing world (Adebiyi & Oluwafemi 2017; Egbe et al. 2019; Pampel 2008; WHO 2014). Without attention to this problem, Africa will lose hundreds of millions of lives due to tobacco smoking (Burki 2018). Generation after generation will continue to use tobacco; the poor are most likely to smoke and less likely to quit (Dobson 2004).

Sudan typifies the challenges of use of multiple types of tobacco that is the current pattern in the country. The health risks of tobacco are still vastly underestimated in Sudan, especially the local, socially accepted use of the smokeless tombak. Sudanese oncologists from the national radiation therapy hospital reported that every day the hospital detects more new cases of cancer related to tobacco use, yet less attention has been given to the risk factors of non-communicable diseases, including tobacco use (SMOH 2018). For the past several decades, the financial and political priority, international donations, and programmatic funding have been given for controlling communicable diseases, which constitute the major causative factors of morbidity and mortality in Sudan, and less attention has been given to non-communicable diseases, for which tobacco use is one of the main risk factors.

Finland has knowledge and experiences in establishing comprehensive policies and measures addressing the adult Finnish population. From a long-term perspective, the optimal strategies have been to prevent young people from ever starting to use tobacco. The nation has a goal of ending smoking and other nicotine-containing products by 2030 (Ollila 2019). It is one of the few countries in the world



that have such an ambitious goal. Nonetheless, use of Swedish snus and e-cigarettes has increased over time.

The purpose of the thesis was to examine factors associated to the use of different kinds of tobacco products among adolescents and young adults, and influence of family, school, and social environments. The study is among the few in recent peer reviewed literature that considers smoking, smokeless and other forms of tobacco including vaping, e-cigarettes, and water-pipes. The goal is to understand the most important influential factors that drive the young people to use tobacco.

## 2 LITERATURE REVIEW

### 2.1 HISTORY OF TOBACCO

Exactly when humans started to use tobacco is not known, but tobacco seeds were discovered in Latin America around 3500 BC (Gately 2007). Native American Indians were probably the first people to smoke, chew and snuff tobacco early in the 15th century (Bakdash 2017; Christen et al. 1982). Although tobacco plants were thought to have originated at least 5000 years ago, Europeans first started to know the plant when Christopher Columbus reached the island of Haiti in the West Indies in October 1492, and when he was offered dried tobacco leaves as a gift from the indigenous Arawaks (Routh et al. 1998). In the mid-16th century, the tobacco plants (*herba sancta*) and seeds were brought to Europe by Spanish and Portuguese sailors, who were addicted to tobacco, and planted the seeds in their own countries and at ports of some other countries in Europe. Doctors in Europe first used the tobacco leaves for medical purposes; they believed the plant could cure nearly anything, from bad breath and syphilis to cancer (Goodman 2005; Melikian & Hoffmann 2009; Routh et al. 1998). In 1561, the queen of France, Catherine of Medici, was cured from stomach pain and migraine by tobacco. By the early seventeenth century, tobacco had become one of the major exports of the American colonies. Soldiers during wars spread tobacco and its use in various forms throughout Europe, Turkey, Russia, Arabic countries, China, Alaska, and the rest of the world (Goodman 2005; Axton 2015).

Until the 18th century, lung cancer was not recognized medically. In the western world, where smoking became widespread during the 1940 and 1950s, the effect of smoking now started to be seen. Smoking was first used among witches, priests, and medicine men among North American tribes (Routh et al. 1998). Death and diseases related to tobacco smoking were not suspected until 1954. In 1957, the United States (US) Surgeon General Leroy E. Burney issued a report on Smoking and Health, stating that smoking was a main causative of lung cancer (Shopland et al. 1991; Winkelstein 2002). The first time the US Public Health Service had taken a position on the subject was prompted when the American Cancer Society's National Board of Directors announced publicly that tobacco, particularly smoking, was an

important etiologic factor in the induction of primary cancer of the lung (Winkelstein 2002). That same period, the cancer authorities in the Scandinavian countries and Finland, advised stopping smoking to prevent cancer (Proctor 2012).

Brazilians were the first people known to use snuff (Christen et al. 1982). In Haiti, snuff tobacco powder was first used to clean the mouth and the nose and used as an analgesic (Stewart 1967). From there, snuff was brought to Europe and widely spread throughout the rest of Europe from Spain. The name “snuff” was given to this kind of smokeless tobacco by the Dutch in 1650. In the middle of the 17th century, snuff was introduced into Sweden. The first time “snuff” was named “snus” in Sweden was in 1637. Its popularity reached a height during the eighteenth century, when snus and nasal snuff usage became essential among the ladies and gentlemen of the upper classes (Graham 1996). Snuffbox and snus cans were vital, became valuable symbols of elegance, and fast became one of the most popular gifts of that time, made from very precious materials. In the 19th century, producers began to spread manufacturing local brands of moist snus in many Swedish cities like Gothenburg, which was considered the centre of snus production (Rodu 2004). Marketing of snus is banned in all EU countries except Sweden, largely due to the cultural acceptance of this form of tobacco. The sale of snus was legal in Finland until it entered the EU in 1995. Although banned, snus use in Finland is increasing, especially among the younger age population. Chewing tobacco is not known to be used in Sudan and rarely used in Finland and other Nordic countries. The use of chewing tobacco was widespread in South America in the late 1500s (Axton 2015; Christen et al. 1982), and among Native Americans. People who chewed tobacco believed that it had several medicinal benefits, like curing pain of teeth, wound healing, and for the treatment of snake and spider bites (Routh et al. 1998; Christen et al. 1982).

Smoking and smokeless tobacco were mentioned nowhere in Africa before the beginning of the seventeenth century. For instance, during mediaeval times, Arabic travellers’ and other geographers’ records contain no mention of tobacco anywhere and no specific account of tobacco use. Although tobacco plant remains have been found in Egyptian tombs and references on Egyptian monuments, there has been no trace of any smoking use until recent centuries. Tobacco came to Africa through different routes (Routh et al. 1998). One main route was from Europe; the Portuguese brought tobacco directly from Brazil and Portugal to West and East Africa in 1560-1600 (Bakdash 2017). One of the earliest accounts of tobacco smoking in Africa was found in Sierra Leone in 1607 by William Finch. It is

documented that the European settlers used to grow tobacco and used it as a form of currency (WHO 2017).

In 1500s, the known forms of tobacco at that time, were first introduced to North Africa when the Turks invaded Egypt. From Egypt, tobacco gradually spread south and to Sudan and sub-Saharan Africa by caravan trade. Tobacco was also introduced to Sudan by caravans dispatched from marginal countries and cities on the Mediterranean shore (Tripoli, Tunis, Algeria, and Morocco), carrying tobacco into oases of Sahara and sub-Saharan Africa. The first trade points were Nubia Dongla (North Sudan), Sennar (Central Sudan), Darfur (West Sudan), and then into other provinces and later to South Sudan. The present shisha (water-pipe) was known to be used since the 16th century in India and spread throughout the Middle East in the 19th century where it became famous with flavoured tobacco and cafes especially in Egypt. Shisha (water-pipe) was discovered and first documented in Egypt as early as 1926 by Thomas Herbert, then spread from there by Arabs to Sudan and subsequently to the rest of Africa.

The use of tobacco has been a debatable topic since its introduction. In Europe, in 1603, King James I of England and Ireland increased taxes on tobacco by 4000% to reduce the amount of tobacco imported into England. In Turkey, the Sultan Murad IV of Turkey punished the tobacco users by hanging, as he believed that tobacco could cause infertility and reduce the fighting capabilities of his soldiers. The Russian Czar Fedorovich, the first Romanov (1613–45), prohibited the sale of tobacco, by physical punishment to users; persistent users would be killed. In 1590, in Japan tobacco was prohibited; the users were punished by taking away their property or jailed. Not far from Japan, a Chinese law in 1638 threatened that anyone who possessed tobacco would be executed (Christen et al. 1982). In America, during the nineteenth century, there was a theory called ‘germ theory of infection’ about the spread of germs that cause infectious diseases. Spitting tobacco on the floor could be a source of germs and so a source of contamination. After spitting was forbidden by law, the course of chewing in America changed. By the 1890s, tobacco chewing socially became unacceptable behaviour and not allowed, as it was against the law in most public places (Kozlowski 1981; Christen et al. 1982).

## 2.2 TOBACCO POLICIES

### 2.2.1 Framework Convention on Tobacco Control (FCTC)

The Framework Convention on Tobacco Control (FCTC) is the first-ever global health treaty. It provides the basic tools for countries to enact comprehensive tobacco control legislation and resist the pressures of the tobacco industry (WHO 2015) and reaffirms the right of all people to the highest standard of health. The treaty entered into force in 2005 (WHO 2004) and has been ratified by 182 parties (Last Party: Andorra. Entry into force: 11 May 2020). The parties (member countries ratifying the treaty) agree to a set of guidelines of the Convention covering various demand and supply reduction aspects of tobacco control of all kinds of tobacco products (WHO 2003; WHO 2004).

The idea of the Convention was first formally initiated in May 1995 at the 48th World Health Assembly. The following year, the 49th World Health Assembly requested the Director General to initiate the development of a WHO Framework Convention on Tobacco Control. It is the primary international tool for tobacco control and applies to all tobacco products, including smokeless tobacco products. Dr Kimmo Leppo, from Finland, was one of the first who participated when WHO began to draft and adopt a framework on tobacco control. In 1998, the WHO Director General, Dr Gro Harlem Brundtland, had made global tobacco control a priority for WHO by creating the WHO tobacco free initiative (FCTC). The negotiation of WHO FCTC took two and one-half years. The sixth and final session ended in March 2003, and the FCTC was opened for signatures and became effective on the 27<sup>th</sup> of February 2005 (Mackay 2003; WHO 2005). All African countries have signed the treaty of WHO FCTC except Malawi, Eritrea, Somalia and South Sudan (after separation from the north), apart from Morocco that signed but did not ratify the convention. On June 10, 2004, Sudan signed the WHO FCTC and ratified the convention on October 31, 2005, when it became a Party member.

### 2.2.2 African and Sudanese Tobacco Control and Policies

Tobacco policy varies among the African countries. It ranges from comprehensive ban of tobacco advertisement and ban of smoking in public places to high percentages of tobacco taxation that reach up to 88% as in Ghana (Brathwaite et al.

2015). African countries are still very far from full implementation of the WHO FCTC guidelines, especially regarding protection of minors from exposure to smoking; promotion; packaging and labelling of tobacco products and tobacco advertising (J. Tumwine 2011). However, tobacco control remains a lower health priority for most African governments, and little or no information exists for tracking the progress on the tobacco control activities in most African countries.

The National Initiative for Tobacco Control in Sudan largely aims to promote healthy lifestyles and therefore to reduce the prevalence of high-burden tobacco-related diseases. Despite the challenges, more interest and efforts have been geared towards fighting tobacco by Federal and Khartoum Ministries of Health to limit tobacco consumption since 2001. The efforts are mainly through increasing awareness of the health risks of tobacco consumption through media outlets and school health education. Some efforts were made by the Ministry of Health in collaboration with local organizations to make significant steps in the direction of activation and reinforcement of anti-tobacco law in the subsequent years and to fulfil FCTC policies. The main obstacles facing tobacco control program in Sudan include lack of human and financial resources and political commitment, as well as a comprehensive national plan for fighting tobacco. In addition to the lack of sustainable research on tobacco-related diseases, there is lack of reliable specific benchmarks regarding the risk factors and their contribution to the overall burden of risk and tobacco-disease. In the absence of reliable baseline tobacco data, tobacco policy programs will not be able to make informed decisions and subsequently to measure the effectiveness of its interventions targeting the general population and adolescents in specific.

Tombak is one of the largest cash crops in Darfur (West Sudan); it has been produced in Darfur since 1850. An important obstacle to tobacco control in Sudan is its economic significance. The combined incomes of the Sudanese tobacco companies in 2013 were 83% larger than the Gross National Income of the Sudan. The Federal government of Darfur depends heavily on revenue from tombak taxes. According to Sudan Federal Ministry of Health report in 2014, one of the main efforts to control tobacco use was with tobacco farmers at North Darfur in west Sudan, who act as the main supplier of smokeless tobacco for the rest of the country and for the nearby countries. The farmers were asked to find an alternative livelihood following its prohibition in tobacco sales. However, that is not easy, as more than four million people in Darfur depend on the cultivation and sale of tobacco for their livelihood, and without offering an alternative solution for those farmers, the cultivation will continue in Darfur. In short, the tobacco industry in Sudan is a

powerful force that makes it difficult to challenge because they have no fear of actions due to their power and the resources. The social acceptability of tombak, based at least in part on its economic value, plays a big role in its wide use that challenges the health promotion messages intended to discourage the users from dipping.

### 2.2.3 Tobacco Products Directive (Europe)

The Tobacco Products Directive is based on the proposal of the European Commission in May 2014 and became applicable to EU members in May 2016. The Directive lays down rules governing the manufacture, presentation, and sale of tobacco and related products. The law is for fighting all kinds of tobacco products including cigarettes, cigar, pipe tobacco, smokeless tobacco, and electronic cigarettes and even herbal products for smoking, while ensuring a high level of health protection for European citizens. The legislative action is necessary with adoption of a set of guidelines for implementation of the WHO FCTC, the provisions of which are binding on the European Union and its Member States. The new legislation does not ban e-cigarettes, although the long-term effects of the product is not yet well known. However, the new rules are directed toward harmonizing the quality and safety requirements of e-cigarettes, including rules of labelling and packing. The law also sets maximum nicotine concentrations and maximum volumes for cartridges, tanks, and nicotine liquid containers with high purity of ingredients. European countries have implemented comprehensive smoke-free school policies that prohibit adolescents from smoking during school hours and decrease adolescent smoking behaviour. The new European Tobacco Products Directive sets out important steps for EU-level regulation of e-cigarettes and their marketing.

The Directive also grants Sweden a derogation from prohibition of placing oral tobacco on the market and making Sweden the only member state in which the placing on the market of tobacco for oral use is permitted. The Directive also grants Austria a derogation from prohibition for the marketing of chewing tobacco. However, there has been an increasing debate about this permission. In 2014, Swedish Match filed a marketing modified risk tobacco products (MRTP) application for general snus products, addressing the regulations required for advertising and packaging of smokeless tobacco to display warnings labels together with statements indicating the product is addictive and harmful to health (Mays et al. 2016).

## 2.2.4 Finnish Tobacco Control and Policies

The Ministry of Social Affairs and Health has been the main guiding body and plays a leading role in tobacco control and policy in Finland. The first significant effort to prevent and reduce tobacco use was in the year 1960, when smoking entered the awareness of decision-makers and was considered as a major health problem that needed solutions. A resolution was passed by Parliament as early as 1961. It called on the Government to take immediate steps to enact a law prohibiting the sale of tobacco products to minors, restricting advertisement, and enacting other measures to reduce smoking. It took another 15 years for Parliament to pass the Tobacco Act of August 1976. The main goal was to reduce smoking and its attendant health hazards, with three main sets: health education, price policy, and various restrictions, in addition to research and development (Leppo & Vertio 1986).

The first actual measure to reduce tobacco use was the Tobacco Act of 1976 – 77. This law enacted smoking restriction for the indoor premises of day care, schools, and public transportation; limited the use and sale for those under apparently 16 years old; and completely prohibited tobacco advertisement. With further smoking constrictions in 1995 and 2000, age limits for sales of tobacco were raised to 18 years of age, smoking was also prohibited inside bars and restaurants, and smokeless tobacco was also prohibited. In 2007-2009, special smoking rooms at bars and restaurants were allowed. In February 2016, Finland notified the European Commission of a draft law regulating the sale and import of smokeless tobacco products. The draft law provides the prohibition of placing smokeless tobacco for oral use on the market with respect to the importation of limited quantities of such products by private individuals for personal use.

The new stricter tobacco law in Finland came to effect in year 2010 with new limitations to sales, import and use of cigarettes, smokeless tobacco, and e-cigarettes with a goal of ending the use of tobacco by 2030. More protection for young children is considered, by banning smoking in cars when a child under the age of 15 is present. Smoking in public buildings and around schools is also strictly forbidden. Finnish policy aims at both tackling inequalities in health (Melkas 2013) and ending the use of tobacco products. Before 2016, e-cigarettes were classified as a tobacco product, and the nicotine-containing e-liquids were considered as medical products and regulated under the Medicine Act (Kinnunen et al. 2016) for treatment of tobacco addiction. The sale of e-cigarettes was not regulated in Finland before 2011. In 2016, the Finnish Tobacco Act was modified to fulfil the new European Union Tobacco



Products Directive with the main objective to end the use of nicotine-containing products that are toxic to humans and cause addiction.

## 2.3 FACTORS INFLUENCING TOBACCO USE

Many factors are known to influence adolescents and young people to use tobacco. Given the variety of factors, many theories and conceptual frameworks can be applied to explain tobacco use. Factors are mixed in their effect: they can create high risk or be protective. With regards to risk factors that increase the likelihood that young people will use tobacco, giving an example of this study, having parents and friends who smoke, low academic achievement, the social acceptance of some types of tobacco, have all been found to increase the likelihood that a young person will smoke. Protective factors are behaviour or conditions that decrease the likelihood that young people will use tobacco, such as school anti-smoking policies. In the review of the literature of the current study, not all factors can be discussed, as most are out of the scope and objectives of the study. The literature review thus focuses on the factors most relevant to the main and specific objectives of the thesis.

### 2.3.1 Why Adolescents and young adults?

Tobacco use behaviour is a complex phenomenon, and it is a function of one or more factors that change with the tobacco context (Baker et al. 2004). A key platform of tobacco control and prevention is the investigation of why adolescents use tobacco. As smoking is mainly initiated during adolescence, the optimal strategy has been to prevent young people from using tobacco. Few people initiate smoking once past the period of adolescence (O'Loughlin et al. 2017; Lantz et al. 2000). Identifying factors related to the initiation or onset of tobacco use can lead to effective intervention strategies targeting adolescents to stop or not to start using tobacco from the very beginning.

Adolescence is a complex and confusing period characterized by experimentation, fluctuation, and ambivalence, and it is the period that the regular tobacco users usually tried tobacco for the first time and formed their habits. Understanding what is known about why young people start and continue to smoke and the main factors related to their tobacco use is one of the important keys for development of policies to tackle the tobacco problem. Findings from different

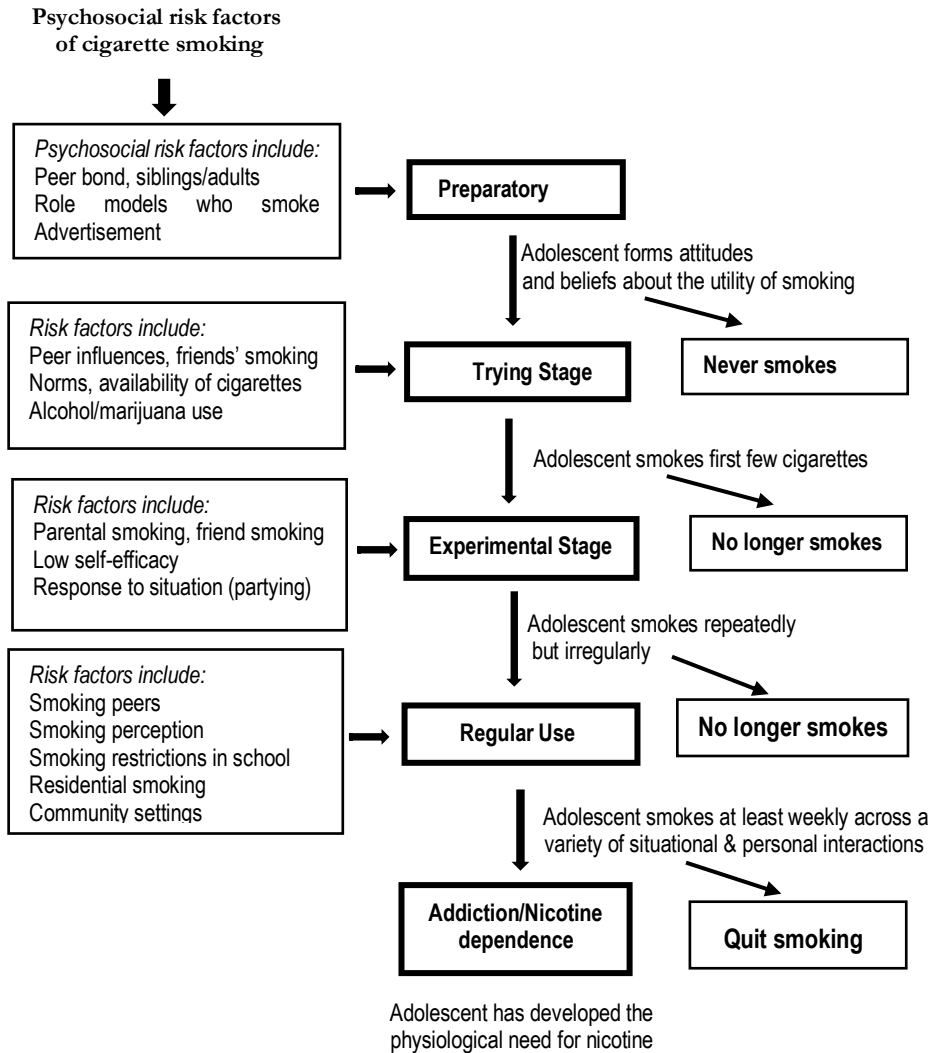
studies indicated that the adolescents' tobacco use behaviour and attitudes could be mainly influenced by social relationships, including family, school, peers, and neighbourhoods. In general terms, the factors of tobacco use, especially the onset of use, are three: individual factors (knowledge, beliefs, and self-image), social and community factors (family situation), and societal factors (tobacco marketing). For successful intervention, all domains should be addressed. Social and psychological transitions of adolescents are important to consider when dealing with young people's tobacco use.

Psychosocial theories help to determine and explain the risk factors that are implicated at every stage of tobacco use and progression, from start to addiction. Theories of human social behaviour reveal influences on tobacco use and demonstrate the complexity of the aetiology of tobacco use. These factors including health-related knowledge, attitudes, beliefs, and behaviour imbedded within the contextual neighbourhoods, institutions, education, income and wealth, and places in which people reside. Most of these factors are distinguishing those at risk from those not at risk, and those who are susceptible, or have intention of smoking in the future or not (Pierce et al. 1996; Warren 2006). For each stage of smoking, there are different risk factors and influences that play different roles in influencing the individual to start smoking or to become a regular tobacco user. Researchers have divided the process of smoking into different stages (Flay 1993; Mayhew 2000), beginning with non-smoking and ending with established daily smoking and addiction. Flay conceptualized smoking as a gradual progression through these stages (Figure 1) starting with preparatory stage, trial, experimentation, regular use, and nicotine dependence (Mayhew 2000). Each stage has different or shared factors that influence an individual. The experimental stage, when the young people have the first experience of tobacco, is the testing phase before the adolescent's smoking behaviour becomes a habit.

### 2.3.2 Personal Factors

The personal risk factors include attitudinal factors, poor self-esteem and confidence, and low academic achievement. Those factors can be explained in part by some sociopsychological theories that briefly explained below.

**Figure 1. Psychosocial risk factors of cigarettes smoking and stages of smoking initiation of children and adolescents**



(Source: Adapted from Surgeon General Report /Department of Health and Human Services - SDC)  
 Modified from Flay – 1993/1998

### 2.3.2.1 Social and Behavioural Theories (SBT)

Psychosocial theory helps to describe the causal mechanisms and explain the associations between different risk factors. The risk factors that are implicated at every stage of tobacco use and progression and demonstrates the complexity of the aetiology of its use. Behavioural theories are important to consider because the concepts from theoretical models are often used to clarify health behaviours and can be used to guide interventions, with recent work focusing on integrating these models. However, from a research prospective, these models provide a useful framework to test the existing theories on the tobacco behaviour of adolescents and young people in the developed and the developing worlds, with integration of various conceptual approaches into the studies and participation of researchers from different disciplinary backgrounds.

### 2.3.2.2 Social Cognitive Theory (SCT)

Bandura set out the Social Cognitive Theory, SCT, in 1989. It addresses the social, structural, and personal determinants of health (Bandura 1991; Harrison et al. 1997). In the theory, behaviour is widely motivated and regulated by the continuing exercise of self-influence that can be operated through three main sub-functions: personal, behavioural, and environmental (Bandura 2002, 1991). The theory affects well-being as well as the self-regulation of health habits; it works on the demand and helping people to stay healthy through good self-management of health habits. The regulation of behaviour is not only personal, as some of the obstacles to healthy life are within the health system itself. Some people may know the risks of their behaviour, but they lack the ability to change their bad health habits, or they may be unwilling to change because they are ignorant or uninformed about the risks of their habits or the benefits of alternative solutions. For instance, within the contexts of tobacco habits, the SCT is very important because it postulates that the person is learning through observing and experiencing the tobacco use within the social environment (Turner 2004). For example, some people refuse to quit smoking because of low self-efficacy and negative outcome expectations. They need an effective intervention to motivate them, to inform them about the benefits of quitting, and to believe that they can succeed. This knowledge provides an example of guidelines for how to structure effective interventions to maintain habit changes.

The theory also explains smoking behaviour as a process involving the dynamic interactions among the three factors, or determinants, that are relevant to smoking

initiation such as emotions, thoughts, genetic and biological susceptibilities, and the ability determined by the behaviour, and if the person has high or low self-efficacy towards smoking behaviour, and the role of the perceptions of friends' smoking behaviours. The environmental factors are external settings or aspects that influence a person's thoughts, behaviour and abilities, and highlight how people acquire certain behaviour and maintain its pattern mediated through cognitive processes such as role modelling of family, schools, friends, media, and other known environmental factors (Menati et al. 2016; Hiemstra et al. 2012; Gilman et al. 2009).

### 2.3.2.3 The Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (TPB) was proposed by Icez Ajzen in 1985-1987 (Ajzen 1985). This is one of the most influential theories predicting smoking behaviour. The theory is mainly about understanding and changing human behaviour. It demonstrates efficacy in predicting deliberate behaviours of different kinds and acts as a guide to predicting and changing health-related behaviour (Symons et al. 2005). The social influences and personal factors act as predictors that influence a certain behaviour targeting intention of change. Thus, TPB predicts the person's intentions to change and future actions and its relationship with attitudes, subjective norms, and perceived behavioural control (Ajzen 1991; Symons et al. 2005; Topa & Moriano 2010; Armitage & Conner 2001). To understand the determinants of tobacco in the context of the TPB, a variety of TPB models and theory-based intervention programs have been applied to reduce tobacco consumption (Harakeh et al. 2004). According to the theory, smoking behaviour is related to smoking intentions; and intentions are based on attitudes and subjective norms. Some studies have found that the intention to smoke cigarettes was predicted by attitude and perceived behavioural control but not fully mediated through the subjective norm-behaviour relationship (Alanazi et al. 2017) or intention to quit (Hukkelberg et al. 2014), although the affective attitude and descriptive norm play a more essential role than the other TPB predictors in motivating smokers to quit (Rise et al. 2008). The moral norm explained additional variance in intentions, but not in smoking (McMillan & Conner 2003). The subjective norm was likely to be a predictor of smoking behaviour among adolescents. The referent Wium et al. (Wium et al. 2006) assumed that the nominative beliefs can be a person's or individual's opinion of societal norms. For example, if cigarette use is considered, people may have different attitudes towards smoking based on their location and relationships with important others.

#### 2.3.2.4 Theory of Triadic Influence (TTI)

The theory of Triadic Influence (TTI) is one of the most complicated comprehensive integrative theories of health-related behaviours. It was developed by Flay, Snyder and Petraitis in 1994. This is not the only behavioral theory, but it encompasses most of the primary theories in its structure. The theory mainly focuses on substance abuse and risk behaviours, which make it very important when considering tobacco use. It assumes that the trail of a behaviour is determined by one's own decisions or intentions. The theory has provided a useful model for understanding the development of adolescent behaviours and tobacco use interventions (Flays et al. 2009). It organizes these variables along two dimensions (the levels of causation and streams of influence). It consists of three relatively independent frameworks of levels of causation that predict behaviour, ranging from ultimate through distal to proximal levels of causation, which converge on health. The three causal levels are mediated through three streams of influence: interpersonal, social, and cultural-environmental streams. Each factor in one stream can influence or interact with the factors in another stream, and each of the three streams acts through the multiple levels of causation (Flay e al 1995; Nyambe et al 2016).

The ultimate level is the first level of causation on personality characteristics and from where the interpersonal and social streams begin. The interpersonal stream represents the personal characteristics, for example, self-esteem and skills, which contribute to self-efficiency regarding specific behaviours. Whereas the social stream influence and contributes to social normative beliefs about specific behaviours, it is largely outside the control of the person, for example, schools and the practices of the parents during early childhood, or peer behaviour. The ultimate influence is the most difficult level to predict behaviour, because the individuals have little or no control over their cultural environmental influences that contribute to attitudes towards specific behaviours (like religion, politics, socioeconomic status, parental values, among others). However, if the individual could change his cultural environment or if the change has happened for any other reasons, they are likely to have long-lasting influence (Flay et al. 1995; Flay 2002). The distal level is mainly socio-personal between the individual and his surroundings (socio-environmental influences). It includes, for example, bonding to parents, peers, and general self-control. Individuals are likely to have some self-control over themselves but not as much as proximal influences. The proximal level, or the immediate level, is more directly predictive of specific behaviour and influenced by the distal and ultimate aspects, although it can be under the control of the individual (Flays et al. 1995; Flay

2002). The TTI is major modern theory and more relevant to understanding smoking acquisition, especially among adolescents (Petratis 1995; Flay 1999) or younger age children (Defoe 2016). The TTI is one of the most effective theories regarding efforts to prevent and reduce tobacco use among the young.

Tobacco use behaviour can be explained by the three major levels of the theory; they can act all together as one causative factor or some factors can moderate the effects of others, taking into account the adolescent's smoking, such as an adolescent's attitudes toward smoking or intentions to use tobacco. In case of initiation for example, the influences include interpersonal factors, such as skills and self-efficacy (avoid using tobacco), or other specific behaviour. The interpersonal factors are mainly due to emotional attachments with "significant others", which is mainly attitudinal (Flays 1999; Petratis et al. 1995). For instance, peer pressure may be a more appropriate example in explaining the roles of both proximal and distal influences, for example, the influence of close friends (Paek & Gunther 2007), suggesting that close friends' smoking may be more influential than the other general peers. Another important influencer in the case of onset are family and school situational that influences adolescents' perceptions of social norms concerning tobacco use. Distal level, such as the motivation of an adolescent to comply with significant others such as parents or close friends and teachers, refers to the smoking behaviours of influential role models or important others (social environments).

### 2.3.3 Environmental Factors

#### 2.3.3.1 Family and neighbourhoods

The family is the most important and essential setting for the development of the child, and the most important context in which health-related concepts emerge and in which social behaviour and attitudes are first adopted (Slomkowski et al. 2005; Currie et al. & WHO 2004). The mechanism behind the family influence and tobacco use transmission across families is a complex net that can be explained by biological, social, cultural, and genetic factors (Avenevoli & Merikangas 2003). Some studies about parents' styles and behaviours revealed that smoking behaviour is transmitted coherently from generation to generation, and that the child of a smoking family has tendency to smoke (Peterson et al. 2006). Some research and a considerable number of twin studies have provided evidence for genetic predispositions and heritability of smoking, showing that the child of a smoking family has tendency to smoke

(Agrawal & Lynskey 2008; Munafò & Johnstone 2008) and becomes nicotine dependent (Lerman & Berrettini 2003). Studies have also described the role of genetic determinants in smoking initiation across different cultures and periods (Maes et al. 2017) and genetic predisposition in cessation of cigarette smoking (Uhl et al. 2008). Findings from some family studies support the findings of genetic influence on smoking behaviour between biological siblings, but not between adopted children and their new parents (Sullivan & Kendler 1999). Other researchers have revealed that there are several genes, and not only one gene, that determine who will develop smoking addiction and cause an individual to become more susceptible of being addicted to nicotine (Davies et al. 2009). Regardless of transmission of smoking being genetic or not, family factors concerning tobacco use by adolescents are important in the onset and in the transition of smoking habits from experimental smoker to a regular user (Flay et al. 1994; Otten et al. 2007).

Parents' smoking is considered one of the most consistent predictors of a child's daily smoking: the less parental smoking, the more likelihood of a lower daily smoking in their teenagers (Hill et al. 2005). Functioning as role models, parenting styles, their values and norms can directly influence their children's behaviours (Bandura & Walters 1977). Findings from the literature show that exposure to parents' smoking is the source of vulnerability to initiate smoking among their own children, mainly during early adolescence (Gilman et al. 2009). Children were more likely to be early regular smokers if their parents were nicotine-dependent (Mays et al. 2014), suggesting the dose-response relationship between parents and their smoking kids. Furthermore, some researchers showed that low parental bonding to their children predicted initiation of smoking in the future (Fleming et al. 2002; hills et al. 2005). The influence of smoking parents on their children and adolescents has been widely studied and has been explained by sociopsychological theories about modelling (Bandura et al. 1977) and parenting (Engels et al. 2005). The family structure, educational level, parents' attitudes and values, and employment status can predict the future behaviour of the child towards tobacco. The child of single parents and a split family (Griesbach 2003), from lower socio-economic family status, and less educated parents is at a higher risk of using tobacco compared to others and to start smoking regularly at a younger age (Tyas & Pederson 1998). Smoking behaviour of the relatives can also affect the children to try using e-cigarettes (Cardenas et al. 2015).

Considerably less researchers have emphasized on grandparents' smoking, compared to other family members, yet this is one of the strong predictors for children's smoking. Studies addressing the role of grandparents in adolescents'



smoking are scarce (Melchior et al. 2010; Göhlmann et al. 2010). The few that have been found show that parents are mediating the effect of the grandparents (Vandewater et al. 2014). Many studies about parents' styles and behaviours revealed that smoking behaviour is transmitted coherently from generation to generation (Peterson et al. 2006). They also showed that authoritarian parenting was linked across generations, both directly and through the personality characteristics of the parents and grandparents (like support, psychological control, and knowledge).

Many researchers explored that the neighbourhoods in which people live might influence health and tobacco use by adolescents specifically (Xue & Caldwell 2007). Understanding the effect of neighbourhood smoking on young people's tobacco use is important for policy measures to reduce social inequalities and lessen the burden of smoking health-related consequences and tobacco use among the young age population.

The **socioeconomic status (SES)** of countries, families, or individuals proved to be directly linked and connected to health behaviour of adolescents, and an extremely important predictor of health at all ages (Boyce et al. 2006). Literature reported different findings about the effect of SES on tobacco use by adolescents (Paavola et al. 2004; Graham 1996; Blum et al. 2000). The findings from these studies were mixed and unclear, while some show an inverse association between parental SES and smoking adolescents (Langille 2003), most found different patterns as low SES of family associated with a higher prevalence of smoking among adolescents relative to high SES teens. On the contrary, findings from some other studies found a positive association, indicating that high SES adolescents smoked more than their low SES counterparts (Hanson & Chen 2007). In Africa, and despite the progress made in some African countries, the socioeconomic inequality is difficult to change at the country and family level, making the measurement of socioeconomic status concerning tobacco use among adolescents difficult by using the same indicators as Western countries. A report from a recent study shows that lower SES related to an adolescent's tobacco use in developing countries is like that of Western countries based on different relevant indicators (Doku et al. 2010; Choi et al. 2001; Tuinstra et al. 1998).

### 2.3.3.2 School Environment and peer's pressure

At this phase of ego development and transitional conflicts, youngsters usually interact with people having a broader array of perspectives and start to have new friends. They are dealing with their teachers as role models, experiencing academic

pressure, confronting school policies, engaging in social networking, and responding to peer behaviour. However, at university young people find themselves in a unique social structure that influences student behaviour, with more responsibilities and even mental health problems (Morrell et al. 2010; Primack et al. 2013; Oducado et al. 2017; Øverland et al. 2010) that are different from basic and high school contexts (Lantz, et al. 2000). Schools are established systems in which students' behaviour can be shared and targeted, and where social behaviours are reinforced (Maes & Lievens 2003). It is the place where students, teachers and staff work together most of the daytime. Hence, undoubtedly, peers', staff and teachers' smoking can influence a student's smoking behaviour, particularly if the teacher has been seen smoking on school premises. Although several studies have found that school-based tobacco strategies are a key element in controlling students' use of tobacco, still substantial variation in students' behaviours has been observed across different schools in different settings. In Africa, schools vary between countries, and between regions in the same country, where school policies and regulations and resources differ widely from one country to another. A school's tobacco control policies and tobacco-based curriculum creates an awareness of the dangers of tobacco use, and ultimately leads to prevention of both initiation and continuous use of tobacco. Several studies have suggested that tobacco control policies in the school environment may decrease smoking prevalence among students and enhance the chance of not starting and successfully stopping (Wakefield & Chaloupka 2000; Levy et al. 2004).

Peer relationships are particularly influential on adolescents' behaviours, and thus are important to consider. Adolescents and young people usually look for and get independence from their parents, during which the open social life starts and gives peers the strongest influence on their behaviour and attitudes, by reinforcing new values and norms. Considerable research has identified adolescent-peer relationships as a primary factor involved in adolescent cigarette smoking, as friends often provide the first access to cigarettes at this stage of life (Umberson et al. 2010). The effect of peers is based on susceptibility; if the adolescent has strong convictions to refuse a friend's offer to smoke, he is non-susceptible to start smoking compared to those with weak convictions (Unger et al. 2001). Studies found higher rates of smoking among adolescents who had friends of the same habits, and due to selection or tendency to choose friends with similar smoking behaviour during formation of friendship, or as a response of direct peer pressure (Simons-Morton 2001; Villanti et al. 2011). The opportunities for peer contact with students who smoke in schools are influenced by the school system, curriculum, and anti-smoking measures among the younger age group (Powell et al. 2005; Bafunno et al. 2019). Much research

evidence suggests the selection of friends process as one of the main roles of smoking among adolescents (Vitória et al. 2020; Mercken et al. 2013; Lorant et al. 2015; Go et al. 2010). Friends socialization results from the existing social relationships; accordingly, the friends of the same group accept to share the same behaviour as part of norms and social environment (Evans et al. 2006). Peer pressure is known in the literature with a term to describe that the adolescent is directly persuaded by her/his friends to imitate their behaviour (Flay et al. 1994) or sharing activity (Rich & Xiao 2012; Eiser et al. 1991). Some studies point to the variation of peer influence on adolescents' smoking by sociodemographic characteristics, such as gender differences, with girls shown to be more strongly influenced by peer smoking than boys and that adolescents without friends who smoke are less likely to take up smoking than adolescents with friends who smoke (Simons-Morton & Farhat 2010; Hoving et al. 2007).

Considering all these factors, together with their new mates, they are exposed to a wider environment and greater scope of beliefs and socio-structural influences, that influence their behaviour and beliefs about tobacco use. These factors may act individually or combined, and the family influence continues along-side the new factors (Clark et al. 2006; De Vries et al. 2003; Mehanović et al. 2020; Huang et al. 2014). According to Finnish legislation, smoking is forbidden in schools and school areas. It is also forbidden to smoke in Sudanese basic and high schools, with more restrictions in the basic schools. Peers include classmates, friends, and girlfriends or boyfriends.

### 2.3.3.3 Tobacco-related media and advertisements

Tobacco-related media is a challenging issue. Tobacco use is shown everywhere that adolescents spend time; chatting with their smoking friends by internet, text messaging, sharing videos and gaming (O'Brien et al. 2019). Tobacco marketing and tobacco trading companies are always trying to find new business channels, by using modern information technology and media to advertise their tobacco products and make tobacco accessible for young people, shaping their attitudes, particularly with the booms in smart mobile phones and computers (Hirschhorn 2004; Lee et al. 2012). Tobacco-related media use social media for communication and have their impact on young people to start smoking and use other kinds of tobacco products, including electronic cigarettes. Adolescents' smoking increased and proved to be strongly associated with increased exposure to cigarette advertising (Timberlake 2016) especially on social media like Facebook. On the other hand, mass

communication can have both positive and negative effects on tobacco use and prevention. It can have a powerful role in influencing both users and policymakers to control tobacco by interventions, show the health hazards of tobacco use, and create the motivation to quit smoking. Tobacco marketing on television and in movies have become less common and regulated by various countries, but still some movie stars and celebrities can be seen smoking (Wellman et al. 2006). In Finland, and recently in Sudan, anti-tobacco advertisement laws were implemented, and explicit advertisements for tobacco products are not allowed on TV.

## 2.4 TOBACCO FORMS

### 2.4.1 Smoked Forms

**Cigarette:** Is defined as any rolled-tube containing processed chopped up leaves of rolled tobacco in paper or other non-tobacco material; usually containing a filter-tipped or untipped at the mouth end; it is approximately 8 mm in diameter, 70-120 mm in length. Cigarette is the most commonly used form of tobacco. Machines break up the dried tobacco leaves into small pieces, adding artificial flavourings and processed with hundreds of chemicals. Each single cigarette has approximately 600 ingredients. When burned, they create more than 7,000 chemicals. At least 69 of these chemicals are known to cause cancer, and many are poisonous. The most widely known chemicals in cigarettes are nicotine, tar, and carbon monoxide.

**Roll-your-own cigarettes (RYO):** The RYO is tobacco that can be used for making cigarettes. RYO are another kind of cigarettes that are hand-filled by smokers/consumers or retail outlets from fine-cut loose tobacco leaves rolled in a cigarette paper. It has the same negative health consequences as cigarettes.

**Cigar:** Is made from air-cured and fermented tobacco leaves, usually made by tobacco-leaf wrapper, by rolling and wrapping tobacco leaves in a particular way, mostly handmade, which make them more expensive than normal cigarettes. The concentration of toxins is higher than normal cigarettes because a cigar has a longer aging and fermentation process, a process making it highly concentrated with carcinogenic compounds and toxins.

**Shisha (Water-pipe):** Is a major public health concern and accounts for a significant and growing use globally. It is also known as gouza, hookah, narghile and hubble-bubble, depending on the local tradition of the country or the group of users. Recently, its popularity has increased among adolescents and young adults in Europe (Filippidis 2019; Barnett et al. 2013). A water-pipe is operated by indirect heat of flavoured tobacco that can be smoked via pipe; the smoke passes first through water before inhalation. To attract users, shisha tobacco is moist and flavoured with many fruit flavours, which increases the appeal of its tobacco product. Its use is widely spread in Asian and Arabic countries. In general, a moderate shisha user is exposed to 3-4 sessions of shisha smoking per day, each one session varies between 15-90 minutes. One-shisha tobacco smoking session is equivalent to 10-12 cigarettes per portion of tobacco (called Hagar). The regular user usually smokes several Hagers per session, making it more dangerous than smoking cigarettes. However, water-pipe smoking produces more smoke than cigarette smoking, and a session could be as much exposure as the equivalent of 50-100 cigarettes for heavy users, that might be equal up to 90.000 ml/unit of smoke inhalation; more than 50-times higher than smoking cigarettes (López-Ozuna 2020). In addition, more health risks are associated with water-pipe use and sharing the same pipe among different people in one setting, besides that the smokers are more attracted to use shisha (dual users) and become less likely to quit.

**E-cigarette (EC):** Is a product that can be used for consumption with or without nicotine-containing vapor via a mouthpiece. The instrument includes a cartridge, a tank and the device without cartridge or tank; it can provide inhaled doses of nicotine. E-cigarettes can be disposable or refillable using a refill container, vials, and a tank. This makes children at risk of exposure to nicotine toxicity from refilling cartridges (Bahl et al. 2012). It includes a group of devices that allow the users to inhale an aerosol that might contain nicotine, propylene, glycerine, glycol, flavour, and sometimes other addictive substances (Landry et al. 2019). The EC use battery power heat and dissolve a solution of propylene glycol or glycerol vapour as main components in addition to water. Nicotine resulting in aerosol is inhaled by the user. It does not contain tobacco; hence, it does not create smoke (McNeill et al. 2015). The e-cigarette was first created as an alternative to tobacco smoking to help smokers to reduce the harms associated with smoking and to achieve long-term abstinence (McRobbie et al. 2014; Regan et al. 2013). Since e-cigarettes first appeared for use in 2006, introduction of e-cigarettes has developed rapidly, and there has been a steady

growth in sales. They have gained in popularity and are becoming widely used everywhere.

The lack of combustion likely reduces toxicant amounts compared to traditional cigarettes, and people think that e-cigarettes are less harmful than regular cigarettes and an alternative to smoking tobacco. However, nicotine toxicity is possible due to the availability of high concentrations of nicotine with a slow absorption rate (Glasser et al. 2017). The nicotine level in the cartridges varies from 26.8 to 43.2 µg nicotine/100 ml puff (Westenberger 2009). Increased heart rate and cardiovascular measures were found to be associated with vaping (Vansickel et al. 2010). E-cigarettes are one means used by tobacco companies to recruit adolescents to nicotine use, and eventually to cigarette smoking (Ordonez et al. 2013).

A recent study conducted in 2019 showed that e-cigarette use was found to be associated with lung injury, suggesting caution; this condition is primarily attributed to vitamin E (Blount et al. 2020). E-cigarettes were first introduced as a harm reduction alternative to cigarettes to decrease smoking among adults without stimulating e-cigarette use by adolescents (Beard E. 2019). Its use among youth and young adults has dramatically increased, and e-cigarette popularity is growing rapidly everywhere. Marketing of e-cigarettes appears to be higher in countries with relatively high income like the European Union. If history is an example, we can expect that e-cigarettes will soon be marketed everywhere unless strong measures are considered to prevent further spread, especially if e-cigarettes are available via the internet. In addition, some companies are only selling disposable nicotine atomizers, which are very easy to use.

Most young adults who reported using e-cigarettes were current smokers (dual users), and among those who had never smoked because there are no restrictions on the marketing and sale of e-cigarettes in the internet, similar findings were also noted (Bunnell et al. 2015; Coleman et al. 2015). From the findings, the intention to quit smoking in the future was observed to be low among adolescents with more frequent e-cigarette experimentation and heavy smokers. A Finnish study on e-cigarettes conducted in 2016 investigated the change of e-cigarettes use from 2013 (the sub-study II) and 2015 regarding ever use and weekly use (Kinnunen et al. 2016). The researchers noted that the awareness of e-cigarettes increased significantly between the first study in 2013 and that of 2016, from 17% to 25%. Various types of e-cigarettes include harmful contents in both nicotine and non-nicotine e-cigarettes, including e-liquids, the flavouring, vapor and metallic coil that trigger oxidative stress and risk for attention deficits (Tobore 2019). E-cigarette use may play a role in young adults' social maladjustments including poor learning and academic performance; it

increases levels of psychological distress and depression and has also been found to be associated with marijuana use (Park et. al. 2017; Chadi et al. 2019; Tobore 2019).

## 2.4.2 Smokeless form of tobacco (SLT)

Smokeless tobacco is a kind of tobacco that is consumed without burning, either orally (spitting, dipping, chewing) or nasally. The names of the products and composition vary widely according to different countries, geographic regions, and manufacturing process. Smokeless tobacco is a recognized public health challenge (Mehrotra et al. 2018) and is widely used and consumed by 356 million people around the world (Mehrotra et al. 2019), most of them live in Asia (Sinha et al. 2018). Snuff is the ground form of tobacco leaves that can be used orally or nasally. This kind of tobacco is very popular throughout the world, with different types of contents, process, and use. The oral tobacco products are placed (dipped) in the mouth between the lips or cheeks and gum. The nasal tobacco form is a fine form of tobacco powder that usually inhaled and absorbed in the nasal passages.

**Chewing tobacco:** This can be used as loose small pieces of raw finely cut tobacco leaves. In the moist form in USA, users usually leave the tobacco stems and the seeds; they are not removed as in some other countries. The moisture content in this type is up to 50%, and it is sold loose or in sachets.

**Table 1. List of some selected kinds of smokeless tobacco products according to their mode of use <sup>‡</sup>**

Oral use			Nasal use (sniffing)
Sucking	Chewing	Other oral uses	
Chimó	Betel quid	Creamy stuff	Dry snuff
Dry snuff	Gutka	Gudhaku	Liquid snuff
Gutka	Iq'mik	Gul	
Khaini	Khaini	Mishri	
Loose-leaf	Khiwam	Red tooth powder	
Maras	Loose-leaf	Tuibur	
Mishri	Mawa		
Moist snuff	Plug		
Naswar	Tobacco chewing		
Plug	gum		
Shammah	Twist or roll		
Snus	Zarda		
Tobacco tablets			
Tombak			

<sup>‡</sup> Source: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, volume 89, Smokeless Tobacco and Some Tobacco-specific N-Nitrosamines

#### 2.4.2.1 Tombak

The term tombak /təʊm'bæk/ is generally used to describe the smokeless loose moist form of locally grown tobacco leaves in Sudan. Soute /saʊt/ is another local name for tombak, which means, “sniffing”. This might be an indication that tombak was first used for sniffing and then dipping. The tombak tobacco plant is of species *Nicotiana Rustica* and/or *Glaucia*, a tobacco species with a high content of nicotine and minor alkaloids. It grows in silty and sandy soils in the north-west of Sudan, where the soil and the climate determine nicotine content and the quality of the product. Tombak is usually planted when the temperature is lower than the rest of the year. The farmers leave the plant growing without irrigation or interference until the harvest season, when the leaves colour change to yellow with brownish spots on top of the surface of the leaf, the stage named “small box” by the farmers. At the small box stage, the farmers leave the leaves, tied into bundles, on the same field to dry naturally under the sun. The dried leaves are then sprinkled with water and stored for 2-3 weeks at temperatures up to 45 degree Centigrade for fermentation. The fermented leaves are separated, and then ground for maturation for uniform drying, storage and aging for up to one year (Idris et al. 1992).

The fermented sun-dried, aged leaves are then ground to fine powder and processed into a loose moist form by mixing it with Atrun /æt'rəʊn/ or Natrun (approximately four parts of tobacco to one part of Atrun). Atrun is a kind of raw alkaline material consisting of naturally occurring chemical substances including sodium bicarbonate. Atrun is usually used in processing of certain local Sudanese food to homogenize vegetables during cooking. People usually bring it from hills and valleys of certain oasis areas in the Sahara Desert of North Sudan. Before used by buyers and dippers, Atrun is made ready by diluting and soaking the solid small rocks in water overnight or for few hours before mixing with tobacco leaf powder. Atrun is believed to hasten the nicotine absorption from tombak. After that, in a process called “Tatmeer /tɑ:tæm.iər/”, the ingredients are mixed with water, and rubbed between the two palms of the hands, by skilled tombak vendors, for blending and constantly testing the texture and smoothness with the tips of the fingers. This process takes about 15-30 minutes to make strong aroma semi-solid moist form of tombak that will be ready for dipping after about 1-2 hours resting in an airtight container. The quality of tombak depends on the soil, fermentation, the percentages and concentration of Atrun, and the resting time before use. Tombak is highly addictive with nicotine contents up to 102 mg/g.



The “dip” in Sudan named *suffa* /sə'f'fə/, which is a small moist lump that is made by rubbing and rolling a small amount of tombak of about 10 mg repeatedly on the palm of the hand using the thumb, index and middle fingers of the other hand in a circular manner. When the rounded-shaped pinch *Suffa* is about 2-3 cm in diameter, it is ready to be placed in the mouth. *Suffa* is usually dipped in the lower labial groove between the lower lip and the gum (vestibule and the gingivae), under the tongue, or upper lip. Recently, they place smaller *suffa* in the mandibular groove in the premolar region of the upper jaw and the cheeks, especially among young females and students at schools, where it is easy to hide. Dippers usually leave *Suffa* in the mouth for about 10 - 15 minutes or more, sucked slowly until the nicotine is absorbed then spat out. Some of the users swallow the generated saliva that is mixed with nicotine products, typically women or men in places where it is forbidden to spit. They usually rinse their mouth with water after insipid *Suffa* is removed. The addicts may use *Suffa* 10-20 times a day and even more, with regular use causing irritation of the oral mucosa. It is a common belief that tombak is less harmful to users than smoking; therefore, smokers who quit cigarettes often become tombak dippers.

Tombak is very prevalent in Sudan, where it has been used for over four centuries. Eight - nine million Sudanese use tombak daily. This represents about 34% of men and 2.5% of women from entire population. Dipping tombak is a socially accepted behaviour in most Sudanese communities when used by adults, old women, and labourers of very young ages. Although not accepted behaviour when used by younger women and adolescents, tombak is widely used by them, especially in rural areas of North Sudan. It is five times cheaper than cigarettes. It is also advertised and sold in small shops (Kiosks) along streets, that make it readily available for all. The main sources of the dip for users among young school-age children are friends, family and tombak-kiosks. With increasing age, the main source are kiosks, friends, then co-workers. Tombak is accessible from kiosks for all ages, because parents or relatives can send their own kids to buy them tombak from the nearest kiosk. It is not forbidden for children to buy, regardless if it is for their own use, for a relative or for a friend. Currently, tombak is sold in small polythene bags; each containing about 100-150g, and one bag is enough to be shared among friends.

#### 2.4.2.2 Snus

Snus is a known local Nordic name given to the form of smokeless tobacco snuff, commonly used in Sweden, Finland and other Scandinavian countries for more than

200 years. Snus is known in Finland as “Nuuska”. Sweden has the highest per capita consumption and sale of snuff in the world (Fould et al. 2003; Idris et al. 1998). Snus is two forms: the dry form used in the nasal cavity, and a moist ground form used in the oral cavity. The moist form is either used as a loose moist form or wrapped in sachets or tea bag-like pouches. Most moist form users typically placed the quit behind the upper lip. Users can hold it in the mouth without chewing for approximately 30 minutes before discarded. The other form is sold in small sachets that look like small teabags.

Snus consists of finely ground dry tobacco; the leaves go through different stages before making it ready for the users. In stage one (the cure method), the moist forms go through high heat tobacco-cure methods that prevent the microbial activation of nitrites. Consequently, the process reduces the levels of nitrites and hence the level of Nitrosamines presents in raw tobacco (Foulds et al. 2003). In the second stage (the pre-processing stage), the tobacco-cured raw forms are cut into small pieces, then left to dry, grounded, and then sifted to make it ready for processing. In stage three, the processing is by treating the tobacco-cured leaves by heating with steam for 24–36 hours. During the last stage, stage four, the tobacco is made soft and moist by adding more ingredients like water, sodium bicarbonate, and sodium chloride (buffering agents), humectants, and mixed with aromatic substances to give the flavour. Modern day Swedish snus production and retailing has reduced the concentration and the formation of most toxic constituents, like tobacco-specific nitrosamines (TSNAs), and some other carcinogens. Because of the improvements in manufacturing techniques and the added materials, using Swedish snus is considered to be less risky than smoking cigarettes (Rutqvist et al. 2011; WHO 2009).

**Table 2. Overview summary of the major differences and similarities between tombak and snus**

	<b>Tombak (Sudanese)</b>	<b>Snus (Swedish)</b>
<b>History</b>	Roughly go back to the 1600s	First used by Swedish about 1637.
<b>Contents</b>	Tobacco, Atrun (the raw solid form of sodium bicarbonate) and water	Tobacco; sodium carbonate; sodium chloride; water; moisturizer; flavoring; nicotine and aromatic substances.
<b>Selling</b>	Selling and advertising everywhere, no restriction or age limits	Selling allowed only in Sweden.
<b>Processing</b>	Tying the harvested leaves into bundles, sprinkled with water, leaving them for fermentation for about 2 weeks, then sun drying. No curing or heating methods, only raw grounded tombak go through different simple manual steps, by adding sodium bicarbonate and blending the mixture by hand. keeping it in high temperature for aging (high level of bacterial activity).	Go through different stages of curing methods before processing, including fermentation (no added sugar) Cure tobacco: dried in air or in barns by heating the air with open fires (dark-fired) Pasteurization: heating at high temperature to kill the bacteria and mixing with humidity agents. keeping it cool to avoid aging (low level of bacterial activity)
<b>Forms</b>	Moist form only	Moist and dry forms
<b>PH</b>	8-11	7.8±8.5
<b>Nicotine level</b>	32.2-102.4 mg/g	12.4-15.1
<b>NNN level</b>	115,000–368,000 ng/g wet weight	-
<b>NNK level</b>	147,000–516,000 ng/g wet weight	-
<b>How to use</b>	A dip rolled as small ball then dipped behind lower lip ( <i>Suffa</i> ), or between gum and cheeks. Some dippers placed the dip on the floor of the mouth, usually held in mouth for 10-15 minutes for nicotine to be absorbed and sucked slowly.	A quid ( <i>pris/ prilla</i> ) usually placed in the upper gingivolabial sulcus, lower lip, or the alveolar process as in Denmark. Majority place the quid in the vestibular area anterior part between the upper lip and gingiva, usually for 30-60 minutes, and up to 2hrs.
<b>Risk of cancer</b>	Risk is higher than Snus because: - Contamination during processing - No heating process is used to reduce the bacteria activation - High level of nitrosamines. - Long time fermentation - Long storage time.	Risk is lower than tombak because: - Lower level of nitrosamine. - Pasteurization reduces the risk of carcinogens. - Heating reduces the formation of tobacco-specific nitrosamines
<b>Cancer rate</b>	Tobacco-related cancer: Increase with increase tombak consumption. No modification concerning the health of the users done to tombak quality since introduction	Tobacco-related cancer decrease with snus use instead of cigarette smoking due to the new modified product developed by industries.

NNN= *N*-nitrosonornicotine NNK= *N*-nitrosoanatabine (sample based on dry weight)

TSNAs (Tobacco-specific nitrosamines, includes: NNN and NNK) are not present in green tobacco leaves but can be formed during the drying, processing and storage of the tobacco leaves.

CT: concentration in Tombak/snus, CV: concentration in saliva.

## 2.5 HAZARDS OF TOBACCO

### 2.5.1 Nicotine addiction

Nicotine is alkaloid, nitrogenous, bioactive and an addictive powerful drug; it is one of the main constituents of tobacco. Although the toxicity of smoking is related to the total composition of the cigarettes, nicotine is the one substance that causes addiction (Benowitz 2008). Nicotine addiction is a chronically relapsing disorder characterized by a compulsive desire to seek and use tobacco and loss of control in limiting its intake, reflected in withdrawal symptoms when access to tobacco is prevented (Koob & Volkow 2010; Reynaga 2017). Tobacco users find it increasingly difficult to quit despite a persistent desire to do so (Bauzo & Bruijnzeel 2012; Koob & Volkow 2010; Lynch & Sofuoglu 2010). A few seconds after inhaling tobacco smoke, the smoke particles carry nicotine to the lungs from where it enters the blood circulation then goes directly to the brain and throughout the body (Karan et al. 2003; Mineur & Picciotto 2008). Nicotine crosses the blood-brain barrier, then binds itself immediately to nicotine cholinergic receptors of the excitable cells and by bridging the synaptic gaps between nerve endings, the cells then become activated and desensitized. Nicotine interfaces between two subunits of the receptor and opens the channel, permitting the entrance of sodium and calcium into cells. The more the entrance of sodium into neuron cells, the more the release of dopamine and other neurotransmitters that sustain addiction (Leslie et al. 2013; Dajas-Bailador & Wonnacott 2004; Benowitz et al. 2008), providing conditions known as nicotine dependence resulting in establishment of addictive behaviour (Goodman 2005; Dani & De Biasi 2001; Liu et al. 2012).

According to studies that have examined nicotine addiction among adolescents, the development of dependence symptoms suggest that nicotine dependence follows different developmental trajectories in different individuals (Hu et al. 2008), and that for some adolescents, symptoms begin at low levels of nicotine exposure before they become daily smokers (Dierker & Mermelstein 2010). The younger the age of starting smoking, the greater the nicotine dependence and addiction (Buchmann et al. 2013). Most smokers started to smoke during adolescence; more than half initiated before the age of 18 years old; many became addicted after smoking a few cigarettes (Duncan et al. 1995). The size of nicotine dose matters because the different dosage levels have different impacts on cells. For instance, small doses of nicotine act as a stimulant neuromodulator and can unlock the vital neurotransmitter

and cause immediate pleasurable and satisfying functions and mood by reducing stress and anxiety. In larger doses, nicotine acts as a depressant, while overdose might cause instant death because it can lock the neurotransmission instead of unlocking it (Benowitz 2010; Dani & De Biasi 2001).

Regular smoking or using any other kind of tobacco products results in neuroadaptation, then the development of tolerance and chronic nicotine addiction. When a smoker quits or delays smoking, the absence or lower level of nicotine in the blood results in lowering the release of dopamine and other neurotransmitters. This results in the signs of physical and mental dependence, like fatigability, malaise, restlessness, anxiety, irritability and later resulting in inability to experience pleasure (Hughes 2006; Koob & Volkow 2010; Spinella 2005). Confronted with craving and negative emotional states, the smoker then returns to smoke, called “compulsive tobacco use”, despite the knowledge of the smoking threats to their health, and this time it might be for a longer time (Benowitz 2008; Reynaga 2017; Koob & Volkow 2010).

## 2.5.2 Health hazards of smoking tobacco

No less than 4,000 chemicals have been identified in one cigarette, and at least 43 of them cause cancer. Despite the knowledge of the health hazards of smoking, millions of people continue to smoke. The non-smokers who are exposed to second-hand smoking may suffer from serious health problems, including lung cancer (De Groot et al. 2018) and deaths, in addition to respiratory infection in children and infants (Vanker et al. 2017). Exposure to environment smoke has been shown to increase the heart problems and stroke in adults (Law & Wald 2003; Kromhout 2001). A study from the United States indicated that approximately 15 million children were exposed to secondary smoking from one or all members of their families in their homes (Homa et al. 2015). The exposure to environmental tobacco can cause serious reproductive complications, including infertility, spontaneous abortion, low birth weight, and sudden infant death syndrome (Florek & Marszalek 1999; Sontag et al. 2020).

An extensive number of research studies document that smoking cigarettes has health consequences by acting as a risk factor for many diseases and other conditions (Pepper et al. 2020; Kenfield et al. 2010). Cigarette smoking causes accelerating and aggravating cardiovascular disease, pulmonary disease, and cancer, which are well known and well documented in the literature. Recent evidences indicate that

smoking and using shisha could increase the risk of severe influenza, pneumococcal disease, and tuberculosis (Bhatnagar 2019). It also affects the endocrine system and increases insulin resistance, thereby increasing the risk and development of diabetes. It could also cause several pharmacodynamics interactions with medications, including insulin injection (Eliasson 2003; Beziaud et al. 2004). Cigarette smoking enhances the effect of hormonal contraceptives with high risk of risk of cervical intraepithelial neoplasia, especially those with high contents of oestrogens (Oh et al. 2016). Hence, obstetrics and gynaecologists prescribe oral contraceptives with cautious to women who smoke cigarettes.

### 2.5.3 Health and economic hazards of smokeless tobacco (Tombak)

In general, smokeless tobacco, under any name, is a complex challenge to public health that has received limited attention from researchers and policymakers, as most efforts of control have largely focused on smoking tobacco (Hatsukami et al. 2014). Smokeless tobacco remains a subject of controversy. There is enough evidence, based on epidemiologic research and laboratory studies, and supported by the International Agency for Research on Cancer (IARC), to determine that smokeless tobacco is harmful. It causes cancer of the pharynx and the oral cavity, mainly at the site where the dip was placed. It also causes cancer of the neck and other organs of the body, including pancreas and oesophagus (IARC 2004; Mehrotra et al. 2019; Babikir et al. 1989). Smokeless tobacco is addictive due to its nicotine content, although of the large variation in nicotine concentration and percentages of toxic substances differ in the various products of smokeless tobacco worldwide. There is no denying that more than 30 carcinogens have been identified in smokeless tobacco, including Tobacco-Specific Nitrosamines (TSNAs).

***Economic hazards of tombak:*** Tombak cultivation causes reduction of the soil fertility and draught; because at tobacco fields, no animal or even human being can live nearby, and no other kind of crops can grow on tombak fields. Therefore, tombak threatens the food security of families, such as those in Darfur, who have already been suffering from conflicts and war for decades. Significant intersect or collaboration and interventions are needed to solve the complicated problem.

***Health Hazards of tombak:*** The highest levels of TSNAs ever detected in tobacco products have been found in Sudanese tombak. A study conducted by Idris et al. (Idris et al. 1995; Idris et al. 1994) among Sudanese patients revealed that the high

prevalence of oral cancer in the Sudan is largely due to chronic use of tombak; the elevated risk occurs in the oral cavity when tissues have direct contact with the tombak dip or are adjacent areas. The TSNA group are the most harmful compounds in smokeless tobacco ever detected. Their levels are directly related to the risk of oral cancer, and the level in saliva of the Sudanese patients has been found to be very high (Murphy et al. 1994; Idris et al. 1992). Sudan has a high frequency of oral cancer compared to the nearby countries, especially Squamous-cell carcinoma (Elbeshir 1989; Idris 1996). Other evidence suggests that tombak is a risk factor for cancer of the oesophagus and salivary glands (Babikir et al. 1989).

The high level of nicotine concentrations found in many samples of tombak in various studies may possibly be due to the use of tobacco leaves of species *N. rustica*, which is known to contain higher concentrations of nicotine than other species like *N. tabacum*. Table 2 compares tombak with snus. In a comparison study between the Swedish snus and Sudan tombak in 1998, tombak dippers were found to be at high risk to develop a clinically and histologically characteristic lesion at the site of dipping. On the other hand, snus was associated with a lower risk of cancer of the oral cavity (Idris et al. 1998). The pH of tombak is more alkaline (8-11). This is important because the rate of nicotine absorption through the mucosal membrane depends on the pH that determined the level of free-base nicotine. The more alkaline the product, the more will be the absorption. In other words, the pH of tombak makes the nicotine be absorbed at higher levels than that of Swedish snus, for example.

### 3 THE AIMS OF THE STUDY

The purpose of this study was to investigate the determinants and the use of five different kinds of tobacco products among adolescent and university age students. The framework used to examine the influences on individual behaviour regarding tobacco use is organized from the perspective of family factors to community norms to societal policies. The data were from young people in Sudan and Finland at various points in time.

The specific objectives of the four sub-studies were

1. To investigate the association between adolescents' tobacco use, exposure to smoking and dipping tombak with the social environment (parents, friends and teachers) (SUB-STUDY I - SUDAN)
2. To investigate the associations between school anti-smoking policies, exposure to residential smoking and Health Sciences students' tobacco use (SUB-STUDY II - SUDAN)
3. To investigate determinants, awareness, source and use of electronic cigarettes (SUB-STUDY III - FINLAND)
4. To investigate the transmission of tobacco smoking across three generations from grandparents to parents to their children (SUB-STUDY IV -FINLAND)



## 4 SUBJECTS AND METHODS

The four studies that comprise this thesis used data from three data sets focused on participants of two countries: Sudan and Finland. Two data sets were surveys conducted among adolescents, whereas the third data set is based on a survey conducted among young adults. The studies addressed tobacco use and the effects of family, friends, teachers, school smoking policies, and exposure to residential smoking on use of tobacco.

Five different kinds of tobacco products were investigated in the four sub-studies, namely:

- 1- Cigarettes
- 2- Electronic cigarettes
- 3- Shisha (water-pipe)
- 4- Sudanese tombak
- 5- Swedish snus

### 4.1 STUDY SETTINGS

#### 4.1.1 Sudan

The data used in the studies reported here were collected when the country was unified. Therefore, the background information is given for the two parts of the country. Sudan is a decentralized federal state with a multi-tiered government structure. It was the largest country in Africa. It was and spread over 2.5 million square kilometres until 2011, when South Sudan was separated into an independent country following an independence referendum and became the world's newest nation. North Sudan is now the third largest country in Africa with a total area of 1,882,000 square kilometres having seven international borders: Egypt, Eritrea,

Ethiopia, South Sudan, Central African Republic, Chad and Libya, and a population size of 41 million (2019). South Sudan is bordered by Sudan, Ethiopia, Kenya, Uganda, the Democratic Republic of the Congo, and the Central African Republic to the west, with a population size of 12 million (2017). Sudan encompasses virtually every geographical feature, from the harsh deserts of the North to the rainy forests on its southern borders. Its geographic location has made it the recipient of migrations of many people of different ethnic origins and backgrounds. Sudan's ethnic and linguistic diversity is complex; its nearly 600 ethnic groups speak more than 400 languages and dialects. Languages, cultural characteristics, and common ancestry are used as markers of ethnic identity or difference.

Administratively, the country was divided into 25 states, 10 of which became South Sudan. Currently, there are 87 localities in northern Sudan and 78 counties in South Sudan; however, this administrative level is undergoing change as new localities and counties are being created by redrawing the boundaries of the existing ones. Sudan has a very low median age compared to the nearby countries. Women slightly outnumber men; about 68% of the population lives in rural areas. The modern health care system in Sudan goes back to 1899, when the army was delivering health care. In 1924, the Sudan Medical Services was established, and it became the Ministry of Health in 1949. Each state has a ministry of health, and within each state there are several localities, managed through a district health system approach according to the local government. Starting from 2017, the health policy and systems have changed from the bottom up, starting with basic community needs at locality levels, up to states and federal levels for integration of health into all policies.

#### 4.1.2 Finland

Finland is one of five Nordic countries located in Northern Europe to the north-east of the Baltic Sea, where it is bordered by Russia, Estonia, Norway, Sweden, and the Gulf of Finland. Finland is the fifth-largest country in Western Europe and covers an area of 338,440 square kilometres. The largest city and capital city is Helsinki, which occupies a peninsula and surrounding islands in the Baltic Sea. Finland's local governments operate in 317 municipalities. Although Finland does not keep official statistics on ethnicity, it is known to be very homogeneous ethnically with only a minority of Sami people living in the North of the country and a small population of gypsies. About 4.5% of the population are foreign citizens, most of them from Russia. The organization of the health system has been in flux for several

years. As of the year 2018, the country had five regional referrals medical specialty centres, each with a large medical teaching complex of clinical services. However, primary health care starts as the responsibility of each municipality.

**Table 3. Sudan and Finland basic population indicators and statistics**

Indicator	Sudan	Finland
Total population (2017) in millions	40.53	5.51
Population under age 15 (2016)	45%	16.4%
Population over age 60 (2016)	6.2%	27.2%
Life expectancy (2017)	65 years	81.4 years
Probability of dying between 15- and 60-years m/f $\infty$ (2016)	253/195	95/44
Gender in equality index rank (2014)	135	11
Total expenditure on health as % of GDP* (2014)	8.4 (2014)	9.7
Income group	Lower-Middle income	High income
Human development index rank (2014)	167	24
School enrollment, Primary (% Gross)*, (2017)	74.4	100
School enrollment, secondary (% Gross), (2017)	44.1	153.9

**Data source:**

Finland: Global demographic estimates and projections by the United Nations, Statistics Finland, World Bank

Sudan: Ministry of Health, Sudan Central Bureau of Statistics and Global health observatory 2017, World Bank

\* GDP: Gross enrolment ratio is the ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to the level of education shown)

<http://www.who.int/countries>

<http://apps.who.int/gho/data/node.cco.keyind?lang=en>

<https://data.worldbank.org/country>

.....

$\infty$  m/f = Male/Female, per 1 000 population. \* GDP: Percentage **G**rowth **D**omestic **P**roduct

The four studies reported here drew data from four sources. The two Sudanese data sets were drawn from the Sudanese Youth Tobacco Survey (SYTS) and the Sudanese Health Professional Student Survey (SHPSS). The Finnish data were drawn from the Adolescent Health and Lifestyle Survey (AHLS) and the Finnish registration system. A summary of similarities and differences across the three data sets of the studies of the two countries are shown in Table 3.

## 4.2 SUDANESE DATA

### 4.2.1 Sampling and tools of data collection of sub-study I & II

The Sudanese data were collected as part of The Global Tobacco Surveillance System (GTSS) developed by WHO, US Centres for Disease Control and Prevention (CDC), and the Canadian Public Health Association (CPHA) to assist all WHO Member States in collecting data on youth and adult tobacco use to promote tobacco control at the global level. The goal of GTSS is to enhance the capacity of countries to design, implement, and evaluate their national comprehensive tobacco action plan, using a common methodology and core component questionnaire. The flexibility of the global questionnaire allows countries to include optional questions on specific information according to the needs of each country to track tobacco use, tobacco advertising, cessation, second-hand smoke, school policies, and perceptions of smoking behaviours.

The Global Tobacco Surveillance System consists of four surveys:

*Global Youth Tobacco Survey (GYTS)*

*Global School Personnel Survey (GSPS)*

*Global Health Professional Student Survey (GHPSS)*

*Global Adult Tobacco Survey (GATS)*

The tobacco coordinators trained the leaders of the fieldwork, led the main important preparation, collaboration, and connections for the successful implementation of conduction of the four main tobacco surveys in different time periods (only two included in this study). The coordinators, together with representative persons from Ministries of Basic and High education, visited the selected schools and universities to inform them about the importance of the surveys and what was needed from schools on the day of the surveys. Both surveys, independently, were first piloted before implementation.

The questionnaires used in Study I and II were originally in English, and later translated by an expert team under supervision of MOH tobacco coordinators. They were first translated into Arabic and back translated into English to check for validity, accuracy, and compatibility with the core questionnaire. The questionnaire of the Health Science students underwent pilot testing among 50 subjects and 120

subjects of the GYTS to determine clarity of questions and length of time needed for completion. After completing the pilot surveys, discussion was held that resulted in removal, addition or changing some questions. After incorporating the corrections, the revised questionnaires were back translated into English to check for validity to avoid bias or misunderstanding. The questionnaires were distributed during regular lectures and class sessions. The students were informed twice about the study by the Sudanese tobacco focal point, explaining the purpose and the importance of the study and procedures. After the implementation, the Federal and Khartoum state co-ordinators finalized the survey reports that were sent to MOH, stakeholders, and the CDC in Atlanta, USA. A few months later, the tobacco coordinators attended the discussion of the results at the WHO-Cairo office, Egypt.

#### 4.2.1.1 Sub-study I

A list of public and private schools (girls, boys and mixed schools) was collected from the Sudan Ministry of Basic Education. A two-stage cluster sampling technique was used, and weights were applied to effectively re-size the sample to be representative of the population. At the first stage, primary sampling units were schools that were selected with probability proportional to the number of students that were enrolled in the specified grades. First, we sampled 15 basic schools and 10 secondary schools. Two of the basic schools were closed at the time of the survey, due to construction issues after the perfused flood of the River Nile, hence were excluded. This resulted in a final number of 23 schools. At the second stage, classes within the selected schools were obtained by random selection recruiting adolescents of grade eight of basic schools and grades one and two of secondary schools. All students in the selected classes were eligible to participate regardless of their age; the adolescents in these classes were usually between the ages of 11 to 17 years old. The total sample of this study consisted of 4277 adolescents; they were all school-going students. The educational system in Sudan comprises eight years basic education, followed by three years of secondary education. The number of the schools and the number of the classes were different from locality to locality due to school size differences.

The school-based Sudanese youth tobacco questionnaire is a modified form of the 56 items GYTS questionnaires. It included questions on knowledge and attitudes towards cigarettes and other kinds of local tobacco products (tombak and shisha). More questions were added about perceptions of tobacco, access and availability, susceptibility to initiate and cessation of cigarette smoking, in addition to questions

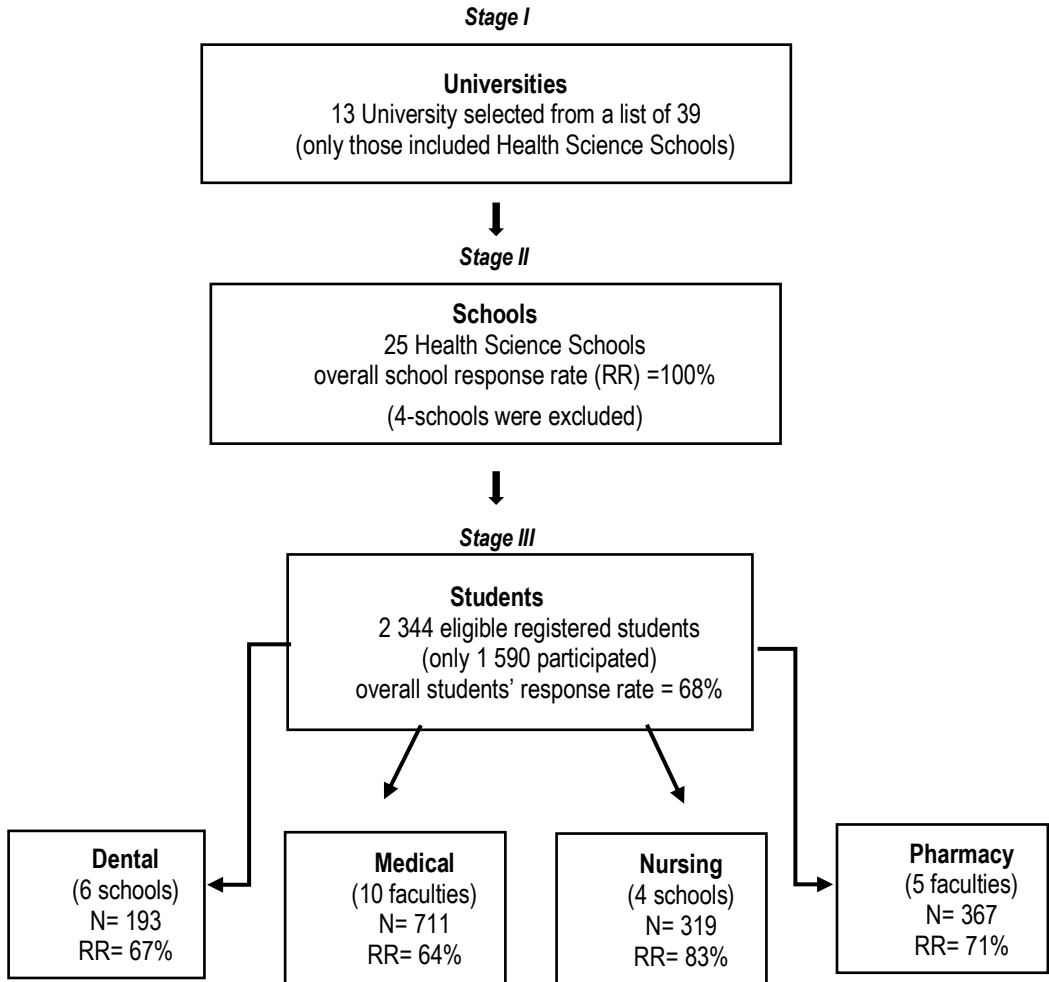
about the adolescent's personal characteristics. Yet additional questions were on environmental tobacco smoke concerning exposure to second-hand smoke. Four questions were removed from the original GYTS questionnaire because they were not relevant to Sudan and did not fit the norms and cultural sensitivity of the country. By adding 12 questions, about other types of local tobacco products, namely tombak and shisha, the final questionnaire had 64 questions. It was designed without skip patterns to allow all respondents to answer all questions. The questionnaire was labelled before distribution with identification numbers identifying only schools and classes. On the day of the survey, the questionnaires were distributed to students attending classes by skilled personnel from MOH with a representative of the school, who left the class immediately after the questionnaire distribution. The students completed answering the questions during class time, in approximately 45 minutes (the time of one class period). To maintain confidentiality, class teachers were not present.

The school response rate was 100%. The student response rate was 93%. The non-respondents (7%) were those who were absent from school the day of the survey. Irrespective of the reasons for their absences, no make-up round was prepared for non-respondents.

#### 4.2.1.2 Sub-study II

A three-stage cluster sampling technique was used (Figure 2). In the first stage, a sample of 13 universities was selected from lists of 39 public and private universities, with probability according to the number of Health Science Schools in the selected universities. For the second stage, 29 schools were drawn with probability proportional to enrolment in 13 universities. For the third stage, 25 schools were selected with probability proportional to students enrolled in third class. The remaining 4 schools (three Medical and one dental) were new and had no third-year class of students yet at the time of the survey, hence they were dropped from the sample. The final selected sample was from 10 Medical; 6 Dentistry; 4 Nursing; and 5 Pharmacy schools (Table 4).

**Figure 2. Sampling strategy of the Sudanese sub-study II**



The response rate of schools was 100%. All third-year students were eligible to complete the survey; students who were not in the classroom or those who were absent for any other reasons were not followed. Of the 2344 registered students, 1590 responded, giving an overall response rate of 68%, with 67% response from dental schools; 64% from medical faculties; 83% from nursing schools; and 71% from faculties of pharmacy. The data collection of this part of the study was carried out in 25 Health Science Schools/faculties. It constituted a representative sample of the whole country before South Sudan seceded from the North. The sample included students from South Sudan. The exact number of those from South Sudan

was not known, as the delivered questionnaire included no questions about the place of birth, ethnicity, or tribal relevance. Table 4 shows the disciplines represented in the universities that participated in the survey.

**Table4. Names of the Sudanese selected universities by sampled schools and number of students ◀**

School type	Discipline												
University/College	Dental (n: 6)			Medical (n: 10)			Nursing (n: 4)			Pharmacy (n: 5)			Total (N: 25)
Sex <sup>z</sup>	M	F	T	M	F	T	M	F	T	M	F	T	
U. of Khartoum	25	74	99	60	180	240	20	80	100	17	50	67	506
Omdurman Islamic U	-	-	-	101	65	166	-	-	-	41	40	81	247
U. of Sudan	-	-	-	-	-	-	14	76	90	-	-	-	90
Juba U.	-	-	-	23	37	60	-	-	-	-	-	-	60
U. of Elnyleen	-	-	-	20	30	50	6	19	25	-	-	-	75
Elazhary C.	-	-	-	27	73	100	8	52	60	-	-	-	160
U. of Elribat	26	50	76	60	102	162	14	78	92	40	81	121	451
African C.	-	-	-	27	33	60	-	-	-	-	-	-	60
Alahfad U.	-	-	-	-	76	76	-	-	-	-	50	50	126
Eltigana C.	14	35	49	15	19	34	-	-	-	27	41	68	151
Medical Technology C.	14	18	32	30	33	63	3	14	17	11	31	42	154
C. of Medical Science	11	30	41	41	50	91	-	-	-	19	31	50	182
Elrazy C.	17	29	46	-	-	-	-	-	-	12	24	36	82
Grand total	107	236	343	404	698	1102	65	319	384	167	348	515	2344

(A census was done for all Health Science Schools and faculties in Sudan).

◀ Only universities included Health Science Schools and 3rd year students were included in the sampling frame.

<sup>z</sup> M = Male, F = Female, T=Total. U = University. C = College

## 4.2.2 Measurements of sub-study I & II

The tobacco use behaviour in the Sudanese Study I and II was measured in terms of ever and current tobacco users.

**Ever tobacco use:** Ever use of each tobacco product (cigarette, tombak, shisha, other kinds of tobacco products) indicates at least one-time use of the product. The questions assessing ever tobacco use included in the Sudanese data questionnaires



were: “Have you ever tried or experimented with cigarette smoking/shisha/tombak dipping, even if it was one puff/dip or two?” (Responses: “Never” / Ever-used “Yes”). Each product had a separate question using the same stem of the main question.

**Current tobacco use:** The question was: “During the past 30 days, on how many days did you smoke cigarettes/dipped tombak?” Students were classified as current smoker and current dipper if they reported smoking cigarettes or dipping tombak on more than one day of the preceding month of the survey.

#### 4.2.2.1 Sub-study I

In addition to the above-mentioned definitions of tobacco use measures, the tobacco habits of parents, friends and teachers were also assessed in study I, with additional questions. Adolescents were asked to indicate whether their parents were smokers or tombak dippers at the time of the survey using the categories: had never, both, father only, mother only and I don’t know. The only question about teachers’ dipping tombak on school premises had the responses of “Yes” and “No”. No other questions about teachers’ smoking or using other kinds of tobacco products were asked. The questions concerning friends’ tobacco use were only for smoking cigarettes and not for tombak dipping.

#### 4.2.2.2 Sub-study II

In addition to the questions testing the students’ tobacco use, more questions were added to study II to test the school smoking policy, smoking on school premises, and residential smoking.

##### **School smoking policy**

The variables are based on the responses to two questions. The answers were further categorized for purpose of the analysis.

*School policy banning smoking:* Does your school have an official policy banning smoking in school buildings and clinics (no official policy, exists in either of them, exists in both)?

*Smoking restriction:* Which of the following best describes your school's official smoking policy for indoor or common areas (no official policy, complete restriction, partial restriction)?

- *Complete restriction:* Smoking not allowed in any of the mentioned places.
- *Partial restriction:* Allowed in one of them.

### **Smoking on schools' premises**

"Have you smoked cigarettes on school premises during the last 1-year?" (non-smoker, not smoked, smoked). The current smokers who responded to this question were defined as "current smoker who smoked on school premises during last 1-year".

### **Residential smoking**

This question was defined as exposure of students to people smoking in their presence in places where they live, on one or more days during the last 7 days. "Has anyone smoked in your presence in places where you live, on one or more days during the last 7-days?" ("No" = 0 days, "Yes" = 1-7 days).

## **4.3 FINNISH DATA**

### **4.3.1 Sampling and tools of data collection of Sub-study III & IV**

The Adolescent Health and Lifestyle Survey (AHLS) is a nationwide multidisciplinary research and monitoring system about adolescent health and health behaviours that has been conducted in Finland since 1977 by Tampere University (previously University of Tampere). The Finnish adolescents have been followed every second year since the establishment of the program by a nation-wide postal survey using comparable methods. It was widened into a repeated biennial cross-sectional survey for monitoring a wider range of adolescents. It is one of the first monitoring systems in the world to include wide-ranging questions on young people's health and health behaviours, in addition to the socioeconomic health differences, risk and protecting factors. In 2009, the survey started to be conducted also via a protected online form. The overall response rate has declined over the years, particularly due to a decrease in responses among 18-year-old boys.

The data collection methods, scheduling, timing and procedure of the surveys and questions were maintained as similar as possible to enhance comparability of the results across study years. The samples of the AHLS included all Finnish adolescents aged 12, 14, 16- and 18-year old who were born on certain consecutive days in July.

Later, those born on certain days in June, July or August in each age group were selected, in order to avoid sampling the same persons again and to minimize the age variation within age groups. The sampling was conducted by The Finnish National Population Register Centre. The main topics of the surveys include tobacco use, alcohol use, nicotine addiction, stress, physical activity, special diets, and obesity.

The Ethics Committee of the Tampere region, Finland, approved the study protocol. Completing the questionnaire by the adolescent was considered as consent to participate in the study; no parental consent was required.

### 4.3.2 Measurements of sub-study III & IV

Study III and IV used data from AHLS. Self-administered questionnaires in two official languages (Finnish and Swedish), were sent to 9398 adolescents in 2013. The questionnaire was first sent via post with a cover letter including the personal code and the password for answering online. Respondents were 3535 adolescents (2130 girls and 1405 boys). The first questionnaire was followed by three reminders to non-responders, followed by a short last reminder that included the main questions on tobacco use. These responses were used also for assessing non-response by comparing early and late responders.

#### 4.3.2.1 Sub-study III

Awareness and use of e-cigarettes were assessed with questions on whether respondents have ever tried electronic cigarettes or not and how many times with two more options: “I don’t know” and “do not know what electric cigarettes are”. The question on e-liquid contents was assessed according to the e-liquid included, and whether it contains nicotine or not, in addition, there was an option to report more than one liquid. The source of e-cigarettes was asked with an open-ended question; six sources were categorized from the 29 different responses. Exposure to e-cigarette advertisement during the previous month was assessed with space for free text, from which thirty different responses were categorized further into six groups in the study (Facebook, other internet pages, kiosks, traditional media, streets, and elsewhere). Cigarette smoking status of the participants was divided into three groups (Never, tried but not a daily smoker, and daily smoker). With “no” and “yes” options, the participants were also asked about whether they are thinking of quitting smoking in the near future.

This study also included questions about other kinds of tobacco products, namely snus and water-pipe, the answers dichotomised further into “tried” and “not tried”. Respondents’ attitude toward smoking was assessed with how much she/he agreed with the statement, “smoking is for losers”, the five-item scale ranged from “definitely agree” to “definitely disagree”. School performance was based on the respondent’s subjective assessment of her/his school performance compared with the class average, with three categories: “much or slightly better,” “about class average,” or “slightly or much poorer”. Parents’ smoking status, education and work situation were separately asked for both the mother and the father. Family structure was also included in the study, and if the adolescent was living with his parents or not; the answers were dichotomized accordingly for the analysis.

#### 4.3.2.2 Sub-study IV

This study investigated transmission of smoking across three generations from grandparents to parents to their children.

##### **The third generation: Children**

The children’s cigarette smoking was assessed with three questions: “Have you ever tried smoking?” with answer options “no” and “yes”. To examine the current smoking status of those who answered “yes”, two additional questions were asked about the number of cigarettes smoked in a lifetime until now: “How many cigarettes have you smoked during your life-time until now?”, with options “none”, “only one”, “about 2-50” and “more than 50”. The third question used in Study IV was: “Which of the following options best describes your current smoking?” with the options “I smoke once per day or more often”, “I smoke once per week or more often but not daily”, “I smoke less than once per week”, “I have stopped smoking” and “I don’t smoke”. Based on their answers, the third-generation smoking status variables were divided into three groups “never tried to smoke” were those who had never tried conventional cigarettes, “tried but did not smoke daily” were “experimenters”, and “daily smokers” were those who reported daily smoking and had smoked more than 50 cigarettes in their lifetime. For the purpose of analyses, “tried smoking” and “daily smoking” were dichotomized further into no/yes.

To assess the use of other kinds of tobacco and e-cigarettes vaping, adolescents’ status of use was assessed by three separate questions about if they have ever tried to use snus, water-pipe, and e-cigarettes and the number of times used. For the

analyses, the questions of the three products were combined as one variable “other tobacco products”. Their answers were dichotomized with no/yes, where “yes” meant a trial of at least one product.

### **The first and second generation: Grandparents and parents**

The family smoking was assessed with six separate questions in which adolescent grandchildren were asked to report whether their mothers, fathers, maternal grandparents, and paternal grandparents have smoked during their lifetime with the question: “Have your parents/grandparents smoked during your lifetime?”. The options were “never smoked”, “has stopped = ex-smokers”, “smokes currently”, and “I don’t have one” or “I don’t know”. For ease of analysis, combined variables were created for parents’ and grandparents’ smoking with categories “never, has stopped, smokes currently, I do not have one, and I do not know.” Combined variables were “neither of them smoked”, “one or both has stopped”, “one of them smokes” and “both smoke”; the other options of “I don’t have one” or “I don’t know” were included in the category “never” in the analysis of this part.

Parents’ employment was assessed and categorized separately for fathers and mothers as “working”, “unemployed” and “other = retired or on a long sick leave”. Parents’ education was also assessed separately and combined according to the highest level that the parents had achieved with the categories “high level of education = over 12 years of education”, “middle level of education = 9–12 years” and “low level = Less than 9 years of education.”

**Table 5. Overview summary of differences and similarities of definitions and terminologies of independent variables in the Sudanese and Finnish studies**

Independent variables	Sudanese study	Finnish study
Trying smoking	<u><b>Ever smoker</b></u> Tried, even if one puff	<u><b>Tried to smoke</b></u> Tried, but did not smoke daily
Experimenting smoking	-	Smoked 2-50 times during lifetime, but did not smoke daily
Regular smoking	<u><b>Current smoker</b></u> Smoked on 1 or more days in the preceding month of the survey	<u><b>Current smoker</b></u> - smokes once per day or more often - smokes once per week or more often, but not smoking daily - smoke less than once per week  <u><b>Daily smoker</b></u> smoked >50 cigarettes in lifetime (represents regular smoking when nicotine addiction has a stronger role)
Smokeless tobacco	<b>Tombak</b> <u><b>Ever dipper</b></u> Tried, even if one dip <u><b>Current dipper</b></u> on 1 or more days on the last 30 days	<b>Snus</b> - Tried once - Have used 2-50 times - Have used more than 50 times
Shisha (water-pipe)	<b>Shisha</b> <u><b>Ever shisha</b></u> Tried once or more	<b>Water-pipe</b> - Tried once or twice - ≤ 20 times - > 20 times
E-cigarettes	-	Tried once or twice - ≤ 20 times - > 20 times

\* The Finnish definition of the independent variables depend on the number of the times/piece the product used, while in the Sudanese definition depended on the number of the days and trials

## 5 STATISTICAL ANALYSIS

### 5.1 General analysis for sub-studies I-IV

The statistical significance of the differences in frequencies was tested by chi-square ( $\chi^2$ ) test at a significance level of  $p < 0.05$ . Percentages and  $\chi^2$  from cross-tabulations were calculated for the explanatory variables to examine the association between the participants' tobacco use and significant others or school tobacco policies, depending on the exposure variables and the kind of tobacco or the device used for each sub-study separately. Then all the associations between the participants and tobacco use and other variables were assessed using logistic regression models. Results from adjusted and unadjusted logistic regression analysis are presented as odds ratio (ORs) with 95% confidence intervals (CIs). In addition, specific analyses were performed in the Sudanese sub-study II and the Finnish sub-study III based on the research question and objectives.

### 5.2 Specific analysis

#### 5.2.1 Sub-studies I-IV

##### Sub-study I

(The role of parents, friends, and teachers in adolescents' cigarette smoking and tombak dipping in Sudan)

Two adjusted models were fit using logistic regression analysis to examine the association between explanatory variables (tobacco use by parents, teachers and friends) and the adolescents' tobacco use (smoking, dipping and the use of other tobacco products as outcome variables). Results from logistic regression analysis were presented as ORs with 95% CIs. The first model was adjusted for age, sex, and school grades. Tobacco habits of the parents, friends and teachers were simultaneously included in the first model to generate the second adjusted model.

## Sub-study II

(School smoking policies and health science students' use of cigarettes, shisha and dipping tombak in Sudan)

Both SPSS (IBM SPSS Statistics version 23.0) and STATA gllamm (Generalized Linear Latent and Mixed Stata/SE 14.0) software packages were used to run the analysis. For the basic analysis, Pearson's  $\chi^2$  test was performed for descriptive analysis of frequencies, differences in proportion, and associations between variables. The two-sided statistical significance is reported at  $p < 0.05$ .

For the second part of the analysis, the STATA package was used for multilevel logistic regression to fit random-intercept logistic models and to examine the strength of the association between school policies and residential smoking, as exposure variables, and tobacco use by students as an outcome variable. This kind of analysis was used because of the hierarchical and the tiered nature of the data, assuming having two level data structure. The outcome tobacco variables (smoking cigarettes, dipping tombak, shisha use, smoking and dipping on school premises) were dichotomized first. The individual cases (students) were nested in higher-level groups (schools) with simultaneous inclusion of policy and residential smoking in the models using student as the level one unit of analysis. A null model was fitted and included only a random intercept to estimate the variations of tobacco use across schools. Subsequently, an unadjusted model was separately fit for smoking policy and residential smoking in relation to each tobacco use outcome. A final age and sex-adjusted model was fitted, with school level as a random effect. Analysis was performed separately for smoking on school premises. The ORs for the fixed part of the models were estimated with their 95% CIs. The school level variance (SE) was estimated for the differences between schools.

## Sub-study III (Awareness and determinants of electronic cigarette use among Finnish adolescents in 2013)

To conduct the study, data were analysed using IBM SPSS Statistics, V.20. For descriptive analysis tabulations, the Pearson  $\chi^2$  test was used to test for statistical significance. The awareness and the type of liquid content of e-cigarettes variables were cross-tabulated with age, sex, tobacco use, and with the socioeconomic background of participants. Age and sex-adjusted analysis for prevalence was conducted separately for all independent variables and calculated using direct adjustment, giving equal weights to each group. A stepwise approach to logistic regression was performed to analyse the factors associated with ever use of e-cigarettes. The analysis for the age and sex adjusted independent variables were first



conducted separately, and then included in a multivariate model with all independent variables. Results are presented as ORs and 95% CIs.

#### Sub-study IV (Transmission of smoking across three generations in Finland)

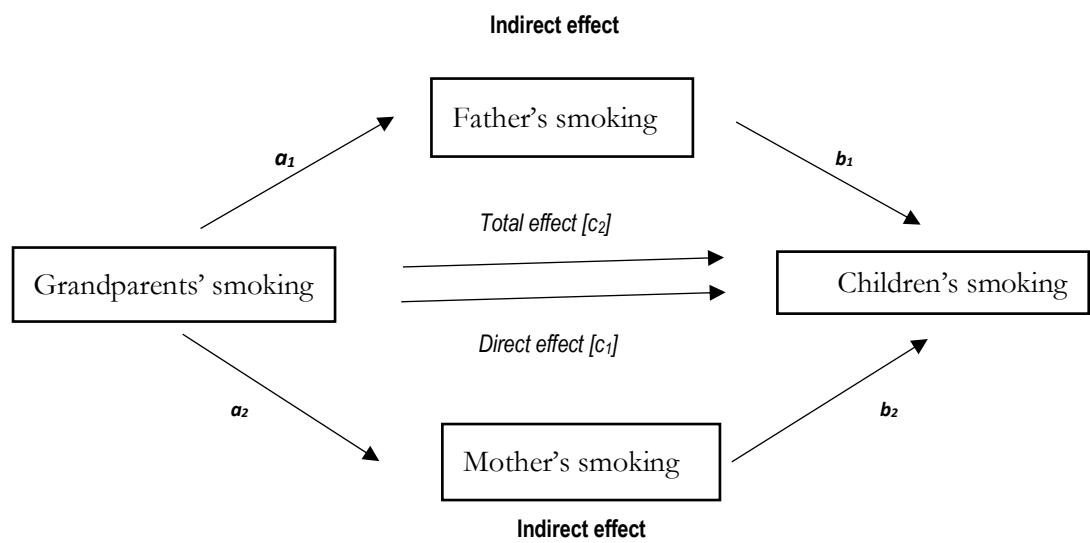
The statistical significance of the associations between parents' and grandparents' smoking and the grandchildren's tobacco use (tried smoking, daily smoking, using other kind of tobacco products) were examined using the Pearson  $\chi^2$  test. Logistic regression analysis (LRA) was then applied. All the results of LRA are presented as odds ratios (ORs) and 95% confidence intervals (CIs). In the first set, the age adjusted LRA were performed separately for tobacco use variables of girls and boys, according to the mother's, father's, and each of the four grandparents' smoking statuses. In the second set of LRA, the analyses were conducted for boys and girls combined with two models: The first model adjusted for age and sex only; in the second model, the parents' and grandparents' smoking, employment and educational background of parents were simultaneously included in model 1. The third set of LRA was performed according to the number of smokers among parents and grandparents; first with adjusted for age and sex only, and then adjusted for parents' employment status and educational background. These analyses were conducted with IBM SPSS Statistics v. 20.0 software (IBM Inc. Armonk, NY, USA).

#### 5.2.2 Mediation analysis (Study IV)

Mediator variables (Figure 3) were those variables that sit between the independent variables and dependent variables and mediate the effect of the grandparents' smoking on grandchildren. All mediator variables in this study were connected to parents and grandparents; no other members of the family were tested. It was performed to assess the extent of the effect of the exposure to grandparents' smoking on children's smoking and whether it is mediated through mothers' and fathers' smoking or has a direct effect. All grandparents' smoking variables were combined into one variable that was performed to investigate how much of the effect of exposure of grandparents' smoking on their grandchildren's tobacco use is mediated through parents' smoking. The analysis assumed that the grandparents' smoking influences parents' smoking, and grandchildren's smoking, either directly or through their parents' smoking. Father's and mother's smoking were assumed to have effect only on their children's smoking. All the dependents and independent

variables (maternal and paternal grandparents’ smoking) and mediator variables (mother’s and father’s smoking) were coded as binary. The proportion of the total effect that is mediating through parents’ smoking was calculated by dividing the sum of the indirect effect by the total effect. For this analysis, STATA v. 13.1 software with binary-mediation program was used, together with a ‘bootstrap’ command for estimating the confidence intervals.

**Figure 3.** Diagram illustrates the paths of mediation analysis in In the Finnish Sub-study IV



**Total effect [ $c_2$ ]:** represents the effect of grandparents on grandchildren with no mediators in the model.  
**Direct effect [ $c_1$ ]:** represents the effect of grandparents’ smoking on grandchildren’s smoking when smoking of the mother and father mediators are included in the model.  
**Indirect effects [ $a_1b_1$  &  $a_2b_2$ ]:** represent the indirect effect of grandparents’ smoking on grandchildren’s smoking through their mother or father smoking separately.

### 5.2.3 Analysis of non-responders

#### Sudanese data

A weighting factor was applied to each student record to adjust for non-responses and for the varying probabilities of selection. No more rounds were done for non-responders.

#### Finnish data

The original first questionnaire was followed by reminders to non-responders, the last short one included the main questions on tobacco use. These responses were used for comparison of responders and non-responders. The effect of non-response was assessed by comparing those who responded to the full questionnaire with those who responded to the short one and assumed that this latter group closely represented all non-responders. Compared to the total sample of the Finnish data, boys were underrepresented among the responders. Regarding age, adolescents aged 12 years were overrepresented and those aged 18 years underrepresented, whereas differences were small for those aged 14 years and 16 years. Boys were more likely to be non-responders, but the differences between the age groups were not significant. According to the results of the analysis, in the e-cigarette study (Study III), the use of e-cigarettes and the age were not different between the groups. On the other hand, girls studying in vocational upper secondary school were more likely to be classified as non-responders compared with girls in general upper secondary schools and with those with average or poorer school performance. In Study IV, the intergenerational transmission of smoking study, for example, the effect of non-response on the reports of parents and grandparents' smoking was assessed by dividing the responders into four groups according to how promptly they had answered the survey. It was assumed that the later the adolescent answered, the more her/his answer was similar to a non-responder. To conclude, there were no systematic differences between the groups that had answered early or late that would have suggested an over- or under-representation of parental or grandparental smoking among the non-respondents.

## 6 SUMMARY OF THE RESULTS

### 6.1 Sudanese studies (sub-study I and II)

#### 6.1.1 Sub-study I

The main objective of this sub-study was to examine the association between adolescents' tobacco use, exposure to smoking and dipping tombak by parents, friends, and teachers. It mainly described the role of tobacco use by significant others and the effect of the teachers' dipping on school premises and their role on adolescents' tobacco use.

The 100% response rate of the 23 selected basic and secondary schools resulted in 4277 participating students. Two thirds (66%) were between the age of 13 and 15 years old; slightly more than half were boys (53%). The prevalence of smoking cigarettes was about 24% (33% of the boys, 13% of the girls); 8 % of them reported being current smokers. About 8% had tried to dip tombak, and 12% had tried to use other kinds of tobacco products (mostly shisha). Although smoking or using any other kinds of tobacco is not accepted socially, girls, too, had tried to use it at some point, and, they were almost (11%) equal to boys in trying to use tobacco other than cigarettes and tombak. Boys and older students from high schools were more likely to be tobacco users than the younger ones in basic schools, except for the use of other kinds of tobacco; those from basic schools used other forms (17%) more than cigarettes (Table 6).

**Table 6. Percentages of tobacco use by Sudanese adolescents, parents smoking and dipping, friends smoking, and teachers dipping by sex and school grades**

	SEX <sup>Ω</sup>			SCHOOL GRADES <sup>€</sup>		
	Total▼ N=4277	Girls n=1740 41%	Boys n=2270 53%	Basic (8th) n=902 21%	Secondary(1st) n=1595 37%	Secondary(2nd) n=1461 34%
<b>ADOLESCENTS</b>						
Ever smokers	24 (1022)	13 (222)	33 (719)	20 (168)	25 (380)	28 (392)
Current smokers	8 (320)	3 (46)	11 (251)	6 (52)	7 (111)	9 (132)
Ever dippers	8 (382)	4 (60)	13 (287)	7 (66)	8 (132)	10 (146)
Current dippers	4 (173)	2 (35)	5 (116)	4 (38)	3 (53)	4 (60)
Other tobacco products*	12 (454)	11 (185)	12 (269)	17 (149)	11 (162)	10 (140)
<b>PARENTS' SMOKING</b>						
Either or both	17 (719)	16 (271)	18 (404)	14 (126)	19 (302)	17 (244)
<b>PARENTS' DIPPING</b>						
Either or both	14 (597)	13 (223)	15 (334)	13 (112)	13 (206)	16 (233)
<b>TEACHERS</b>						
Dipping tombak	44 (1896)	20 (323)	66 (1575)	25 (221)	47 (717)	59 (839)
<b>FRIENDS' SMOKING</b>						
Some or most of them	41 (1751)	35 (593)	48 (1055)	35 (297)	44 (678)	46 (650)

Ω Missing = 6% (n=267).

▼ N: Grand Total. Total for each variable varies due to missing data.

€ Grade 8 basic schools, and the first and second classes of secondary school

Among all adolescents, 18% of boys and 16% of girls reported having at least one of their parents currently smoking or dipping. In the same manner, 44% of respondents had seen one of their teachers dipping tombak on school premises. About 41% of the participants reported most of their friends were current smokers, with higher percentages in higher grades (Table 6). The results of logistic regression confirmed the importance of friends as the most important influencing factor on adolescents' tobacco use. Adolescents were significantly almost four times ({Adjusted odds ratios A-OR}, A-OR 3.77) at risk to be a current smoker and three times are likely (A-OR, 3.33) to be a current tombak dipper when some or most of their friends were smoking cigarettes. The parents' smoking effect was the second strongest influence. When at least one parent is smoking, the child is at risk to start smoking (A-OR 1.79). After adjusting to confounders, the dipping teachers, although important, played a minor role in a student's smoking behaviour (A-OR 1.50) compared to that of the friends and parents (Table 7).

**Table 7. Adjusted odds ratios (OR) and 95% confidence intervals (CI) of the relation between tobacco use by parents, friends, and teachers and adolescents' tobacco use**

	Ever smokers <sup>∞</sup>	Current smokers	Current dippers <sup>∞</sup>	Other tobacco products
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>PARENTS' SMOKING</b>				
None of them	1	1	1	1
Either of them	1.79 (1.46 - 2.20) **	1.67 (1.22 - 2.27) **	0.83 (0.50 - 1.36)	1.43 (1.09 - 1.89) *
Don't know	1.48 (0.72 - 3.02)	0.97 (0.32 - 2.91)	0.58 (0.14 - 2.52)	1.80 (0.77 - 4.21)
P-value	<0.001	0.005	0.624	0.021
<b>PARENTS' DIPPING</b>				
None of them	1	1	1	1
Either of them	1.13 (0.90 - 1.43)	1.34 (0.95 - 1.89)	1.84 (1.17 - 2.90) **	1.05 (0.77 - 1.44)
Don't know	1.82 (0.78 - 4.27)	2.13 (0.73 - 6.23)	6.55 (1.94 - 22.12) **	0.81 (0.25 - 2.58)
P-value	0.243	0.117	0.001	0.887
<b>FRIENDS' SMOKING</b>				
None	1	1	1	1
Some or most	1.94 (1.64 - 2.29) **	3.77 (2.80 to 5.07) **	3.33 (2.20 - 5.05)	1.16 (0.92 - 1.45)
P-value	<0.001	<0.001	<0.001	0.204
<b>TEACHERS' DIPPING</b>				
No	1	1	1	1
Yes	1.50 (1.24 - 1.82)	1.14 (0.84 - 1.54)	1.14 (0.75 - 1.74)	0.78 (0.60 - 1.01)
P-value	<0.001	0.397	0.548	0.054

In addition to age, sex and school grade, ORs simultaneously adjusting for the tobacco habits of parents, friends and teachers  
 \*p<0.05; \*\*p<0.001.

## 6.1.2 Sub-study II

This study intended to examine the associations between school tobacco policies and residential smoking and tobacco use by students studying in the Health Science disciplines of medicine, dentistry, nursing, and pharmacy, as well as examining their tobacco use behaviour regarding smoking or dipping on school premises. Smoking policies were presented as policies banning smoking and restrictions in school buildings, school premises, public places, and clinic.

Of the 1590 respondents, female students constituted 66%. Just over half of the students were less than 24 years old. The prevalence of tobacco use was 40% for smoking cigarettes, 34% for using shisha, and 16% for dipping tombak. Those currently smoking were 8%. The higher percentages of ever smokers (47%), ever shisha (41%) and ever dippers (19%) were those at the age of 24 or older, raising a question about if they started using tobacco at the university or before. The older students were also more likely to be current smokers than students of younger age. Around half of ever smokers and slightly less than half of shisha users reported being exposed to smoking by one or more persons at the places where they live. Students

at dental schools were the most frequent tobacco users and smoked more on school premises. Those who reported the existence of a school policy pertaining to tobacco use were more likely to use tobacco and more likely to smoke on school premises than those who reported no policy, and they were also more aware of the smoking restricted areas in their schools (results not shown).

As shown in Table 8, adjusted models (A-OR) of multi-level analysis were used to examine the relationships between variables. Despite that they self-reported the existence of a policy banning smoking in their school, the current smokers and dippers were significantly twice as likely to report smoking on school premises than those who said no policy existed (A-OR: 2.38 for smokers and 2.60 for dippers). For smoking restriction variables (partial or complete restriction of smoking in school), the risk of current smoking was almost three times (A-OR : 2.91), twice for using shisha (A-OR : 2.17), and almost the same for dipping tombak on school premises (A-OR : 2.30). The current smokers were at three times increased risk when exposed to smoking in places where they live (A-OR 3.12), and nearly twice for shisha users (A-OR 1.73) (Table 8).

**Table 8. Adjusted Odds ratios (OR) and 95% confidence intervals (CI) for students' tobacco use and smoking and dipping tombak on school premises by and school smoking policies (in both clinic & public places) and exposure to residential smoking**

	Ever Smoking OR (95% CI)	Current Smoking OR (95% CI)	Ever Shisha OR (95% CI)	Ever-dipping Tombak OR (95% CI)	Current smoking on school premises <sup>1</sup> OR (95% CI)	Ever dipping on school premises <sup>2</sup> OR (95% CI)
<b>SCHOOL SMOKING POLICIES</b>						
<b>Policy Banning Smoking *</b>						
No official policy	1	1	1	1	1	1
Exists for either	1.24 (0.92-1.67)	0.95 (0.55-1.64)	1.52 (1.12-2.07)	1.24 (0.86-1.80)	0.23 (0.08-0.67)	2.32 (1.06-5.12)
Policy exists for both	1.34 (0.99-1.80)	1.34 (0.81-2.23)	1.80 (1.33-2.45)	1.04 (0.72-1.52)	2.38 (1.34-4.25)	2.60 (1.22-5.56)
P-value	0.055	0.251	<0.001	0.819	0.003	0.013
<b>Random Part</b>	0.11 (0.07)	0.19 (0.15)	0.11 (0.07)	0.04 (0.05)	1.54 (0.79)	6.84 (1.39)
<b>Smoking Restriction</b>						
School level variance (SE)						
No Official Policy	1	1	1	1	1	1
Complete restriction	1.24 (0.94-1.63)	1.32 (0.82-2.16)	1.36 (1.02-1.80)	1.04 (0.73-1.47)	1.38 (0.77-2.47)	2.30 (1.16-4.53)
Partial restriction	1.35 (0.96-1.90)	2.91 (1.68-5.02)	2.17 (1.54-3.06)	1.14 (0.74-1.75)	1.30 (0.61-2.80)	1.60 (0.64-3.97)
P-value	0.083	≤0.021	0.034	0.544	0.489	0.311
<b>Random Part</b>	0.12 (0.08)	0.08 (0.10)	0.07 (0.06)	0.04 (0.05)	1.40 (0.72)	4.48 (3.99)
<b>RESIDENTIAL SMOKING</b>						
Not exposed	1	1	1	1	1	1
Exposed	1.66 (1.31-2.10)	3.12 (1.98-4.92)	1.73 (1.36-2.21)	1.33 (0.98-1.80)	0.85 (0.50-1.44)	1.35 (0.74-2.49)
P-value	≤0.001	≤0.001	≤0.001	0.069	0.554	0.324
<b>Random Part</b>	0.05 (0.05)	0.19 (0.14)	0.09 (0.06)	0.01 (0.04)	0.50 (0.38)	7.80 (1.66)

Variance of random effects [SE] for "ever smoking" (0.17 [0.08]), "current smoking" (0.38 [0.20]), "ever shisha" (0.18 [0.09]), "ever dipping tombak" (0.07 [0.06]), "current smoking in 1-yr" (1.39 [0.68]) and "dipping tombak on school premises during the last 1-yr" (0.30 [0.28]).

<sup>1</sup> Those were only current smokers who smoked on school premises = 77 students constitute 59.2 %, of all current smokers (total current smokers = 130).

<sup>2</sup> Those were only dippers who dipped on school premises = 56 students constitute 21.9% of all dippers (total dippers = 256 dippers).

‡ Adjusted for age and sex and school level as a random effect

\* For both clinic and public places



## 6.2 Finnish studies (sub-study III and IV)

### 6.2.1 Sub-study III

These results concern the Finnish study about the awareness and the use of electronic cigarettes (EC). Around 85% of the 3475 adolescents who participated in the survey reported being aware of E-cigarettes, irrespective of their age and sex.

**Table 9. Percentages of the source of e-cigarette and its use among Finnish adolescents by sex, and the use among daily smokers**

Use of e-cigarettes	Girls %	Boys %	All Total <sup>β</sup> %	% among daily smokers %
I know what e-cigarettes is	83	88	85	35
Have tried it 1-2 times	11	14	13	77
Have tried it ≤ 20 times	2	3	3	67
Have tried it ≥ 20 times	1	3	2	49
Total (N)	2106	1369	3475	

<sup>β</sup> the total columns are adjusted for age

As shown in Table 9, the awareness is slightly higher among boys than girls. Most adolescents who had experienced e-cigarette had tried to use it only once or twice (13%). Friends were found to be the main source of adolescents' access to EC compared to family and internet (Table 10). In total, the prevalence of EC was 17%, e-liquids with nicotine were the most used type of EC (66%); mostly by those who had tried to use EC more than twice (84%).

**Table 10. Percentages of the source of e-cigarettes among ever e-cigarettes users**

Source of e-cigarettes	%
Friends	80
Internet	7
Family	5
Abroad	3
Shops	2
Other places	4

The prevalence of using EC among daily smokers, ever snus users and ever use of water-pipe were 81%, 63%, and 56%, respectively. In the model adjusted for age and sex, the odds ratio for EC ever use by daily smokers was significant (A-OR: 120.9) indicating the high-risk group of daily smokers (Table 11). The risk among daily smokers remained significant and high, although it was reduced by almost two-thirds in the second model when all the other variables in Table 11 were included in the stepwise forward logistic regression analysis (A-OR 41.4) (results of model II not shown).

Strong associations with ever e-cigarette use were observed with snus use, water-pipe use, parents' smoking, attending vocational education, and with poor school performance (Table 11).

**Table 11. Prevalence percentages and ORs (95% CI) for e-cigarettes by tobacco related factors, type of school and school performance**

	<b>Prevalence %</b>	<b>Adjusted prevalence<sup>β</sup> OR (95% CI)</b>
<b>Smoking cigarettes*</b>		
Experimenter	33	14.2 (10.35-19.41)
Daily smoker	81	120.9 (81.72-178.74)
<b>Snus*</b>		
Ever use	63	12.1 (9.69-14.98)
<b>Water-pipe*</b>		
Ever use	56	6.5 (5.27-8.12)
<b>Parent smoking*</b>		
Only mother smokes	31	2.2 (1.58-3.16)
Only father smokes	28	1.8 (1.42-2.38)
Both smoke	33	2.7 (1.99-3.62)
<b>School<sup>Σ</sup></b>		
Comprehensive	20	1.4 (0.77-2.46)
Vocational	51	3.3 (2.60-4.17)
Combined	25	2.0 (1.28-3.05)
Not in school	47	2.2 (1.26-3.76)
<b>School performance<sup>α</sup></b>		
Class average	25	1.8 (1.45-2.17)
Poor	42	3.9 (2.96-5.12)

<sup>β</sup> Adjusted for age and sex (all OR are significant except boldface OR not significant)

Reference: \*Never use tobacco, <sup>Σ</sup> General upper secondary school, <sup>α</sup> Better than class average

## 6.2.2 Sub-study IV

Sub-study IV examined the intergenerational transmission of tobacco smoking across three generations from grandparents to parents to their children.

**Table 12. Distribution of adolescents' tobacco use and smoking of parent and grandparents by gender**

<b>Smoking of family members</b>	Girls n = 2130 % (n)	Boys n = 1405 % (n)	Total N = 3535 % (n)
<b>Children</b>			
Tried smoking	40 (851)	38 (531)	40 (1382)
Daily smoking	11 (226)	9 (126)	10 (352)
Use of other products ◀	27 (583)	33 (458)	30 (1041)
<b>Parents</b>			
Mother smoking status			
Ex-smoker	14 (288)	15 (199)	14 (487)
Currently smokes	16 (333)	14 (181)	15 (514)
Father smoking status			
Ex-smoker	20 (406)	23 (303)	21 (705)
Currently smokes	23 (477)	21 (282)	22 (759)
<b>Maternal grandparents</b>			
Grandmother smoking status			
Ex-smoker	9 (155)	9 (102)	9 (257)
Currently smokes	10 (186)	9 (100)	10 (286)
Grandfather smoking status			
Ex-smoker	17 (273)	18 (188)	17 (461)
Currently smokes	12 (190)	11 (117)	12 (307)
<b>Paternal grandparents</b>			
Grandmother smoking status			
Ex-smoker	8 (133)	7 (82)	8 (215)
Currently smokes	9 (145)	7 (80)	8 (225)
Grandfather smoking status			
Ex-smoker	14 (204)	17 (171)	16 (375)
Currently smokes	10 (144)	10 (99)	10 (243)

◀ includes snus, water-pipe and electronic cigarettes.

### 6.2.2.1 Tobacco use among the three generations

As shown in Table 12, about 40% had tried smoking in 2013, and 10% of them smoked daily. Girls had tried smoking more than boys. Girls also reported daily smoking (11%) more than boys (9%). In contrast, boys had tried at least one of the other kinds of tobacco products (e-cigarettes, water pipe or snus) significantly more often (33%) than girls (27%). Altogether, 15% of mothers and 23% of fathers were

current smokers. Currently smoking grandmothers ranged between 8% to 10%, slightly less than currently smoking grandfathers (Table 12).

**Table 13. Adjusted ORs and 95% CIs for children smoking experimentation, daily smoking and other tobacco product use\* by number of smoking parents and grandparents †.**

	<b>Tried smoking</b>	<b>Daily smoking</b>	<b>Other tobacco-related products</b>
	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>
<b><u>Parents</u></b>			
Never smoking	1	1	1
One ex-smoker &/or both	2.04 (1.71–2.42)	2.79 (2.11–3.69)	1.73 (1.45–2.07)
One smoker	1.87 (1.50–2.33)	2.20 (1.54–3.15)	1.78 (1.42–2.24)
Both smoker	2.55 (1.93–3.37)	5.63 (3.93–8.07)	2.42 (1.82–3.20)
<i>P-value</i>	<0.001	<0.001	<0.001
<b><u>Paternal grandparents</u></b>			
Never smoking	1	1	1
One ex-smoker &/or both	1.42 (1.15–1.75)	1.76 (1.28–2.41)	1.35 (1.08–1.68)
One smoker	1.22 (0.93–1.60)	1.85 (1.24–2.78)	1.28 (0.97–1.70)
Both smokers	2.92 (1.65–5.15)	3.45 (1.73–6.86)	3.16 (1.80–5.55)
<i>P-value</i>	<0.001	<0.001	<0.001
<b><u>Maternal grandparents</u></b>			
Never smoking	1	1	1
One ex-smoker &/or both	1.34 (1.10–1.64)	1.57 (1.14–2.14)	1.38 (1.12–1.70)
One smoker	1.50 (1.18–1.92)	2.02 (1.40–2.91)	1.28 (0.99–1.67)
Both smokers	2.00 (1.22–3.23)	2.67 (1.33–5.33)	1.50 (0.88–2.58)
<i>P-value</i>	<0.001	<0.001	0.008

\* Snus, water pipe and electronic cigarettes

† Model : Adjusted for age and sex

Note: OR is given in boldface when it indicates a statistically significant

### 6.2.2.2 Parents' and grandparents' smoking

According to the results of the logistics regression analysis; significant association was found between the smoking parents and their children's tobacco use; very strong association were detected when parents were both smokers (Table 13). Both smoking paternal and maternal grandparents were associated with grandchildren's daily smoking by almost three-fold, and two-fold with trying smoking (Table 13). However, the associations were significantly strong. The gender specific results as summarized in Table 14 show that the adolescent, whether a girl or a boy, was at risk of smoking and using any other kinds of tobacco or related devices when parents were smoking. Mother's current smoking was strongly associated with daily smoking among both girls and boys, but with higher odds among girls (A-OR 5) compared to boys (A-OR 3), indicating the important role of the mother on her children's

behaviour with regards to smoking. The previously smoking parents (ex-smokers) were associated with their children's use of all kinds of tobacco, except for the boys daily smoking, which was not significantly associated with their ex-smoking mothers (Table 14).

In gender-specific analyses for grandparents' (Table 14), the strongest association was found between paternal grandmothers' current smoking and boys' daily smoking (A-OR 3). Maternal grandfathers' smoking was also associated with boys' daily smoking but not with the girls' daily smoking. The gender-specific results of grandparents' smoking association varied for trying smoking and the use other tobacco products (Table 14).

**Table 14. The age-adjusted magnitude (Odds ratios), smoking by parents and grandparents according to the sex of adolescents**

<i>Gender of adolescents</i>		<b>Girls</b>			<b>Boys</b>		
<i>Smoking status of the family members</i>		<b>Tried smoking</b>	<b>Daily smoking</b>	<b>OKTPs<sup>β</sup></b>	<b>Tried smoking</b>	<b>Daily smoking</b>	<b>OKTPs<sup>β</sup></b>
<b>Mother</b>	Ex-smoker	●●	●●•	●●	●●	○	●•
	Current smoker	●●•	●●●●●	●●●	●•	●●●	●•
<b>Father</b>	Ex-smoker	●•	●●	●•	●●	●●•	●•
	Current smoker	●●	●●●	●●	●●	●●•	●•
<b>Maternal Grandmother</b>							
	Ex-smoker	●•	○	●●	○	○	○
	Current smoker	●•	●●●	●•	○	●●	○
<b>Maternal Grandfather</b>							
	Ex-smoker	○	○	○	●•	●●•	●•
	Current smoker	●•	○	○	●●	●●	○
<b>Paternal Grandmother</b>							
	Ex-smoker	●●•	●●	●●	○	○	○
	Current smoker	○	●•	○	●•	●●●	●●
<b>Paternal Grandfather</b>							
	Ex-smoker	●•	○	●•	○	●●	○
	Current smoker	●●	●●•	●●•	○	○	○

<sup>β</sup> = Other Kinds of Tobacco Products (snus, water-pipe and E-cigarettes)

Boldface dots indicate significance, size indicates the magnitude of the risk

● = Adjusted ORs, significant (adjusted OR, ● = 1).

• = Adjusted ORs, significant (adjusted OR, • = less than 1)

○ = Adjusted ORs, not significant (indicating non-significant results)

### 6.2.2.3 Results of mediation analysis

The mediation analysis was performed to assess whether the effects of maternal and paternal grandparents' smoking on grandchildren's tobacco use is a direct effect or mediated through parents (more details in Figure 3). The effect might be from one grandparent, through one parent or both, and might be from or through all of them together. It is a kind of correlational measure between grandparents' smoking and grandchildren's tobacco use. The results of the mediation analysis also showed the effect of the grandparents' smoking on children's use of any other kind of tobacco products (snus, water-pipe, e-cigarettes), as well as on smoking. In this study, the effect of grandparents' smoking was found to be mainly mediated through mother's smoking to grandchildren that was higher than that of a fathers' (the indirect effect). Measuring the total effect that is mediated through parents was arrived at by dividing the sum of the indirect effect by the total effect, the result giving the proportion that is mediated through parents for all indicators.

**Table 15. The association between grandparents' smoking and grandchildren's, considering mother's and father's smoking as mediators.**

Effect	Tried smoking	Daily smoking	other tobacco products
<b>Indirect effect</b>			
Mother's smoking ( $a_1b_1$ ) *	0.036	0.066	0.041
Father's smoking ( $a_2b_2$ )	0.026	0.034	0.013
<b>Direct effect (<math>c_1</math>)</b>			
Grandparents' smoking	0.035	0.037	0.032
<b>Total effect (<math>c_2</math>)</b>	0.097	0.137	0.086
-Proportion of the total effects mediated through parents	64%	73%	63%
-Proportion of the total effect that is direct from grandparents to grandchildren	36%	27%	63%

\* More information in figure 3 footnotes

Of the total effect of grandparents' smoking, 64% of smoking experimentation, 73% of daily smoking, and 63% of other tobacco product use were mediated through parents. That means about one third (36%, 27% and 37%, for trying to smoke, daily smoking, and using other tobacco products, respectively) of the total effect was transmitted directly from grandparents to their grandchildren. Of the total effect, 14% (0.137) of daily smoking, 10% (0.097) of trying smoking, and 9% (0.089) of using other tobacco products was explained by the transmission of smoking from the grandparents to their grandchildren (Table 15).

## 6.3 OVERVIEW SUMMARY OF SIMILARITIES AND DIFFERENCES OF SUDANESE AND FINNISH DATA

**Table 16. Overview summary of similarities and differences of Sudanese and Finnish data**

Country	SUDAN		FINLAND
Data source	SYTS <sup>∞</sup> (Sub-study I)	SHPSS <sup>Σ</sup> (Sub-study II)	AHLS <sup>α</sup> (Sub-study II & IV)
Study subjects	School-going adolescents Basic and Secondary schools	Health Science Students University-level	Age-based selected adolescents from Finnish Population Register Centre
Number (N)	N = 4277 Girls = 41% Boys = 53%	N = 1590 Girls = 66% Boys = 31%	N = 3535 Girls = 60% Boys = 40%
Age	11 – 17 years old	17 - 30 years old	12, 14, 16 and 18 years old
Design	Cross-sectional	Cross-sectional	Cross-sectional
Tools of data collection	School-based Self-administered questionnaire 68- items	School-based Self-administered questionnaire 44-items	Mailed and Internet Self-administered questionnaire. Selected questions for each study
Languages used in questionnaire	Arabic & English	Arabic	Finnish and Swedish
Response rates	School: 100% Student: 93%	School: 100% Student: 67%	- Participants: 38%
Non-respondents	Those absent on the day of survey were not followed	Those absent on the day of survey were not followed	Non-respondents were followed by 3 reminders and a short questionnaire
Topic addressed	The role of "significant others" in adolescents' tobacco use	Effects of university's smoking policy and residential smoking	Awareness of e-cigarettes + transmission of smoking across three generations
Type of tobacco assessed in study	Cigarettes Other kinds (mostly shisha) Tombak	Cigarettes Shisha Tombak	Cigarettes E-cigarette water-pipe Snus
Specific Analysis	Binary logistic regression analysis	Binary logistic regression analysis, multi-level analysis	Binary logistic regression mediation analysis

<sup>∞</sup> SYTS: Sudan Youth Tobacco Survey

<sup>Σ</sup> SHPSS: Sudan Health Professional Students Survey

<sup>α</sup> AHLS: Adolescents Health and Lifestyle Survey





## 7 DISCUSSION

### 7.1 Preface of the discussion

The four studies that comprise this thesis and the accompanying literature review offer key insights about the status and the factors affecting tobacco use by young people, the influence of family, and the significance of the environmental and social context. According to many studies, youngsters learn normative and deviant behaviour from three main sources: family, peers and school (Villanti et al. 2011; Haas & Schaefer 2014). While research has shown the role of family, friends, and teachers in influencing adolescent tobacco behaviour, few research studies have examined all three main factors together; all three sources were considered in this thesis. Although the research producing the articles and thesis cannot capture the entire body of worldwide literature related to tobacco use, which is enormous, the author is not aware of any research on all these topics combined on the use of five kinds of tobacco products. All these factors increase considerably the strength of the information presented here and the accompanying discussion.

Incontestably, the discussion about tobacco use varies significantly between Sudan and Finland, and the comparisons are nuanced, as the two communities differ economically and culturally. Different communities vary in their susceptibility to different factors; different factors may play out differently in different regions and play different roles for different individuals even within the same country and in the same household. Tobacco use influence by communities may also be affected by the existence of cultural differences among regions and countries. Despite these cultural and the geographical differences, the study concluded that the two countries meet at the point that the tobacco uses by their adolescents are similar regarding the influences and the sources and the risk factors targeting the same age population.

## 7.2 The main highlights of this study

- Tobacco use by young people continues to be a problem around the world. Although the prevalence in countries differs, use of any type of tobacco products remains a major health concern in both low- and high-income countries.
- Since the implementation of anti-tobacco policies and the knowledge of its adverse effects have been described, rates of smoking of cigarettes are declining globally, especially in the developed world, but the decline is not consistent among the youth. In Finland, smoking and vaping trends are decreasing, but snus has been a matter of apprehensions, and its use is particularly increasing among girls.
- Family influence has a significant effect on whether young people start to smoke or not, specifically parents and grandparents. The children of current smokers and former smokers' families are more likely themselves to smoke. Thus, the "smoking environment" of a young person's residence is a major factor in tobacco use.
- The study highlights the importance of friends in tobacco use as the most important factor influencing smoking during adolescence. In the Sudanese study, friends were found to be the most important influential factor in tobacco use during adolescence, even more than parents.
- School policies, at university level, and where anti-smoking policies exist, are poorly enforced, and thus abused. In addition, weak anti-smoking policies may lead young people to use alternative forms of tobacco on the campus, like smokeless tobacco, as well as to smoke.
- Smokeless tombak dipping is common in Sudan because tombak is culturally accepted and cheap indicating that cultural context and social norms are important to consider specially in the developing world. In Finland, although using smokeless nus is legal and both genders are using it, selling is illegal. Nonetheless, it is also cheap and easy to access from Sweden, but it is not allowed for sale in any retail sales in Finland, which is a clear deterrent.
- From literature, although research on tobacco is common, smoking cigarettes usually has the top weight in these studies. In comparison, other forms of tobacco have not been well-addressed in the same way. Cigarette smoking rates have declined in developed countries because of major national and worldwide health promotion based on these research findings. Other kinds of tobacco products need more attention.

## 7.3 Discussion of the main findings

Broadly, the discussion of the main findings highlights the importance of the influences of tobacco use by parents, maternal and paternal grandparents, friends, and teachers on the use of cigarettes, water-pipe, tombak, snus, and e-cigarettes by adolescents. In addition, the discussion considers the effects of exposure to residential smoking and school smoking policies on the tobacco use behaviour by young adult university-level students. The study focused on participants from Sudan and Finland, using three data sets. Basic and advanced analyses were performed using various methodologies and software.

For clarity of the discussion, the four objectives of the thesis will be discussed in sections based on the objectives and the topics rather than discussing each article or each country separately and regardless of the time of publication of each sub-study. One article or sub-study may include more than one factor or more than one objective that will be pointed out in the text. In summary, tobacco use by family members, friends, and teachers, together with residential smoking and weak school smoking policies, all appear to influence young people's use of tobacco. As an effort to address these factors, several findings from Finnish and Sudanese studies are discussed in the following sections.

### 7.3.1 Family

Extended family is very important throughout Africa and Sudan in particular, where the basic household structure is traditionally large. Most people in Sudan, particularly in rural areas, live in households that include the nuclear family (mother, father, and children) and the extended family (grandparents, aunts, uncles, cousins, and others), as well as distant relatives, all living in nearby neighbourhoods if not sharing the same house. The proximity of many relatives makes it easy for the child to be influenced by many people and mimic them, as well as facilitates a child's access to cigarettes and/or tombak. In Finland, as most western countries, the number of families with cohabiting couples have grown slowly in recent years. Mothers and fathers in one-parent families differ in their marital status (Statistics Finland). Similarly, extended family members, as grandparents in this study, may also have effects on children; they may act as role models, and they may have contribution to the grandchildren's smoking behaviour. Family smoking environment and tobacco use are the most important key factors that influence tobacco use behaviour of

adolescents (Griesbach et al. 2003). The findings of the Sudanese sub-studies I and the Finnish sub-study IV evidenced with no doubt the significant influence of parents and grandparents on adolescents' tobacco use, which is consistent with previous research findings (Gugushvili et al. 2018; Manning et al. 2017; Aloise-Young & Rosa 2019; Leorandi\_Bee et al. 2011; Mercken et al. 2013; Harakeh et al. 2006). Whereas parents' tobacco use has been widely studied and is proven to be an important contributor in their children's tobacco attitudes and behaviour, smoking transmission through generations has not been widely investigated and less evidence is available on the intergenerational patterns of tobacco use (Escario & Wilkinson 2015; Vandewater et al. 2014).

The findings that emerged out of this study about the parents' influences on their children to use tobacco are not surprising, given the fact that numerous results have been reported previously in the literature regarding whether smoking parents have significant effects on adolescents' smoking. In sub-study I the Sudanese smoking and tombak dipping parents were found to be strongly associated with their children's smoking and use of smokeless tobacco. Likewise, the sub-studies III and IV showed that the smoking parents influence their kids to use other kinds of tobacco products including EC and snus. These findings are worth noting because they underscore the importance of including other tobacco products, such as water-pipe and EC, when studying the parents' influences on tobacco use of adolescents and in establishing more rules in prevention programmes on promoting positive parental control. Moreover, the Finnish ex- and currently smoking parents, maternal and paternal grandparents were also associated with their children's tobacco behaviour either through the mediating role or by direct effect. Consistent with other studies, it was clear that many factors were most likely involved in the intergenerational transmission of smoking and expressing the child's tobacco use. Children appear to imitate their mothers and grandmothers more than their male family members. On the other hand, the influence of the father was still strong, consistent with previous studies (Melchior et al. 2010) and, not consistent with other studies. (Gilman et al. 2009).

Parents influence adolescents to use tobacco through their own smoking behaviour that might also be explained by other factors, regarding certain theories and social norms. Considering several studies on family factors, a vast majority of research on the family influence, mainly parents, on adolescent smoking was designed to examine correlates, and risk factors; only a few studies, in comparison, considered more factors (Gilman et al. 2009; Tilson et al. 2004; Shakib et al. 2005; Foshee & Bauman 1992; Hill et al. 2005; Bird et al. 2016). Some researchers showed

that the intergenerational transmission of smoking involves multiple genetic and environmental risk factors all together, and that the genetic contribution to the risk of smoking initiation is high. Findings from previous studies, a significant number of twin studies (Kendler et al. et al. 1999; Munafò & Johnstone 2008) on smoking behaviour have identified genetics factors, and have yielded results consistent with the overall conclusion that both genetic and environmental factors contribute almost equally to the risk of becoming a long-term smoker (Swan et al. 1997; Avenevoli & Merikangas 2003; DiFranza et al. 2004). More twin studies on tobacco use revealed that the genetic factors were detected mainly among regular tobacco users, whereas environmental factors explain smoking initiation and the number of cigarettes their children smoked (Kendler, et al. 1999; Heath et al. 1993; Sherman et al. 2009). Findings from more studies showed that the family influences continue when their kids grow older but may be ameliorated by the emergence of additional factors in the environment at any point throughout their life (Flay et al. 1995; Kestilä et al. 2006). There are indeed external factors as well as sociocultural and genetic factors behind the involvement of adolescents' tobacco use, and the exact nature of the extended family and parents influences on tobacco use by adolescents is still limited in our understanding, and, in many ways, inconsistent (Vitória et al. 2009). However, Loureiro (Loureiro et al. 2010) noted that the link between children's and their parents' smoking habits does not reflect only causal pathways, mainly because of the presence of unobserved factors common to all family members, such as shared attitudes towards risks. Thus, more research in the future should consider these factors to uncover the reasons and the mediating mechanisms rather than just testing the simple link between the parents and their children with regards to tobacco use.

Whether the tobacco use by children of smoking parents and grandparents was because of the genetic factors, a result of imitation and sociopsychological factors, or sharing the same environment, or because of the role model or the increased availability of cigarettes, all these elements together indicate that the family plays a big role in children's tobacco use. Regardless of the research design or the methods, most of the research conducted indicates that the self-image of any smoking family members may increase the opportunity for children to obtain cigarettes in the stage of experimentation. Not surprisingly, most of research on tobacco use by family reveals that adolescents are significantly more likely to smoke if their parents smoke, but it has not been examined if all these factors act together or separately. In future research, the complex interaction of multiple family-related factors is also important to consider.

The Finnish sub-study IV found increased risk of smoking uptake in adolescence was detected when at least one parent smoked. Moreover, the risk of an adolescent to be a daily smoker increased almost fivefold when both parents currently smoked, and there was an almost threefold risk for her / him to use other kinds of tobacco products. For the most part, the findings appear to be consistent with previous Finnish studies. For example, in 1983, Rantakallio (Rantakallio 1983) reported that the smoking Finnish family had the strongest association with smoking among 14 years old adolescents in Northern Finland. According to another Finnish study conducted by Pulkkinen (Pulkkinen 1983) in the same year, parental smoking was related to female smoking. However, Kestilä (Kestilä et al. 2006) documented in a Finnish study conducted in 2006 that the determinants of children's smoking behaviour are developed throughout the life course, although children's living conditions in their families are strong determinants of daily smoking. Virtanen (Virtanen et al. 2009) detailed that parental behaviour is associated with all health risk behaviours among both sexes, including smoking. Consistent with other studies, our results support that Finnish children with both smoking parents are at high risk of becoming smokers. Other similar studies outside Finland have examined adolescent smoking behaviours and noted that parental smoking is more strongly associated with regular tobacco use by adolescents rather than with experimentation (Chassin et al. 2000). Although the awareness of EC has been detected to be higher among young age groups with higher income and education in other studies (Adkison et al. 2013), in sub-study III; parents of low socio-economic status were significantly associated with EC experimentation by adolescents, relating back to the influence of the parents on adolescents' use of all types of tobacco and tobacco-related products.

Similar findings were also observed in the Sudanese sub-study I; an increased risk was detected of both smoking and smokeless tobacco use among Sudanese adolescents when at least one parent smokes, and this risk increased when both parents smoke. The tombak dipping parents were also found to be associated with adolescents' smoking and current tombak dipping. However, tobacco use by parents and its relation to their kids remains under-researched in African and Mediterranean regions, other than some scattered studies. Giving an example of the nearest country to Sudan, Ethiopia has maintained a low prevalence of smoking among young people in the years 2007 and 2019 (Rudatsikira et al. 2007; Getachew et al. 2019). Both studies reported that parental smoking has been a risk factor for smoking tobacco among Ethiopian young people. Another study from Gambia (Jallow et al. 2017) revealed that family members played a big role in tobacco use among young

Gambians, and that shisha smoking is common, especially among girls. Moreover, in West Africa, particularly in Ghana, Botswana and Nigeria, recent surveys have found smoking prevalence in these countries to be higher among young adults than some years ago (Blecher & Ross 2013; Mbongwe et al. 2017). Research on African Americans also found that smoking parents played a big role in their children's smoking (Clark et al. 1999).

From the findings of mediation analysis, the direct effect of Finnish grandparents' smoking on grandchildren was 27% for daily smoking (10% for trying smoking). These results indicate that the grandparents' smoking plays a perceptible role in the daily smoking of adolescents. Because it is less likely in a northern European countries, like Finland, for the grandparents to live together with their grandchildren, this may give an assumption that the transmission of smoking from grandparents to grandchildren, may be ultimately genetical or due to a causal mechanism. The grandparents' role in this study is not consistent with a study by Vandewater (Vandewater 2014), who stated that the intergenerational transmission of smoking occurred from grandparents to parents, and from parents to children, but not from grandparents to grandsons. The Vandewater study thus dismissed the direct effect of the grandparents, on the smoking of adolescents, which is contrary to the findings of this study.

### 7.3.2 Residential smoking

More than half of ever smoking young adults and little less than half of shisha users were exposed to smoking in places where they were living, as shown in the results of the Sudanese sub-study II among Health Sciences students. Those exposed were more vulnerable to try smoking, and they were at three-fold risk to be current smokers and two-fold more likely to be shisha users. These findings give a clue about the extent and the importance of the effects of residential smoking on young adults' tobacco use, and not only on children and adolescents. It also indicated that exposure to residential smoking can be one of the main factors behind young people to try their first cigarettes when they were already adults. As was previously stated, tobacco use by young adults poses serious concerns, the data show that current cigarette use among adults was highest among those between 21 to 25 years of age (Berg et al. 2015). Regardless if they were still living with their parents or in a new residence far away from them, or living in hostels near their university, residential smoking is important to consider.

### 7.3.3 Friends and school environments

#### 7.3.3.1 Friends

Adolescents usually belong to a group of friends with whom they have similar attitudes and behaviour and try to experience new things together during the friendship formation (Eiser et al. 1991; Cotterell 2007). Sub-study I found that the older adolescents in secondary school smoke and use smokeless tobacco more than the younger children at primary schools. These findings are consistent with other studies reporting similar findings in that adolescents' smoking increases by age or school year (Faulkner et al. 2000). Out of the same study, apart from the role of parents as influencer in adolescents' tobacco use as described above, the influence of friends was found to be stronger than that of parents, which has also been concluded by other studies (Bauman et al. 2001; Avenevoli & Merikangas 2003). Some researchers stated that parents and friends appear to have independent effects on smoking adolescents, and friends are positively associated more with smoking initiation (Simons-Morton 2004) and dynamic-reciprocal relationships (Simons-Morton et al. 2004). At this critical phase of life, adolescent's smoking is usually initiated using the new substance with new selected friend who is a known user (Poulin et al. 2011). More studies showed that the parents' influence on their children's tobacco use decreases when their children growing with the increasing of other influential factors like friends (Bauman et al. 2001; Scalici & Schulz 2014; Krosnick & Judd 1982). On the other hand, Bauman (Bauman et al. 2001) reported that there were no findings to support that the influence of parent smoking weakens, and the influence of friend smoking strengthens with adolescent age and that parents' and friends' effects do not differ with age. Other researcher noted that parental and best friend's smoking is associated with daily smoking of adolescents and positively with the pocket money amount and living in a home where smoking was allowed (Scragg & Laugesen 2007). Whatever the conclusions of these findings, they highlight the importance of friends in increasing the probability of adolescents becoming tobacco users. However, the results are inconsistent with other research findings (McGee et al. 2015; O'Loughlin et al. 2017; Scalici & Schulz 2017; Ali & Dwyer 2009; Defoe et al. 2016; Mercken et al. 2013).

Other findings from the same sub-study I found that the friend acts as the most influential person for an adolescent to smoke and to dip tombak compared to their parents and teachers. Several studies are in complete agreement about the influence of smokeless tobacco use on smoking and vice versa (Foulds et al. 2003; Ramström



& Foulds 2006). Although the research questions and the findings differ, these studies showed how the two products are connected. If used, one can lead to the use of another, or if the use of one is reduced, it reduces the use of the other, as reported by Swedish study in 2006 (Ramström & Foulds 2006). Moreover, and according to the findings of sub-study I, when at least one friend smokes, there was almost a four-fold risk for adolescents to be current smokers and two-fold to try smoking. Although the reasons behind the effect of friends on adolescence tobacco use vary over time and vary with different design and research questions, almost all researchers agreed that the role of friends is important and should not be ignored. Several studies have suggested the reasons behind the association between the smoking behaviour of friends and adolescents' smoking might be because of modelling by the best friend, or simply sharing information that increases the adolescent's awareness, or actual involvement and guidance (Scalici & Schulz 2017). Friends might increase the awareness of tobacco, or they might be the main or the most important source of tobacco. For instance, in the Finnish sub-study III, the awareness of e-cigarettes, friends were found to be the most important source for e-cigarettes among Finnish adolescents. In addition, Facebook is part of social media where friends are usually chatting and sharing information. Although knowing what e-cigarettes are does not necessary lead to use e-cigarettes per se, but it is an indicator of how important the friends are as a source of harmful information and as influencers. In this respect, sharing information might encourage use.

#### 7.3.3.2 School

School is the arena in which adolescent develop her/his own personality and feel a sense of belonging in the new society. School context in general has high levels of risk behaviours, in which tobacco use is one of the most important risk factors (Russette et al. 2014; Schreuders et al. 2017; Cole & Leatherdale 2014). It is the place where teachers, curriculum, friends, and policies have a critical role in students' behaviour. Young people may start smoking when changing from lower to upper level of school, where anxiety and emotional stress during the changeover are high or there is social acceptance in their new place and environment. On the other hand, school is also the place where students learn more about health promotion, and where students have more opportunities to seek help for their tobacco use behaviour (Langford et al. 2014; Hallingberg et al. 2016). In Sudan, universities and colleges are usually located in big cities, where students have more independence, responsibilities, academic stresses, and a new residence, which may act positively or

negatively. It is also where they meet new friends with different backgrounds, away from direct parental supervision. All these factors creating a new school environment that may influence their behaviour. These school environmental factors are where young people are more susceptible and exposed to learning new things, good as well as bad, and more influenced by others' behaviours than ever before.

### 7.3.3.3 Teachers

While researchers have noted the powerful influences of friends and families on tobacco use by adolescents, there has been less studies about how teachers' behaviour concerning tobacco use within the school environment may affect adolescents. In sub-study I, teachers' use of smokeless tobacco (tombak) was found directly associated with ever-smoking and with the increased risk of using tombak among their students. Although, in the same study, the influences of friends and parents were considered the most important predictors of Sudanese adolescents' tobacco use compared to that of teachers, almost half of the adolescents have seen their teachers using tobacco on school premises, which has also been reported by other researchers (Escario & Wilkinson 2018, Wold et al. 2004). The teachers, like parents, are in a particularly influential position with students and young people, and their behaviour can affect their students in positive or negative ways (Poulsen et al. 2002; Johnson et al. 1998). Similar findings stated that students at schools that allowed teacher smoking were more likely to smoke (Andersen et al. 2019; Trinidad et al. 2005; Kwamanga et al. 2003; Wold et al. 2004; Erick & Smith 2013). A study conducted in seven European countries in 2004 examined adolescent students' exposure to teachers who smoke at school. The results suggested that policies on restriction of smoking among teachers are associated with a decreased probability of students reporting that they are exposed to teachers who smoke on school premises (Wold et al. 2004). Teachers are important concerning tobacco use by students because teachers are regarded as significant role models, especially for children and young students. Adolescents experience paradoxes between schools' anti-tobacco policies and smoking teachers (Spratt & Shucksmith, 2006). For instance, when adolescents see their teacher using tobacco in the school, they internalise the belief that tobacco is an accepted habit and it is not too bad to give it a try (Nilsson & Emmelin 2010, Trinidad et al. 2005; Schreuders et al. 2017). Thereafter, adolescents may ignore the no-tobacco messages and signs in their schools and start to believe that the teachers do not take the anti-tobacco policies seriously (Nilsson & Emmelin 2010; Clark et al. 2002). As a result, they might become regular smokers and smoke

inside school (Wakefield & Chaloupka 2000), especially if they are familiar with tobacco at home (Clark et al. 2006; Wium & Wold 2006). In a previous study (de Moor et al. 1992), no links were detected between teachers' smoking and girls' smoking. Another study noted that the role model of a smoking teacher was found to have more negative effect in reducing smoking compared to non-smoking teachers (Higgins et al. 1983). A most recent study in 2019 stated the importance of teacher and school staff in that they can play a key part in improving the effectiveness of school tobacco policies with strict enforcement (Linnansaari et al. 2019).

#### 7.3.3.4 School tobacco policies

Were made to stop students from using tobacco inside and around school buildings during school hours in order to protect students and school personnel from the harmful effects of tobacco and second-hand smoke (Coughlin et al. 2015; Thacher 2017; Frazer et al. 2016). Acknowledging the different definitions and variations of these policies across studies and countries (Schreuders et al. 2017; Fallavollita et al. 2020), sub-study II captured the student awareness of their school's anti-smoking policies and its effect on their tobacco use. Although we did not have a clear written policy that was administratively approved by the school board at the time of the survey, the students' self-reports about banning, restriction and enforcement of smoking, reflect the existence of school policies either as signs or messages forbidding smoking. The sub-study II findings showed that students were aware of the policies and school rules concerning tobacco use, whatever the source of their knowledge. The tobacco user participants' self-reports showed their awareness about policies in their schools, instead of that more than half of current smokers and one out of five of current tobacco dippers had smoked or dipped on school premises. Their awareness of policies did not stop them from smoking or dipping tobacco on the campus, and not only that, the tobacco users were found to be more aware of the existence of policies than the non-users, and nonetheless abused the policies. The awareness of students about restricted zones is explainable for shisha users, as it might not be practical for them to use shisha inside school because of the size of the shisha tools and the strong aroma of the tobacco that is usually used for shisha smoking. The reverse applies to dippers, as they could hide their dip inside their mouth without being seen and it can be kept hidden for long time, even inside the classroom, and then spit it out after one full class period.

Students' use of tobacco on school premises indicates that policies were either not well implemented or not strongly enforced, as weak enforcement allows students

to smoke on school premises (Turner & Gordon 2004). Researchers have noted that for policies to be successful depends on their implementation (Schreuders et al. 2017) and on strict enforcement (Watts et al. 2010; Turner & Gordon 2004). The reasons why young adults in this study continue using tobacco on school premises is not clear and needs more studies. Students' smoking and dipping inside schools were an indication of students' noncompliance with the policies, which is striking and against the schools' authorities (Do et al. 2020; Clark et al. 2002; Turner & Gordon 2004, Braverman et al. 2018). One possible explanation is that the university students, compared to younger students, have no fears if they get caught or are sanctioned for violating the policy (Paek et al. 2013).

The current tobacco users among Health Science students who smoked and dipped on school premises might be explained by the situation that those who are regular smokers and dippers have developed nicotine dependence. Since they usually have long school hours and lectures that require them to stay on campus, the need for nicotine by addicts to smoke or dip may explain their behaviour inside schools. While it may be difficult for them not to smoke or dip at their school, it is possible that their addiction can be controlled by school tobacco prevention strategies and counselling support. Although nicotine addiction was not detected in this study, a study by Soteriades (Soteriades et al. 2003) noted that students who are nicotine dependent tend to violate the school tobacco policies more often than those who are not. Another possible reason was that the school policies were not strongly enforced, which is the most likely explanation in this study (Paek et al. 2013; Clark et al. 2002; Turner et al. 2004).

#### **7.3.3.5 Academic achievement**

One of the most important findings of the Finnish study III is that smoking is higher among adolescents with low academic performance. The reasons were not detected and not known, nevertheless there might be some factors behind their lower academic level that forced them to smoke or to use any other substance. For instance, the psychological effects at schools' level, like academic stress, smoking family member (Simons-Morton et.al. 2004) low family socio-economic background (Ali & Dwyer 2009; Luthar et. al. 2005) and peer pressure, might be the main reasons behind the low academic performance associated with using tobacco. Many studies stated that poor academic performance is associated with a greater risk of smoking initiation (Robert et.al. 2019; Bradley & Greene 2013). On the other hand, the

increasing of using EC may be an indication that the Finnish adolescents simply like trying something new.

### 7.3.4 Gender-specific differences

Differences in tobacco use could be gender-specific, and significant discrepancy in tobacco behaviours in females and males should be considered carefully (Andrews 2005; Schinke et al. 2008; Arndorfer & Stormshak 2008). In the four sub-studies, tobacco use by sex was tested. Most of the results indicated that boys are more likely than girls to be using tobacco. The differences in the prevalence of smoking and daily smoking were very close between girls and boys among Finnish adolescents, along with the use of other kinds of tobacco products, although boys were obviously more predominant than girls in using snus and water-pipe. That gap of differences is close when they reported the use of E-cigarettes alone. Recently, some researchers have noted that girls are closing this gap of the differences in using tobacco compared to boys and might soon tip the balance of young women smoking at a higher rate than young men (Fernández et al. 2003; Schiaffino et al. 2003). The gap in gender use of tobacco was already close in some countries like Germany and Denmark, where the prevalence of smoking is even higher among girls than boys. On the other hand, the gap of gender differences regarding smoking and dipping tombak among Sudanese adolescents is wide between girls and boys, and wider in using smokeless tombak. This could be explained by the fact that using tombak in Sudan is less prestigious among girls and university students in general; it was considered as lower-class behaviour although accepted socially. The increase of shisha use among Sudanese women at younger age has been observed recently in beauty salons and some cafes, with increasing selling of shisha instruments and tobacco to girls in the market (unpublished data).

The differences regarding the gender of adolescents in other variables, including the influence of parents and grandparents, were considered well in the Finnish part of this study. In sub-study IV, ex- and currently smoking parents and grandparents were observed to have effects according to sex of adolescents, with a stronger effect on girls. The currently smoking mothers influenced daughters (fivefold) more than sons (approximately threefold); only the boys were more likely to try smoking when their mothers were ex-smokers, but the girls were not. On the other hand, same as mother, the effect of a currently smoking father is more likely to affect his daughter to be daily smoker than his son. It seems the Finnish girl is more vulnerable to smoke

and to mimic both parents than boys. The findings of this study are the same in some respects, although different in other respects, with other research findings regarding gender congruence. Quite a number of researchers in tobacco have documented that patterns of smoking behaviour do significantly differ by gender, with more evidence of the same sex of child and parent links existing. Loureiro and Hill (Hill et al. 2005; Loureiro et al. 2010) reported that adolescents may draw stronger conclusions about normative behaviour from their gender-congruent parent, and that mothers play a more crucial role in determining their daughters' smoking decisions, whereas fathers' smoking habits are primarily imitated by their sons. Lee and Hughey (Lee & Hughey 2001) stated that parents' risk behaviour influences boys more, whereas conflictual independence from opposite-gender parent operates as a strong predictor of their smoking behaviour even later when they grow up as young adults in college (Lopez et al. 1989). A meta-analysis study conducted in 2010 analysed 57 studies (published between 1989 and 2009) and concluded that mother's smoking influences girl's smoking more than boys (Sullivan et al. 2011).

In this study, the results from grandparents concerning their grandchildren's gender indicated that the maternal grandmother has her influence on the granddaughter more than the son; conversely, the paternal grandmother exerted more influence on her grandson. The Finnish paternal grandfather's current smoker status has strong effect on granddaughters to use tobacco but had no effect on grandsons. In contrast, the paternal grandmothers, whether they were ex- or current smokers, showed threefold risk to influence their grandsons to be daily smokers, which was more than their risk for their granddaughters. These results can be compared to a study conducted by Duarte in Spain (Duarte, 2016), which reported that grandparents' smoking significantly increases grandsons' smoking but does not influence granddaughters' smoking.

In summary, the four sub-studies comprising this thesis confirm the importance of several factors known to affect the tobacco use behaviour of adolescents and young adults. The studies here advance what has been found previously by stratifying the importance of several key variables and by showing that the factors that influence youth behaviour to smoke cigarettes also influence the use of other forms of tobacco, including shisha and e-cigarettes. Family and friends' model and facilitate tobacco use behaviour, but parents have more influence than grandparents, and at the age of adolescence, friends have more influence than parents. Teachers and school policies have the potential to deter tobacco use, but only if practices and policies are made clear to students and enforced.

## 7.4 Methodological consideration

### 7.4.1 Study design, self-report data

In general, observational studies serve a wide range of purposes, but due to their cross-sectional nature, studies are susceptible to various forms of biases. For instance, methodologically and compared to cohort studies, it is difficult in cross-sectional studies to give explanations. Cross-sectional studies only present associations that do not explain causal inference (Levin 2006; DiFranza et al. 2006). For example, regarding friends and peer association concerning tobacco use, many studies have used prospective research designs, which allow the researcher to determine if friends' use of tobacco predicts future use by adolescents. Such studies provide stronger evidence of causality than cross-sectional associations (Simons-Morton et al. 2010). Cross-sectional limitations on data analysis cannot reach more detailed knowledge about processes that influence tobacco use. All data used in this study were cross-sectional and thus limited in the extent to which they could determine causality.

In addition, all data used in the four studies compiled here were based on self-reported information, except for the sample-based demographic information of Finnish data (age, sex, and place of residence). Self-report is subject to respondent recall and deliberate misreporting. The participants may have failed to report the required information accurately due to a variety of reasons. Under-reporting or over-reporting can arise from social desirability and recall bias that may have influenced participants' answers (Brener et al. 2003). Yet, self-report has been shown to be reliable under optimized measurement conditions that assure anonymity with efforts to improve validity of tobacco-related surveillance and research (Dolcini et al. 1996, Caraballo et al. 2004). Self-reports are the most extensively used method in smoking studies, and concerns are frequently raised about the reliability of data obtained, particularly when the data collected among adolescents are from prospective longitudinal studies (Stanton et al. 1996). Some studies have indicated that the adolescents in general give valid reports of their own tobacco use (Post et al. 2005), and if care is taken in the construction of the questionnaire, self-reports generally produce reliable outcomes of participants as young as 8 to 11 years (Henriksen & Jackson 1999). Moreover, smoking status of the parents and the grandparents, as well as occupations or educational levels, were reported by their children. Some researchers suggest that adolescents could not accurately report about their families,

and thus recommend double informants on family behaviour to improve the validity of the results (Currie et al. 1997). Friends' and teachers' tobacco use behaviour was also measured from reports of adolescents. This introduces a greater degree of measurement error than if it was directly reported by the users themselves. Other studies, such as the one conducted in Holland by Harakeh (Harakeh 2006) have demonstrated that adolescents aged 13-17 years are reliable sources for providing accurate and reliable reports on their parents' smoking status.

The author of this study believes that the findings from both the Sudanese and the Finnish data, regarding self-reports about significant others, are valid, and the adolescents in this study are considered the most appropriate source of their families', friends' and teachers' tobacco behaviour.

#### 7.4.2 Response rate

Response rate is important to the validity of any study. Concerning the response rate (68%) in the Sudanese Health Science student sub-study, the students who were absent on the day of the survey (32%) were not followed. They may have given a different response to the questionnaire in term of tobacco use (Criqui et al. 1978; Groves & Peytcheva 2008) from those present at the time of the survey. Although the extent of truancy might underestimate the prevalence of tobacco use, there was no reason to suggest that their absence was linked to their tobacco use behaviour. However, a weighting factor was applied to each student record to adjust for non-responses and for the varying probabilities of selection. Therefore, the author of this study does not expect that the non-response rate of the Sudanese students had a major role on influencing the results of this study. On the other hand, the major concern and challenge of the Finnish data was the declining response rate trend. The response rate of the AHLS data used in the present study was low (38%), which may introduce bias and/or underestimate the results. To assess the potential for bias due to non-response, the non-response data analysis was carried out and showed that the non-response data did not differ from the study data in the background variables of gender and family type. Generally, declining response rates have been common in tobacco surveys (Biener et al. 2004). Therefore, within that context, the results can be generalized to the sample and the target population and to other countries with similar socio-cultural profiles (Saver et al. 2012; Diem 2002).



### 7.4.3 Consideration of other measures

The socio-economic status (SES) in Sudanese sub-studies was not measured, as the questions of SES of the family and the participants were not asked in the questionnaires delivered for the eligible applicants. These questions were present in the questionnaire at the pre-test phase; they were deleted from the final version of the questionnaire after the pilot study that was completed before implementation. Since most of the pilot participants were not able to answer and 70% skipped the questions about the basic income, even after the modification that was carried out, they lack the most basic information to answer, and the question was hence dropped.

The author of this study speculates that the reasons for skipping SES questions might be because in low-income countries, like Sudan, the level of income of the family is not clear for most of the other family members, including their children, especially the poor families with low-level of education, and those living all together in an extended family sharing the same household and income. The workers usually work and earn money on a daily basis, which may vary between days and between the family members, and it is thus difficult to calculate the sum per month. Earned income may be pooled among all family members. In general, the real household income, as well as the size and area of residence, is not easy to report in a country like Sudan, especially in rural areas.

It is important to measure the SES of the families as indicators to explain the current health behaviour of young people, as well as their tobacco use status. Research has shown that adolescents are aware of the socioeconomic health inequity (Hagquist 2007), and they can correctly classify the status of their parents since smoking is generally an easily observed behaviour (Pomerleau et al. 2005). This socioeconomic inequality is difficult to change at the country level, and family structure has also changed accordingly. Therefore, parents' and families' occupational categories, in the future surveys, can be divided into different categories based on certain criteria. This provides important clues on how questions could be improved in the future questionnaires, using different indicators for the developing world. Although important, the author believes including SES would not affect the outcome findings of this study.

### 7.4.4 Variables

Additional factors should be considered when looking at the methods and definitions of the variables of the Sudanese and Finnish studies presented in the four

sub-articles. The definitions of certain concepts and measurements were pointed out in the text above and elaborated more in tables (Table 5 & 16). The tables show the differences and similarities between the three data sets and the definition of each variable. For example, there is variation in the definition of smoking variables and the exact tobacco products in the terms of other kinds of tobacco products compared to those that have been used by the WHO-based Sudanese study.

#### 7.4.5 Validity, reliability & strengths of the study

Despite the limitations of the three data sets described above, several strengths should be mentioned and considered. In addition to the strengths of the results presented in the four articles, the present study represents a significant step toward a better understanding of young people's tobacco use in Sudan and Finland, providing valuable information for future prevention and intervention programs targeting adolescents' and young adults' tobacco use in both countries.

- The Sudanese surveys used methodology that minimised the likelihood of selection bias. The anonymity and confidentiality at the time of data collection improve the reliability of this study. The questionnaire applications were anonymous, with no need for personal identification, to maintain the participants' privacy and responses, and to avoid a further possibility like fear of parents, teachers, and principals accessing or handling the data. This number of aspects of bias were considered when designing the questionnaire either by CDC, WHO and MOH in the Sudanese study.
- Before implementation, the Sudanese research coordinators, including the author of this study, and the research committee who were experts on questionnaire development, together with an expert epidemiologist, read the original WHO questionnaires to understand and evaluate the topics and the questions. The purpose of the committee meetings was to find out whether the questions suit the cultural sensitivity of the country or not, and to modify and edit the questions accordingly either by removal of or/and replacing or adding new questions, as it is allowed for the participating countries to modify the core-questionnaires based on their needs. The same committee re-evaluated the questions after the changes had been made to check if all questions were effectively capturing the topic and the aims. Second, the questionnaires were originally in English and later translated into Arabic by an expert team. They were then back translated into English by an independent professional person

who was not part of the first translation team or study, to check for validity and to avoid bias and/or misunderstanding. The third step for validation was to pilot test the survey to determine clarity of questions and to ensure feasibility of administration and the accuracy of translation. The sample size for pilot testing varied between the two surveys, in the two different years of the conduction. The two surveys underwent minor changes after being piloted, with some questions omitted and some added or modified. After incorporating the corrections, the final sets of questions and the exact completion time were considered to be clean and ready for use.

- The two Finnish studies were a part of Adolescent Health and Lifestyle Surveys (AHLs). The survey monitors a wider range of adolescents and is repeated every other year. The timing, sampling, and the methodology of data collection have remained unchanged and maintained similarly throughout the study period to control the comparability of the repeated survey data. Since 1977, extensive data have been produced. The long follow-up of the surveys over years give strength to the findings obtained from this study. To assess the reliability of the questions for some studies, in earlier years, the self-reported data was studied by sending the same questionnaire at one-month intervals to select sub-samples adolescents from the original subjects by systemic sampling technique. The nationally representative samples (age, sex, place of residence) were always obtained from the Population Register Centre, which is accurate.
- One of the most important strengths of this study is the measurement of different kinds of tobacco use. This study provides additional observed evidence of the influence on tobacco use by parents, grandparents, friends, and teachers on the daily use and initiation of smoking and smokeless tobacco as well as tobacco-like products by adolescents. In addition, it considers the effects of school smoking policies and residential smoking on the tobacco use behaviours of university students.
- The Finnish study about smoking transmission across three generations is unique because of the large sample size of the data on the entire maternal and paternal grandparents that ensures reliability. Our assessment was based on six predictors, including the parents (father and mother), and grandparents (both maternal and paternal), that provide exceptional details and elaborating more about the impacts of family smoking on children. Examining the use of varied tobacco products and their associations; make this study unique.

## 8 CONCLUSIONS AND IMPLICATIONS FOR FUTURE DIRECTIONS

- The findings of this study indicated that the effects of family, friends and school concerning tobacco use influence the youth to use different kinds of tobacco products, which provides a strong basis for the development of prevention programs. The results indicated that the use of various types of tobacco is associated with different individual characteristics and different environmental contexts. It was also found that the cigarettes smoking by families and friends influenced the adolescent to use smokeless tobacco and conversely, students' use of smokeless tobacco can lead to smoking cigarettes. For research pertaining to the behavioural health of adolescents and young people, policymakers need to understand the importance of including all kinds of tobacco in their program. Those running prevention programmes should keep in mind the importance of all major kinds of tobacco, if possible. Based on that, future studies investigating cigarettes smoking should consider the effect of other tobacco products and tobacco-like products, and vice versa.
- In general, none of the parents want their child to use tobacco. Nonetheless, family and parents play an important role in influencing their children's tobacco use; they are directly and indirectly influencing these risks. Adolescence is a period of life and the most intrinsically perilous phase between childhood and adulthood, during which parents' and grandparents' and other family members' smoking behaviour is a key factor in youth smoking, and the likelihood of youth smoking is significantly increased when one of them smokes, specially parents. This study reflected how important grandparents are in influencing the tobacco use of their grandchildren, so in the future research and policy studies, their role should not be ignored. Parents can also act as protective factors, in supporting their adolescents quitting the behaviour and act as role models. Parents can build a good relationship as their children grow older and act as an adviser with respect to tobacco use and when their child is hanging out with friends who use tobacco products at their schools or neighbourhoods. They can also collaborate with their child's school members and participate positively in prevention by their ideas and physically by attending parent meetings. By involving parents in school

tobacco strategies, parents can develop more skills in how to communicate with their children concerning their behaviour.

- The findings from this work show strong evidence of gaps in policy recommendations and implementation. Students' awareness of the existence of official smoking policy did not appear to stop students from using tobacco on school premises. The Sudanese findings show that there is clearly strong evidence of gaps in the school tobacco policy implementation. Schools can have a significant role in preventing tobacco use on premises and in the nearby outskirts of the school's buildings by emphasizing students' tobacco use attitudes and behaviour for every form of tobacco products, not only cigarette smoking, by enforcement of school anti-tobacco policies and evaluation of the program. Tobacco prevention education should be implemented in the context of policies. Tobacco prevention is the responsibility of all stakeholders, the staff working at the school, the community, and the parents.
- Another important lesson is for the teachers to act as role models, not to smoke or to use smokeless tobacco in or around schools. They should be aware of the potential consequences of their behaviour. Therefore, the teachers and school personnel should be included in studying tobacco use behaviour when conducting research among school-going adolescents, together with inclusion of teacher tobacco use as one of the important factors influencing the adolescents' tobacco habits.
- Schools could advocate for tobacco use prevention among adolescents in schools by adding tobacco prevention education to the school health curriculum. This should include the health consequences of smoking and using smokeless tobacco, and adding the other forms, like shisha and e-cigarettes, to the topics rather than concentrating only on smoking cigarettes.
- Health care providers at schools should also be involved and advise adolescents about the dangers of nicotine and discourage tobacco use in any form. Such policy programmes can be very effective, if carried out correctly. A tobacco free policy will be most effective when it includes all stakeholders at school, with, for instance, engagement of students' union (if any) or/and senior students, in the development of anti-tobacco policies and messages. Involvement of students in setting the policies and prevention strategies will enable the administrators to better understand the reasons behind their smoking behaviour on school premises and their compliance. They can also participate in the programmes that are important in building their positive skills in prevention and control to reduce

the risk of tobacco use. By involving students, they can easily develop awareness of health promoting behaviour, including tobacco health consequences.

- The findings about the association of the poor academic achievement and tobacco use warrant attention, as non-academic orientation and low school performance predict smoking (Pennanen et al. 2011). Based on these findings, there may be other factors that increase vulnerability to tobacco use that schools and parents should be aware of. The teacher and the welfare personnel should be encouraged to guide the poor academic student who started to smoke to seek help. Especially when students use tobacco on school premises, it may be an indication of tobacco dependency. Building the self-efficacy enhancement of the young students is very important, as it could be possible through motivation, health education and promotion to increase their self-esteem. Interventions might be important to be directed at the peer group and relationships; adolescents should also be well-prepared and made aware of the effects of peer smoking behaviour and how to choose a positive relationship. Future research could extend the line of investigation by examining the behaviour with a data at a finer level of detail to build strong tobacco use prevention strategies. In summary, poor academic achievement appears to have had a significant negative effect on the smoking habits of adolescents. Schools must find the reason behind the students' poor performance and then address and resolve the issues.
- In the last few years, Western countries have seen a marked decline in smoking among adolescents, except for e-cigarettes. Tobacco companies' expansion is aggressively targeting adolescents, and e-cigarettes seduction for use are widely advertised in the internet to continue recruiting more users. Based on that, it is important to advise adolescents to be aware of the misleading advertisements and not to accept the free gifts tobacco companies are using to especially target youth. The new growing epidemic of e-cigarettes is dangerous, especially for adolescents. Without comprehensive tobacco prevention and control policies considering e-cigarettes, water-pipes and smokeless tobacco in specific advertisements, the efforts to recruit adolescents to use other forms of tobacco might have far reaching effects. Unless action is taken soon, the increase will be similar to the widespread use of cigarettes. The recent findings of e-cigarette vaping associated with lung injury in America suggests caution, and more regulation should be implemented before it is too late, especially in young adolescents and before an epidemic of e-cigarette use arises.
- Finally, much work remains to be done with current tobacco strategies in both high-income countries like Finland and low-income countries like Sudan to

support the young people in having healthy behaviours. The rate of tobacco use in the developed world has decreased. More work is needed to stop tobacco companies by regulating their distribution or raising taxes for consumers. Fighting tobacco companies is not a single process; it is a web of processes that should be enacted together, in both developed and developing countries. This might take a long time to achieve because tobacco companies will always find a way to keep their trade going by invading new areas in different countries with new creative strategies. Countries of all income levels and geographies must work together, and prevention must span all age groups, collaboration is essential.

## 9 ETHICAL CONSIDERATIONS

Before conducting the Sudanese study, permission was obtained from Federal and State Ministries of Health, Ministries of Basic and High Education, the university authorities' board, the Dean of each school / faculty and from the principal of the selected primary and secondary schools. The entry point for conducting the student survey for each school was through a designated faculty member to identify the student subject pool, and from the superintendents and school authorities. The contact persons and the representative persons from State Ministry of Health informed the students about the survey and obtained their consent and confirmed that participation was voluntary and anonymous. This process involved explaining the purpose of the research, and why they had been selected; the students were given the chance to ask questions prior to the distribution of the questionnaires. No written permission was required of individuals at the age of 18 and above; their consents was obtained verbally, for those who were 17 years old or less; parental consents were requested. Since the questionnaires were anonymous, they were labelled before distribution with Identity numbers (ID) identifying schools and classes. Completed questionnaires were returned in a sealed envelope, which were collected by the research team on the day of data collection. The CDC-Atlanta, WHO-EMRO, SFMOH and KMOH were informed about using the data for research.

For the Finnish data, the Ethics Committee of the Tampere region approved the study protocol considered an adolescent's consent to participate, and no parental consent was needed according to the Ethics Committee. The participation was voluntary.



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## PUBLICATIONS



# **PUBLICATION**

## **I**

### **The role of parents, friends and teachers in adolescents' cigarette smoking and tombak dipping in Sudan**

Salma El-Tayeb El-Amin, Bright Nwaru, Ibrahim Ginawi, Paola Pisani,  
Matti Hakama

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## Research paper

# The role of parents, friends and teachers in adolescents' cigarette smoking and tombak dipping in Sudan

Salma El-Tayeb El-Amin,<sup>1</sup> Bright I Nwaru,<sup>1</sup> Ibrahim Ginawi,<sup>2</sup> Paola Pisani,<sup>3</sup> Matti Hakama<sup>4</sup>

<sup>1</sup>Tampere School of Public Health, University of Tampere, Tampere, Finland

<sup>2</sup>College of Medicine, University of Ha'il, Ha'il, Saudi Arabia

<sup>3</sup>Cancer Epidemiology Unit, University of Torino, Torino, Italy

<sup>4</sup>Finnish Cancer Registry, Helsinki, Finland

## Correspondence to

Salma El-Tayeb El-Amin, Tampere School of Public Health, 33014 University of Tampere, Tampere, Finland; [salma.el.amin@uta.fi](mailto:salma.el.amin@uta.fi)

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## ABSTRACT

**Objective** To assess the influence of smoking and tombak (local smokeless tobacco) dipping by parents, teachers and friends on cigarette smoking and tombak dipping by school-going Sudanese adolescents.

**Methods** This was a school-based cross-sectional survey was conducted in 2005–2006. Logistic regression was used for the analysis. A total of 4277 Sudanese school-going adolescents (aged 11–17 years) from 23 schools who completed an anonymous self-administered questionnaire on the use of tobacco products. Main outcome measures were self-reported tobacco use during the previous month defined current tobacco use. Ever smoking, tombak dipping and other tobacco products were also considered as outcomes.

**Results** After adjusting for sex, age and school grade, adolescents' smoking habits were strongly associated with the habit in their parents and friends and, more weakly, with tombak dipping by teachers. When adjusted for each other, the association with smoking in friends was unaffected and remained significant (prevalence OR (POR) of having ever smoked was 1.94, 95% CI 1.64 to 2.29; OR of being current smoker was 3.77, 95% CI 2.80 to 5.07). Tobacco smoking in friends was positively associated with adolescents ever tombak dipping (POR 1.81, 95% CI 1.41 to 2.33) and current dipping (OR 3.33, 95% CI 2.20 to 5.05). The association with parental habits was reduced but still significantly elevated. Tombak dipping by teachers was only associated with adolescents ever tobacco smoking.

**Conclusions** Tobacco use by parents, teachers and friends was associated with adolescents' tobacco habits. The influence of friends was the strongest. In developing programmes against adolescents' tobacco habits, there is need to target the influence of these 'significant others'. Sudan needs to develop and implement comprehensive anti-smoking and anti-tombak dipping legislation to reduce the growing prevalence of such habits.

## INTRODUCTION

Tobacco use is the foremost preventable cause of premature death worldwide.<sup>1</sup> Currently, approximately 5.4 million people die each year due to tobacco-related illnesses. Unless current trends are changed, this figure is expected to increase to more than 8 million a year by 2030, and the vast majority are projected to occur in the developing world as the tobacco industry is steadily relocating to these countries due to tighter regulation in the developed world.<sup>1–2</sup> Thousands of adolescents smoke their first cigarette and become daily smokers each day.

Unfortunately, many of these adolescents will become addicted before they are old enough to understand the risks and life-threatening health consequences associated with tobacco use.<sup>3</sup> This is a major challenge in Sudan, where the majority (41.7%) of the population is under 15 years (Sudan National Health policy, 2006). The current implementation of the WHO Framework Convention on Tobacco Control in Sudan is below expectation. There is also no official tobacco control policy specifically targeting adolescents in Sudan.

Parents may influence the likelihood that their child will smoke cigarettes through their own smoking behaviour.<sup>4</sup> Having smoking friend(s) has been considered the most important factor influencing the habit in adolescents in the Western world.<sup>5</sup> Moreover, the impact of parents is assumed to be more important for young children, while the impact of friends is believed to be more important for adolescents.<sup>6</sup> The theory of planned behaviour suggests that approval of smoking by friends, parents and other key persons, for example teachers, is likely to increase the probability of smoking through the imitation of powerful role models.<sup>4</sup>

Unfortunately, among health-damaging habits, cigarette smoking and tombak (local smokeless tobacco) dipping are socially accepted behaviours among adults in Sudan. Cigarettes and tombak are cheap, openly advertised and sold in small shops on the streets. Most users dip tombak between the lower lip, vestibule and the gingivae. Epidemiological and laboratory studies have shown that the use of tombak is associated with increased risk of cancer of the oral cavity, and it is suspected to be associated with neoplasm of the salivary glands.<sup>7–9</sup> In Sudan, little information exists on the prevalence and determinants of smoking and tombak dipping among adolescents. The prevalence estimate of tobacco smoking recorded from the 2001 Global Youth Tobacco Survey (GYTS) was 20%.<sup>10</sup> No study has examined tombak dipping among adolescents in Sudan, or focused on the influence of teacher and parental tombak dipping on adolescent smoking and dipping behaviours. The present study was aimed at assessing the influence of smoking and tombak use by parents, teachers and friends on the use of tobacco among Sudanese adolescents in Khartoum State.

## METHODS

The present study was conducted within the framework of the Global Youth Tobacco Survey

(GYTS) while the questionnaire was modified to the Sudanese context. The GYTS was initiated by the WHO, US Center for Disease Control and Prevention (CDC) and the Canadian Public Health Association to monitor tobacco use, attitudes about tobacco use and exposure to secondhand smoke among students aged 13–15 years. The goal of the GYTS is to enhance the capacity of countries to design, implement and evaluate their national comprehensive tobacco action plan.<sup>11</sup> The Sudanese GYTS was carried out among school students, recruiting adolescents of grade 8 of basic and grades 1 and 2 of secondary schools. The school education system in Sudan comprises 8 years of basic education and 3 years of secondary education.

### Sampling and subjects

A two-stage sampling technique was used to produce representative samples of students in grades associated with ages 13–15 years. At the first stage, primary sampling units were schools that were selected with probability proportional to the number of students that were enrolled in the specified grades. At the second stage, classes within the selected schools were obtained by random selection. All students in the selected classes were eligible to participate in the survey regardless of their age. In the sampling, weights were applied to effectively resize the sample so that it was representative of the population.

The survey targeted school-going adolescents throughout Khartoum State. The state was divided into seven areas, from which the schools were selected according to their enrolment sizes. The number of the schools and classes were different from area to area due to school size differences. We sampled 15 basic schools and 10 secondary schools. Two of the basic schools were closed at the time of the survey, hence were excluded. This gave a final number of 23 schools.

Permission to conduct the study was sought and obtained from the Ministry of Basic Education and from the superintendents and school authorities in Khartoum State. The principal of the selected schools or the contact persons and the representative persons from State Ministry of Health informed the students about the survey and obtained their consent, and confirmed that participation was voluntary and anonymous.

### Measurements

We retained the 56 questions from the GYTS questionnaire and added 12 new ones to address use of local tobacco products, namely tombak; the questionnaire was designed without skip patterns to allow all respondents to answer all questions.

The questionnaire was translated into Arabic and reverse translated into English to check for validity. Questions were formulated to suit local cultural sensitivity. The questionnaire underwent pilot testing among 120 subjects before implementation. Sudanese research coordinators trained the leaders of the field groups, who were responsible for data collection.

The survey was conducted in school year 2005–2006. The questionnaires were distributed to students attending classes and were completed during class time under the supervision of specifically trained research staff; teachers were not present. Completion lasted about 45 min. Since the questionnaires were anonymous, they were labelled before distribution with ID numbers identifying schools and classes.

### Exposure and outcome measures

The questionnaire covered adolescents' personal characteristics (age, sex and school grades) tobacco habits (smoking and dipping tombak) of parents and friends, as well as tobacco use by teachers at school. The tobacco habits of parents, friends and

teachers were assessed according to the adolescents' responses. Ever tobacco users include those who had tried to smoke cigarette or dipped tombak at any time in the past (even one or two puffs/dips). Current tobacco users represent those who had smoked/dipped tobacco products on 1 or more days in the preceding month of the survey. Other tobacco products include other tobacco products other than cigarette smoking.

Tombak is a locally made tobacco, always processed into a loose moist form, and its use is widespread in Sudan where it has been used for over three centuries. It is of the species *Nicotiana rustica* and the fermented ground powder is mixed with an aqueous solution of sodium bicarbonate. The resultant product is moist, with a strong aroma, and is highly addictive. It grows in silky or sandy soils in Northwest Sudan.<sup>12</sup> It is very cheap in Sudan, about five times cheaper than cigarettes. Currently, tombak is sold in small plastic bags each containing about 100–150 g and one bag can be shared by 5–8 students in one sitting. It is also easy to hide the dip inside the mouth ('suffa'), thereby making it easier to be used, and one packet can be shared among friends. In Sudan it is a common belief that tombak is less harmful to users than smoking; therefore smokers who quit cigarettes often become tombak users. Some of the questions on tombak included in the questionnaire were:

1. Have you ever tried or experimented with tombak, even one or two dips? (Yes/No)
2. During the past 30 days (1 month), on how many days you did you use tombak?
3. Do your parents use tombak? (None/Both/Father only/Mother only/I don't know)
4. Do any teachers use tombak inside the school? (Yes/No)

### Data analysis

Data analysis was performed using SPSS V16.0 for Windows (SPSS, Chicago, Illinois, USA). The  $\chi^2$  test was used to examine factors related to adolescents' behaviour (table 1). Logistic regression analysis was used to study the association between tobacco use by parents, teachers and friends (explanatory variables) and adolescents' tobacco use (outcome variables). Results from logistic regression analysis are presented as ORs with 95% CIs. Two adjusted models were created: in the first model, the association between each of explanatory variables was adjusted for adolescents' age, gender and school grade; in the second adjusted model, the tobacco habits of parents, friends and teachers were simultaneously included in the model containing adolescents' age, gender and grade at school.

## RESULTS

### Basic characteristics of the study population

The school response rate was 100%. The student response rate was 93%. Non-respondents were those absent from school the day of the survey. A total of 4277 questionnaires were collected; 41% were completed by girls, 53% by boys and 6% did not reveal their sex. The majority (66%) of the respondents were between 13–15 years. About 24% of the participants reported that they had ever smoked a cigarette and 7.5% described themselves as current smokers. Ever tombak users were 8.1%, 3.5% were current users and 12% stated that they use other tobacco products. About 17% of the respondents reported that at least one of their parents was currently smoking, while 14% said either of their parents was currently dipping. According to their reports, 41% of them said some or most of their friends were currently smoking, whereas 44% saw at least one of their teachers dipping tombak when at school. A higher prevalence of ever smoking, tombak dipping, current smoking and current



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**Table 1** Characteristics of the participating students in relation to their tobacco habits

Variable	Total (N=4277), % (n)	Ever smokers, % (n)	Current smokers, % (n)	Ever tombak* dippers, % (n)	Current tombak* dippers, % (n)	Use of other tobacco products, % (n)
Sex						
Women	41 (1740)†	13 (222)†	2.7 (46)†	3.5 (60)†	2.1 (35)†	11 (185)
Men	53 (2270)	33 (719)	11 (251)	13 (287)	5.2 (116)	12 (269)
Missing	6 (267)					
Age in years						
≤12 years	7 (306)†	27 (76)†	7.3 (21)†	15 (43)†	7.1 (21)†	29 (82)†
13–15 years	66 (2831)	23 (622)	6.4 (178)	7.5 (209)	2.7 (74)	9.1 (245)
≥16 years	21 (909)	31 (268)	11 (100)	12 (106)	6.6 (59)	15 (131)
Missing	6 (231)					
School grades						
Basic (8th)	21 (902)†	20 (68)†	5.9 (52)†	7.4 (66)†	4.3 (38)	17 (149)†
Secondary first	37 (1595)	25 (380)	7.1 (111)	8.4 (132)	3.4 (53)	11 (162)
Secondary second	34 (1461)	28 (392)	9.3 (132)	10 (146)	4.2 (60)	10 (140)
Missing	8 (319)					
Parents smoking						
None of them	80 (3401)†	22 (725)†	7 (217)†	8 (281)†	4 (119)†	12 (377)‡
Either of them	17 (719)	36 (246)	12 (87)	11 (77)	5 (32)	15 (102)
Don't know	2 (69)	36 (23)	11 (7)	16 (11)	13 (9)	16 (10)
Missing	2 (88)					
Parents dipping						
None of them	82 (3510)†	24 (799)†	7 (238)†	8 (275)†	3 (112)†	12 (401)
Either of them	14 (597)	29 (167)	11 (65)	14 (82)	7 (38)	14 (77)
Don't know	1 (39)	46 (17)	6 (16)	6 (15)	6 (15)	11 (4)
Missing	3 (131)					
Friends smoking						
None	55 (2367)†	18 (416)†	4 (87)†	6 (149)†	2 (47)†	11 (259)
Some or most	41 (1751)	33 (562)	13 (220)	13 (218)	7 (113)	13 (219)
Missing	4 (159)					
Teachers dipping						
No	52 (2212)†	18 (385)†	5.3 (115)†	6.5 (142)†	3 (66)†	14 (298)†
Yes	44 (1896)	33 (605)	10 (190)	12 (225)	5 (93)	11 (192)
Missing	4 (169)					

\*Local smokeless tobacco.

† $\chi^2$  significance  $p \leq 0.01$ .‡ $\chi^2$  significance  $p < 0.05$ .

dipping was seen among boys than girls ( $p < 0.001$ ). A higher prevalence of ever and current smoking was related to the secondary school grade ( $p < 0.001$ ), while higher prevalence of use of other tobacco products was seen among students in the basic grade ( $p < 0.001$ ). A higher prevalence of ever smoking, current smoking, ever and current tombak dipping and use of other tobacco products was seen among students whose either parents smoked. Similarly, students whose parents dipped were more likely to ever smoke and dip, and being current smoker and tombak dipper ( $p < 0.001$ ). Those whose friends were currently smoking and those whose teachers were dipping were more likely to engage in any of the tobacco habits (table 1).

### Relation of the tobacco habits of parents, friends and teachers to adolescents' tobacco smoking

After simultaneously adjusting for the adolescents' age, gender, school grade and tobacco habits of parents, friends and teachers, the risk of adolescents to have ever smoked (prevalence OR (POR) 1.79, 95% CI 1.46 to 2.20), being current smokers (OR 1.67, 95% CI 1.22 to 2.27) increased with parental smoking. Parental tombak dipping was only associated with adolescents' ever and current smoking when adjusted for adolescents' age, gender and school grade but not when the tobacco habits of parents, friends and teachers were included into the model. Tobacco smoking by friends was positively associated with

adolescents ever (POR 1.94, 95% CI 1.64 to 2.29) and current (OR 3.77, 95% CI 2.80 to 5.07) smoking. Tombak dipping by teachers was only associated with adolescents ever tobacco smoking (POR 1.50, CI 1.24 to 1.80) (table 2).

### Relation of the tobacco habits of parents, friends and teachers to adolescents' tombak dipping and use of other tobacco products

Parental smoking was positively associated with adolescents' current tombak use in the model adjusted only for age, sex and grade at school, but not when the tobacco habits of parents, friends and teachers were included in the model (table 3). However, when the tobacco habits of parents, friends and teachers were simultaneously adjusted in the model; parental smoking was positively associated with adolescents' use of other tobacco products (POR 1.43, 95% CI 1.09 to 1.89). Parental tombak dipping was directly associated with adolescents' ever (POR 1.77, 95% CI 1.30 to 2.41) and current (OR 1.84, 95% CI 1.17 to 2.90) dipping. Tobacco smoking by friends was positively associated with adolescents' ever dipping (POR 1.81, 95% CI 1.41 to 2.33) and current dipping (OR 3.33, 95% CI 2.20 to 5.05) (table 3).

### DISCUSSION

This survey, the first ever of its kind in this area, provides information on the current prevalence of tobacco smoking, tombak

**Table 2** Adjusted ORs and 95% CIs of the relation between tobacco use by parents, friends and teachers (smoking or tombak (local smokeless tobacco) dipping) and students ever and current smoking

	Ever smokers		Current smokers	
	Adjusted I†	Adjusted II‡	Adjusted I†	Adjusted II‡
Parents smoking				
None of them	1	1	1	1
Either of them	1.92 (1.58 to 2.33)**	1.79 (1.46 to 2.20)**	1.86 (1.40 to 2.48)**	1.67 (1.22 to 2.27)**
Don't know	2.31 (1.31 to 4.09)**	1.48 (0.72 to 3.02)	1.69 (0.70 to 4.06)	0.97 (0.32 to 2.91)
p For trend	<0.001	<0.001	<0.001	0.005
Parents dipping				
None of them	1	1	1	1
Either of them	1.34 (1.08 to 1.66)**	1.13 (0.90 to 1.43)	1.61 (1.17 to 2.21)**	1.34 (0.95 to 1.89)
Don't know	3.28 (1.62 to 6.65)**	1.82 (0.78 to 4.27)	3.01 (1.20 to 7.56)*	2.13 (0.73 to 6.23)
p For trend	<0.001	0.243	0.001	0.117
Friends smoking				
None	1	1	1	1
Some or most	2.05 (1.74 to 2.40)**	1.94 (1.64 to 2.29)**	3.80 (2.86 to 5.05)**	3.77 (2.80 to 5.07)**
Teachers dipping				
No	1	1	1	1
Yes	1.51 (1.26 to 1.81)**	1.50 (1.24 to 1.82)	1.18 (0.89 to 1.57)	1.14 (0.84 to 1.54)

\*p&lt;0.05; \*\*p&lt;0.001.

†ORs adjusted only for sex, age and school grade.

‡In addition to age, sex and school grade, ORs simultaneously adjusting for the tobacco habits of parents, friends and teachers.

dipping and use of other tobacco products in Sudanese adolescents, and the influence of the tobacco habits of parents, friends and teachers on adolescents' tobacco use behaviours. The results show that the tobacco habits of parents and friends influenced adolescents' tobacco use more than that of their teachers. Importantly, our observations indicate that tobacco smoking by these 'significant others' may influence adolescents' tobacco smoking and also increase their risk of use of smokeless tobacco.

Strengths of the study are the large sample size, random selection of subjects and a high participation rate. The results can be regarded as representative of the population of Khartoum State and, because of its multiethnic composition, our estimates may be generalised to most parts of the country, particularly the Central, Eastern and Northern states, but less so to the states in the Southern and Western areas of the country. A second potential limitation of this study is that current adolescent tobacco use and that of their parents was obtained by respondent recall, which is subject to bias and deliberate misreporting. We implemented all standard means to minimise these potential biases: we undertook a pilot study, through which we reworded and revised the contents of the questionnaire aimed at achieving a more reliable and valid response. Furthermore, the failure to include questions to assess the smoking habits of teachers (only tombak dipping was measured) and tombak dipping by friends (only smoking was measured) made us unable to examine the influence of these factors on adolescents' tobacco behaviour. However, considering the strength and direction of the influence of parental smoking and tombak use on adolescents' tobacco use, we believe similar results would have been obtained if we had studied the effects of smoking by teachers and tombak dipping by friends on adolescents' tobacco habits. Finally, the lack of information concerning the socioeconomic status of the participants, such as parental education and income did not allow us to adjust for the effects of these potential confounders. Thus residual confounding by these unmeasured variables may influence our results.

The prevalence of smoking among Sudanese adolescents in this study (24%) was greater than the prevalence measured in 2001 in a previous GYTS (20%),<sup>10</sup> suggesting increasing trends. Compared with other sub-Saharan African countries, the current prevalence of smoking among Sudanese adolescents ranks

among the highest recorded in the same period: 18% in Uganda-Kampala, 10% in Ethiopia, 14% in Ghana, 19% in Nigeria, 9% in Malawi and 15% in Kenya.<sup>13</sup> The prevalence of adolescents' smoking was also high when compared to the nearest countries in the Eastern Mediterranean region, where the prevalence was 14% in Egypt and 15% in Libya; a greater prevalence was reported only in Saudi Arabia.<sup>10</sup>

Our results indicate that school-going adolescents' tobacco behaviour was influenced mainly by friends tobacco use and that of their parents, and less so by that of their teachers. When parental influence is compared to that of the friends, the risk estimates from our results show that the influence of friends was stronger. These observations are in agreement with a study from the US, which showed that the influence of friends on adolescents' tobacco use was stronger than that of the parents.<sup>5</sup> In contrast, a Taiwanese study showed that the influence of the parents was stronger than that of friends, when parental tobacco habits were considered.<sup>14</sup> In a study from Malawi, it was reported that having at least one parent smoker or a friend who was a smoker was strongly associated with increased tobacco use by the adolescent.<sup>15</sup> In general, the influence of friends is considered the most important predictor of adolescent tobacco use compared to that of the parents.<sup>16</sup> Children usually imitate their parents from their early childhood,<sup>17</sup> while the influence of friends may be more important when they grow into their teens.<sup>6</sup> According to the theory of planned behaviour, approval of smoking by friends, parents and other key persons, for example teachers, is likely to increase the probability of smoking, through the imitation of these role models.<sup>4</sup>

Although the influence of teacher tobacco behaviours was less prominent than that of the parents and friends, we also observed a direct influence of the tobacco habits of teachers on that of their students, so that when the teacher dips inside the school buildings, the students are more likely to try smoking. Almost half of the smoking students reported that they had seen some of their teachers dip inside their school buildings. A study from the UK, conducted among 6000 students aged 11–12 years suggested that a higher proportion of student smokers was found in schools having a higher proportion of smokers among the teaching staff.<sup>18</sup> Similar findings were reported in a study

## Research paper

**Table 3** Adjusted OR and 95% CIs of the relation between tobacco use by parents, friends and teachers and students ever tombak (local smokeless tobacco) dipping, current tombak dipping and use of other tobacco products

	Ever tombak dippers		Current tombak dippers		Other tobacco products	
	Adjusted I†	Adjusted II‡	Adjusted I*	Adjusted II‡	Adjusted I†	Adjusted II‡
Parents smoking						
None of them	1	1	1	1	1	1
Either of them	1.26 (0.94 to 1.69)	1.01 (0.73 to 1.38)	1.30 (0.84 to 2.00)	0.83 (0.50 to 1.36)	1.41 (1.09 to 1.83)**	1.43 (1.09 to 1.89)*
Don't know	1.93 (0.88 to 4.21)	1.26 (0.48 to 3.29)	3.37 (1.39 to 8.19)**	0.58 (0.14 to 2.52)	1.50 (0.70 to 3.23)	1.80 (0.77 to 4.21)
p For trend	0.090	0.896	0.018	0.624	0.023	0.021
Parents dipping						
None of them	1	1	1	1	1	1
Either of them	1.85 (1.38 to 2.47)**	1.77 (1.30 to 2.41)**	2.21 (1.47 to 3.34)**	1.84 (1.17 to 2.90)**	1.23 (0.92 to 1.64)	1.05 (0.77 to 1.44)
Don't know	2.75 (1.10 to 6.90)*	2.18 (0.75 to 6.29)	6.17 (2.27 to 16.78)**	6.55 (1.94 to 22.12)**	1.16 (0.41 to 3.32)	0.81 (0.25 to 2.58)
Friends smoking						
None	1	1	1	1	1	1
Some or most	1.88 (1.48 to 2.39)**	1.81 (1.41 to 2.33)	3.48 (2.36 to 5.14)**	3.33 (2.20 to 5.05)	1.15 (0.93 to 1.43)	1.16 (0.92 to 1.45)
Teachers dipping						
No	1	1	1	1	1	1
Yes	1.22 (0.93 to 1.60)	1.21 (0.91 to 1.60)	1.21 (0.81 to 1.81)	1.14 (0.75 to 1.74)	0.79 (0.62 to 1.01)	0.78 (0.60 to 1.01)

\*p&lt;0.05; \*\*p&lt;0.001.

†ORs adjusted only for sex, age and grade.

‡In addition to age, sex and school grade, ORs simultaneously adjusting for the tobacco habits of parents, friends and teachers.

conducted in Denmark among students aged 15–16 years old, in which 57% of the students reported that they were exposed to teachers smoking in the staff room.<sup>19</sup>

An important observation from the present study, which has not been well reported previously, is that tobacco smoking by parents and friends influenced adolescents' smoking and also increased the risk of tombak dipping and the use of other tobacco products, respectively. In addition, tombak dipping by teachers increased the risk of adolescents' tobacco smoking. Although the reason for these observations is not clear in the present study, a Swedish study with similar findings suggested that the contextual social norms related to tobacco habits may explain the observed influence of tobacco smoking in significant others on the use or initiation of smokeless tobacco, or vice versa.<sup>20</sup> Our results indicate that the influence of tobacco smoking may extend to the use of other tobacco products as well. Therefore, it would be useful to more carefully examine this proposition in subsequent studies.

The influence of friends may be difficult to ascertain accurately,<sup>21</sup> considering that smokers may be prone to select other smoking friends, thus may report the habits of smoking friends

more than non-smoking friends. Such selection might likely have produced the association observed in our study between friends and adolescents' tobacco use.<sup>22–23</sup> However, some students do not like to reflect the behaviours of their parents regarding tobacco use, and may be more prone to blame their friends or their teachers regarding their tobacco attitudes, which may mask the real situation at home. Several studies have shown that smoking adolescents actively seek out groups of friends with similar smoking behaviours, and student smokers are more likely to be aware of others who smoke.<sup>22–24</sup> Dippers may also be more likely to be aware of others who dip tombak.

## CONCLUSIONS

Compared with Sudanese GYTS survey in 2001, our study shows that tobacco smoking and use of related products among school-going adolescents is increasing. The study also demonstrates that the tobacco habits of parents, friends and teachers are important predictors of adolescents' tobacco use, although the influence of the friends and parents were the most prominent. In developing programmes against tobacco use by adolescents, there is the need to target the habits of parents, teachers and peers as important influencing factors. This could be achieved by establishing a school-based tobacco policy that targets students and teachers, including anti-tobacco use syllabus as part of the school curriculum and including parents as part health promotion among adolescents. Furthermore, comprehensive efforts focusing on anti-smoking and anti-tombak dipping legislation need to be developed and implemented in Sudan considering their rising prevalence among adolescents.

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## What this paper adds

- This study provides the first assessment of tombak (local smokeless tobacco) dipping among Sudanese school-going adolescents, and showed that tobacco use by friends and parents were the most important influencing factors on adolescents' tobacco use, while tobacco use by the teachers played a minor role.
- The study also shows that tobacco smoking by parents and friends influenced adolescents' smoking and also increased the risk of tombak dipping and the use of other tobacco products, whereas tombak dipping by teachers increased the risk of adolescent tobacco smoking.
- The study points to the need to target these 'significant others' when planning tobacco prevention and intervention programmes among adolescents.

**Competing interests** None.

**Ethics approval** This study was conducted with the approval of the Federal and Khartoum State Ministries of Health.

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## The role of parents, friends and teachers in adolescents' cigarette smoking and tombak dipping in Sudan

Salma El-Tayeb El-Amin, Bright I Nwaru, Ibrahim Ginawi, Paola Pisani and Matti Hakama

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# **PUBLICATION**

## **II**

### **School smoking policies and Health Science Students' use of cigarettes, shisha, and dipping tombak in Sudan**

Salma El Tayeb El Amin

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# School Smoking Policies and Health Science Students' Use of Cigarettes, Shisha, and Dipping Tombak in Sudan

Salma El Tayeb El Amin\*

Faculty of Social Sciences, Health Sciences, Tampere University, Tampere, Finland

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### \*Correspondence:

Salma El Tayeb El Amin  
salmozy@gmail.com;  
salma.elamin@tuni.fi

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The relationship between school smoking policies and students' tobacco use is ambiguous, and little is known about the effect of these policies in low- and middle-income countries. This study was designed to assess the effects of schools' smoking policies and the exposure to residential smoking on cigarette smoking and the use of different kinds of tobacco products by Health Science students. Self-reports of cigarette smoking, use of shisha (smoking of fruits-mixed tobacco using a bowl and a connected hose); dipping tombak (local smokeless tobacco that users usually place inside oral cavity in the groove behind the lower lip), and tobacco use on school premises are analyzed. A cross-sectional survey was carried out using a modified self-report questionnaire, originally developed by WHO, among a representative sample of 1,590 third-year HSS from 25 schools drawn from 13 universities, using a multi-stages sampling technique. The response rate was 100% for schools and 68% for students. A multilevel analysis was performed by nesting student-level in school-level variables. Results from the adjusted models revealed that, when students reported awareness of smoking restriction, they were more likely to be current smokers (OR = 2.91; 95% CI: 1.68–5.02;  $p = 0.021$ ) and shisha users (OR = 2.17; 95% CI: 1.54–3.06;  $p = 0.021$ ). Results from additional analysis performed among tobacco users only, showed increased risk of smokers and tombak dippers who smoked or dipped on school premises (OR = 2.38; 95% CI: 1.34–4.25;  $p = 0.003$ , OR = 2.60; 95% CI: 1.22–5.56;  $p = 0.013$ , respectively). Current smokers (OR = 3.12; 95% CI: 1.98–4.92;  $p = \leq 0.001$ ), ever smokers (OR = 1.66; 95% CI: 1.31–2.10;  $p = \leq 0.001$ ) and shisha users (OR = 1.73; 95% CI: 1.36–2.21;  $p = \leq 0.001$ ) were exposed to residential smoking on one or more days during the previous 7 days. High percentages of those who used any kind of tobacco products reported being aware of school smoking policies, indicating no clear evidence that school smoking policies had an effect on use of any of the mentioned tobacco products. The lack of compliance with school policies shows the need for further policy enforcement and sustainability, taking into account the effect of residential smoking and social influences.

**Keywords:** school smoking policy, residential smoking, tobacco, smoking, tombak, shisha, water-pipe

## INTRODUCTION

Tobacco use is one of the greatest challenges to public health, with steadily increasing consumption and a rapidly growing epidemic in the low- and middle-income countries (1). It has been well documented with overwhelming scientific evidence that trends of tobacco product use are increasing for some sub-groups within the global population, and its effect on health is undeniable. The available data demonstrate that about one quarter of the world's adult population currently smokes, and several million people become fatally addicted every year (2–4). Most documented successes in reducing tobacco use have occurred in developed countries by effective tobacco control policies (5, 6). In contrast, most of the developing countries require more efforts to reach a comparable level. Despite the evidence, some policy-makers in low-income countries have failed to regard tobacco use as a health priority and do not fully appreciate the essential influence of public policies related to tobacco control (7). This lack of understanding is one partial explanation for the near absence of adequate prevention measures in these countries (8).

The problem is particularly challenging in Africa, which presents a great risk in tobacco use. Cigarettes are becoming increasingly affordable, and there are limited strategies to combat the increasing trends in use of shisha (1, 9), use of smokeless tobacco (10), and their harmful effects on future morbidity and mortality (1, 11). This shift to developing settings is partly because of the global tobacco industry fierce marketing strategies and partly due to lack of adequate tobacco control measures (7, 12, 13). In Sudan, as one example of a sub-Saharan African country, smoking cigarettes, shisha use, and tombak dipping are widely spread among adolescents and young adults (14, 15).

Schools are particularly important and considered to be the best places where students' tobacco use can be targeted. Schools represent a key environment where prevention and control strategies can be implemented (16, 17). Anti-smoking policies can reduce the prevalence of smoking by promoting prevention, restriction, cessation, and by preventing students from using tobacco on school premises and protecting non-smokers (18–20). Well-known statements document that smoking behavior is mainly recognized and established at or before the age of 18 (21). Consequently, smoking prevention programs have been focused on adolescents, mainly within school settings. Other researchers have suggested that college students might be an important audience in initiation and in the development of regular smoking (22), whatever the age of the students. In addition to schools, a better understanding of the main factors that affect students' tobacco habits in other environments would be useful for policy formulation in tobacco control programs. For instance, exposure to smoking in students' neighborhoods and residential areas can have an important role in their tobacco use (23).

Regardless of the methodological issues or the heterogeneity of exposure definitions in observational studies, various researchers have evaluated the effectiveness of school tobacco policies (20, 24). Some of them revealed a significant association between student smoking on school premises and weak policy (25). Others concluded that perceptions of students' smoking on the

school premises also varied according to enforcement of smoking restrictions (20, 26).

These policies are particularly important in Health Science students' schools, where students are trained and seeking careers in the health professions. Ideally, they will be role models for patients. The extent to which they effectively guide tobacco users may largely depend on their own tobacco use behavior (27). In Africa, doctors are regarded as the most likely persons from whom advice about tobacco use would be accepted by both users and non-users. Very brief advice from the doctor yields positive 1-year quit rates (28).

Within a multilevel context, the study reported here was designed to examine the effects of university policies and residential smoking on smoking and the use of different kinds of tobacco products by students studying in the Health Science disciplines of medicine, dentistry, nursing, and pharmacy. Third-year students were asked to self-report their use of cigarettes, tombak dipping, and shisha, as well as their awareness of school policies that banned or restricted use of tobacco products, and their exposure to smoking in places where they live.

## METHODS

The current study used cross sectional collection of data as part of the Global Tobacco Surveillance System (GTSS) 2007. Full details of the surveys can be found elsewhere (*Centers for Disease Control and Prevention (CDC) 2006*) (29). Newer data, targeting the same student population, can not be obtained because the conditions of the country have changed, Sudan split into two countries.

A multi-stage cluster sampling design was used in the first part of the sampling technique. *The first stage*: from a total number of 39 public and private universities, 13 universities were selected based upon having a school of medicine, dentistry, nursing, or pharmacy, or any combination of these four schools (one university might have one or more Health Science schools). The rest, 26 universities, were eliminated because they did not meet the selection criteria. *The second stage*: all Health Science schools ( $N = 29$ ) were drawn from the 13 universities. Four of the 29 Health Science schools were eliminated because they were new and did not have a third class at the time of the survey. Thus, the final sample became 25 schools (Medicine 10; Dentistry 6; Nursing 4; and Pharmacy 5). The third year classes in the 25 schools were selected purposively. All students who were enrolled and present in these classes, regardless of their age, were eligible to participate in the study.

The Health Science schools had a 100% school response rate. All third-year students were eligible and invited to complete the survey, with a 67% student response rate from dental schools; 64% from medical schools; 83% from nursing schools; and 71% from schools of pharmacy. On the day of the survey, students who had left the classroom (21 students) or those who were absent for any other reasons were not followed up. From the 2,344 registered eligible students, 1,590 students responded, giving an overall response rate of 68%.

The survey was an anonymous, modified self-reported questionnaire originally developed by the Tobacco Free Initiative

and the World Health Organization (WHO) in collaboration with the US Centers for Disease Control and Prevention (CDC). The questionnaire used was originally in English, and later translated into Arabic by an expert team from the Sudan Ministry of Health (SMOH).

The Sudanese research coordinators, including the author of this study, trained the data collectors from the Ministry of Health, and supervised the data collection. The survey was first piloted among 50 non-Health Science students to determine clarity of questions and to ensure feasibility of administration and the accuracy of translation. After incorporating the corrections, the process resulted in removing, adding or changing some questions, resulting in a final set of 44 questions. These were then back-translated into English, by an independent professional person who was not part of the first translation or study, to check for validity and to avoid bias and/or misunderstanding. The questionnaires were distributed during regular lectures and class sessions. Completion time was about 40–45 min.

## Ethical Approval

Permission to conduct the study was sought from the Ministry of High Education and the Ministry of Health Research Ethics Board, the university authorities' board, and the Dean of each school. The entry point for conducting the student survey for each school was through a designated faculty member to identify the student subject pool. Informed consent was obtained for all eligible students and for each student. This process involved explaining the purpose of the research, and why they had been selected. Their consents were obtained verbally; no written permission was required of individuals at the age of 18 and above, for those who were younger than age 18, parental consents were obtained. Participation was voluntary and confidential, with the option of declining without penalty or loss of benefits to which the student would be otherwise entitled.

## Definitions of Variables and Outcome Measures

The selected questions for this study included demographic characteristics, questions related to school policy and use of three types of tobacco products (cigarettes, shisha and tombak), and a final question related to smoking in places where students live.

### Tobacco Products

**Cigarettes** are the most common type of tobacco used throughout the world. Although cigarettes come in a variety of strengths and styles, the questions on the survey did not differentiate type of cigarettes smoked.

**Tombak** is a loose, moist form of smokeless tobacco. The plant is of the species *Nicotiana Rustica* and/or *glauca*, with a high content of nicotine. *Soute* /səʊt/ is another local name for tombak. The leaves are ground for maturation for up to 1 year for uniform drying and storage for aging (30). Then they are mixed with "Atrun or Natrun," which is a kind of raw alkaline material, consisting of naturally occurring chemical substances, including sodium bicarbonate. The ingredients are then mixed with water and rubbed by hand for blending and constantly tested with the tips of the fingers in a process called "Tatmeer /ta:tæm.iʃ/." The

final product "tombak" will be ready for dipping after many hours (up to 1-day) of being sealed in an airtight container. *tæm tiər tiər tiər* Tombak is highly addictive because of its high nicotine content. Its use results in serious health problems that are related to several forms of oral cancer (10). The dip in Sudan is named *suffa* /səʃfə/, which is a small moist lump/ball that is made by rolling a small amount of tombak repeatedly on the palm using the thumb, index, and middle fingers of the other hand in a circular manner. *Suffa* is usually placed in the lower labial groove between the lower lip and the gum (*usual site of cancer in Sudan*), or under the tongue or upper lip.

**Shisha** is another name for "oriental water-pipe" that is well known and popular in the Middle East and North Africa. Shisha is an instrument used for smoking, consisting of a head, body, water bowl, and rubber-pipe (hose). The smoking involves heating the fruit-flavored tobacco, usually with charcoal, cooled down by passing through the water chamber at the bottom of shisha prior to inhalation. Users believe that shisha is safer than cigarettes because the smoke passes through water before inhalation (9). Shisha use is becoming increasingly popular in Sudan among young people sitting for hours at Internet cafes. Its use is also increasing among young girls and women in some beauty centers and hair styling saloons (unpublished document, SMOH, 2007).

### Tobacco Use Variables

**Ever tobacco user** included anyone who tried any kind of tobacco products, those who had smoked, dipped tombak, or used shisha at least one time, during the course of her/his life. Each question in these categories was treated independently. The question was "Have you **ever** tried or experimented with cigarette smoking/shisha/tombak dipping, even if it was one puff/dip or two?" Responses were "Never"/"Yes."

**Current smoking** question was "During the past 30 days, on how many days did you smoke cigarettes?" Students were classified as "current smokers" if they reported smoking on any day of the previous month. Questions about current use of other kinds of tobacco (*shisha and tombak*) were not available in the survey therefore were not measured.

### School Smoking Policy Variables

For ease of use, the term "school" was used in the text and the tables to refer to all colleges; faculties; and school under study (Dental schools, Colleges of Medicine, Nursing schools, and Faculties of Pharmacy).

### Smoking on school premises

**Smoking on schools' premises** question was "Have you smoked cigarettes on school premises during the last 1-year?" Responses were "Not-smoked"/"smoked."

**Dipping on schools' premises** question was "Have you dipped tombak on school premises during the last 1-year?" Responses were "Not-dipped"/"dipped."

Two additional variables were created from the above two questions, included only the users (the current smokers and tombak dippers) who responded to the questions; and only

those who reported “Yes” they had smoked or dipped on school premises were counted.

**Smokers who smoked on school premises** included both current and ever smokers who smoked during the prior 1-year.

**Current smoking on school premises** includes only current smokers who smoked on school premises during the prior 1-year.

**Ever dippers on school premises** includes only those who dipped tombak for the first time on school premises during prior 1-year. The variables about school policy were based on the responses to two questions; the answers were further categorized for purpose of the analysis.

### Policy banning smoking

(PBS) “Does your school have an official policy banning smoking in school buildings and clinics?” Responses were “No official policy”/“exists in either of them”/“exists in both.”

### Smoking restriction

Which of the following best describes your school’s official smoking policy for public places or common areas “lobbies, restrooms & dining areas”? Responses were “No official policy”/“complete restriction”/“partial restriction.”

**Complete restriction:** Smoking not allowed in any of the mentioned places.

**Partial restriction:** Smoking is allowed in one of the mentioned places.

### Residential Smoking Variable

The residential smoking question was “Has anyone smoked in your presence in places where you live, on one or more days during the last 7-days?” “No” = 0 days, “Yes” = 1–7 days. The terms of “residential smoking” and “smoking where student lives” are used interchangeably throughout this paper.

### Data Analyses

Pearson’s  $\chi^2$  test was performed to examine the descriptive analysis for frequencies, differences in proportion, and associations between variables. Statistical significance is reported two sided:  $p < 0.05$ . IBM SPSS Statistics version 23.0 was used for the preliminary analysis.

Due to the hierarchical and the tiered nature of the data, multilevel logistic regression was used to examine the relationship between school policy and residential smoking (*exposure*) and the use of tobacco by students (*outcome*). The dataset was assumed to have a two-level data structure, where individual cases (students) are nested in a higher-level group (schools). The individual-level of students’ behavior related to tobacco use (*smoking cigarettes, dipping tombak, shisha, and “smoking and dipping” on school premises*) was nested at a higher-level group (25 schools) that simultaneously included policy and residential smoking in the multivariate model with the students as the unit of analysis.

Before conducting the analysis, the outcome tobacco variables were dichotomized. The data were exported to Statistical Package for Stata’ gllamm (Generalized Linear Latent and Mixed Stata/SE 14.0) for multilevel logistic regression to fit random-intercept logistic models and to determine the strength of the hypothesized relationships between school policy and student

tobacco behavior. A *null model* was first fitted and included only a random intercept to estimate the variations in the use of tobacco across schools (this model is not presented in the tables). A *subsequent unadjusted model* was separately fitted for each smoking policy in relation to tobacco use outcomes. A *final adjusted model* was fitted, adjusted for age and sex, with school level as a random effect. Student reporting about smoking on school premises was analyzed separately. The odds ratios for the fixed part of the models were estimated using 95% confidence intervals. To estimate the differences between schools, the school level variance (SE) were also measured.

## RESULTS

### Descriptive Analysis

**Tables 1, 2** provide a summary of the numbers and percentages arranged by tobacco use. Students’ reporting about schools’ smoking policies are presented as policy banning smoking and restriction, together with exposure to residential smoking. Sample sizes differ slightly among the analyses due to differences in the patterns of missing data.

The 1,590 participants included more females (66%) than male students, the majority were between the ages of 19 to 24 years. Overall prevalence of ever smoking was 40.3%, more among males than females. Ever smoking, increased with age and varied between schools (ranging from 30 to 48%). The pattern was similar for shisha use. Overall prevalence of shisha use was 33.8%, dippers (16.2%) and current smokers (8.3%), more among male students. Strikingly, 10.5% of all students smoked on school premises. They were also more male students, older, and from dental schools. Those who reported that a policy existed and that smoking was restricted were more likely to smoke on school premises (**Table 1**).

Most of ever smokers (52%), shisha users (44%), dippers (21%), and 15% of current smokers were exposed to residential smoking on any days of the previous 1 week (**Table 1**). That means 40% of all participants were exposed to smoking where they live; more than half were male students (55%) and older (42%) (**Table 2**).

As shown in **Table 2**, more than half the students reported the non-existence of school smoking policy (54%), and there were no big differences in the percentages between schools. As reported, more nursing students than the rest reported that smoking was completely restricted in public places and common areas (39%).

### Multi-Level Analysis

#### School Smoking Policy

As indicated in **Table 3**, the existence of policy was significantly associated with ever smoking and shisha use after adjusting for age and sex. Odds ratios declined but remained significant compared to non-smokers, with small reduction of school variance. Partial smoking restriction was significantly associated with increased risk of current-smoking (Adjusted OR (A-OR) 2.91), and shisha use (A-OR 2.17), with small reduction of school

**TABLE 1 |** Percentage of tobacco users by age, sex, type of school, school smoking policies, and residential smoking.

		Ever smoking	Ever use Shisha	Ever dipping tombak	Current smoking	Smoking on school premises during last 1-year
	Grand total N (%) <sup>†</sup>	N <sup>‡</sup> = 1570 n <sup>§</sup> (%)	N <sup>‡</sup> = 1587 n (%)	N <sup>‡</sup> = 1583 n (%)	N <sup>‡</sup> = 1574 n (%)	N <sup>‡</sup> = 1545 n (%)
<b>ALL</b>	(1590)	641(40.3)	536 (33.7)	256 (16.2)	130 (8.2)	163 (10.5)
<b>SEX</b>	<b>N: 1547</b>					
Female	1051 (66)	307 (30)	239 (23)	91 (9)	18 (2)	68 (7)
Male	496 (31)	320 (65)	286 (58)	158 (32)	110 (23)	94 (19)
<b>P-value</b>		<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>
<b>AGE</b>	<b>N: 1506</b>					
<19 years' old	77 (5)	23 (30)	18 (24)	7 (9)	1 (1)	2 (3)
19 – 24	749 (47)	260 (35)	206 (28)	103 (14)	44 (6)	59 (8)
>24	680 (43)	317 (47)	278 (41)	129 (19)	76 (11)	83 (12)
<b>P-value</b>		<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>0.006</b>	<b>&lt;0.001</b>	<b>&lt;0.05</b>
<b>SCHOOL</b>	<b>N: 1590</b>					
Dental	193 (12)	92 (48)	87 (45)	29 (15)	19 (10)	27 (14)
Medical	711 (45)	313 (45)	237 (33)	113 (16)	58 (8)	77 (11)
Nursing	319 (20)	96 (30)	90 (28)	51 (16)	16 (5)	27 (9)
Pharmacy	367 (23)	140 (39)	122 (33)	63 (17)	37 (10)	33 (9)
<b>P-value</b>		<b>&lt;0.001</b>	<b>0.002</b>	<b>0.905</b>	<b>0.078</b>	<b>0.056</b>
<b>SCHOOLS' POLICIES</b>						
<b>Official policy banning smoking</b>	<b>N: 1572</b>					
No official policy	863 (54)	307 (36)	232 (27)	115 (13)	51 (6)	64 (8)
Exists in either school or clinic	349 (22)	157 (46)	138 (40)	72 (21)	32 (9)	49 (14)
Exists in both	360 (23)	169 (48)	160 (44)	66 (18)	44 (12)	49 (14)
<b>P-value</b>		<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>0.008</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>
<b>Smoking restriction</b>	<b>N: 1561</b>					
No Official Policy	865 (54)	310 (36)	240 (28)	122 (14)	43 (5)	70 (8)
Complete restriction	469 (30)	210 (46)	177 (38)	88 (19)	47 (10)	60 (13)
Partial restriction	227 (14)	108 (48)	109 (48)	42 (19)	39 (17)	30 (13)
<b>P-value</b>		<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>0.054</b>	<b>&lt;0.001</b>	<b>&lt;0.05</b>
<b>RESIDENTIAL SMOKING</b>	<b>N: 1573</b>					
Not exposed	944 (59)	310 (33)	253 (27)	123 (13)	35 (4)	70 (8)
Exposed	629 (40)	320 (51)	279 (44)	129 (21)	93 (15)	91 (15)
<b>P-value</b>		<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>

▼ N:Grand Total. Total for each variable varies due to missing data.  
N<sup>‡</sup>: Total number of students responded to the question from the total participants (1590).  
§ n:number of tobacco users "Yes%" answers.

level variance. School policy and smoking restrictions appeared to be unrelated to dipping behavior.

A third model was fit and further adjusted for school types and residential smoking as confounders in addition to age and sex. The adjusted odds ratio remained almost the same when adjusted for school types, but when adjusted for residential smoking, the odds ratio decreased and the results lost their significances. The results of this analysis were not presented in the tables. This may underestimate the importance of school factors influencing students' tobacco use (31).

**Exposure to Residential Smoking**

In the adjusted model, exposure to smoking during the last 7-days was significantly associated with

increased risk of ever smoking (A-OR 1.66), current smoking (A-OR 3.12), and shisha use (A-OR 1.73), and marginally (*P*-value 0.06) related to dipping tombak (Table 3).

**Smoking on School Premises**

The results shown in Table 4 are consistent with the previous results of the multi-level analysis. The awareness of an official policy did not appear to stop students from dipping or smoking on school premises, when the students reported the existence of policies, the risk increased for tobacco use (A-OR 2.38, for current smoking and 2.60 for ever dipping). Regarding smoking restriction, it was significant only with complete restriction.

**TABLE 2 |** Percentages of students' awareness of school smoking policies as well as residential smoking by basic demographic characteristics and school type.

	SCHOOL SMOKING POLICY <sup>Σ</sup>						EXPOSURE TO RESIDENTIAL SMOKING <sup>Υ</sup>
	Policies banning smoking in clinics and school buildings <i>N</i> = 1572			Smoking restriction in public places and common areas <i>N</i> = 1561			<i>N</i> = 1573
	Policy not exists <i>n</i> <sup>‡</sup> (%)	policy exists either of them <i>n</i> (%)	policy exists in both of them <i>n</i> (%)	Policy not exists <i>n</i> (%)	Complete <sup>α</sup> restriction <i>n</i> (%)	Partial <sup>β</sup> restriction <i>n</i> (%)	People smoke in places where participant lives <i>n</i> (%)
<b>ALL<sup>§</sup></b>	863 (54)	349 (22)	360 (23)	865 (54)	469 (30)	227 (14)	629 (40)
<b>SEX</b>	<b>839 (54)</b>			<b>848 (55)</b>			
Female	640 (61)	204 (20)	197 (19)	628 (60)	266 (26)	141 (14)	347 (33)
Male	199 (41)	134 (27)	157 (32)	220 (45)	184 (38)	83 (17)	269 (55)
<b><i>P</i>-value</b>		≤0.001	≤0.001		≤0.001	≤0.001	≤0.001
<b>AGE</b>	<b>826 (55)</b>			<b>830 (56)</b>			
<19	40 (52)	23 (30)	14 (18)	38 (51)	22 (29)	15 (20)	25 (33)
19–24	427 (57)	147 (20)	168 (23)	434 (59)	209 (28)	93 (13)	287 (39)
>24	359 (53)	154 (23)	158 (24)	358 (53)	206 (31)	108 (16)	283 (42)
<b><i>P</i>-value</b>		0.187	0.198		0.112	0.117	0.184
<b>SCHOOLS<sup>∞</sup></b>	<b>863 (55)</b>			<b>865 (55)</b>			
Dental	48 (44)	45 (23)	63 (33)	99 (53)	42 (22)	48 (25)	86 (46)
Medical	416 (59)	156 (22)	134 (19)	417 (60)	174 (25)	107 (15)	289 (41)
Nursing	172 (54)	77 (24)	68 (22)	170 (54)	112 (36)	33 (11)	114 (36)
Pharmacy	191 (53)	71 (20)	95 (27)	179 (50)	141 (39)	39 (11)	140 (39)
<b><i>P</i>-value</b>		≤0.05	≤0.001		≤0.001	≤0.001	0.154

<sup>Σ</sup> School policies were examined by students' awareness of banning smoking in clinics and/or school buildings and restriction in public places and common areas (lobbies, restrooms and dining areas).

<sup>α</sup>Complete restriction: smoking not allowed in any public or common areas.

<sup>β</sup>Partial restriction: smoking allowed in either common rooms or public places.

<sup>Υ</sup>Residential smoking: is exposure to smoking in places where student lives.

<sup>‡</sup>*n*: number of tobacco users, "Yes%" answers.

<sup>§</sup>Total for each variable varies due to missing data.

<sup>∞</sup>School, faculty and college (Dental school, College of Medicine, Nursing school and Faculty of Pharmacy). For ease, only (school) will be used in the text.

# DISCUSSION

The present study reveals new information about the pattern of tobacco use among Sudanese university students and its association with school anti-smoking policies. The study makes an important contribution to what is known about the tobacco habits of youth by including tombak dipping and shisha use in addition to cigarette smoking. No known study to date has been published in which the researcher compared these three types of tobacco use among youth or has considered the effect of school smoking policy on dipping tombak and/or using shisha and the effect of residential smoking on using different kinds of tobacco products.

Current smoking was observed in 8.3% of the Health Sciences students, compared to 13.7% among university students in Sudan in a study conducted in 2016 (32). Another study conducted in 2013 among 302 Sudanese Health Professional students from private schools (33) showed the prevalence of current smoking and ever smoking to be 9.6 and 26%, respectively, and 34.5% were exposed to residential smoking (compared to 40.8% of the present sample). Comparing the findings of current smoking from the three studies shows no significant reduction among

current smoking in terms of policy measures, and strategic efforts to prohibit smoking among students during the period in between the three studies (2007, 2013, and 2016) do not appear to have been effective.

Regarding the students' reports about school policy, the results demonstrate a considerable diversity between schools. The kinds of tobacco product used were quite different among students. More than half of all students reported the non-existence of school policy (54%). Most of the tobacco users were aware of the existence of policy and the restriction of smoking in common areas and in school buildings. It would seem that tobacco users are more aware of school smoking policies than non-users, even though they may choose to ignore the policies.

With additional analysis, the awareness of existence of school policies diminished and lost its significant results except for shisha users. On the other hand, awareness of smoking restriction was significantly and reversely associated with increasing risk of current smokers and with shisha users. This implies either the policy was not well-enforced (26), or there was a lack of student commitment to school policy (34).

With respect to the shisha use category, shisha users were more aware of the policy existence and the restricted areas.

**TABLE 3 |** Odds ratios (95% confidence intervals) for tobacco use by school smoking policies and exposure to residential smoking in unadjusted and adjusted models; adjusted for age, sex, and school level as random effects.

	Ever smoking		Current smoking		Ever shisha		Ever dipping tobak	
	Unadjusted OR (95% CI)	Adjusted <sup>‡</sup> OR (95% CI)	Unadjusted OR (95% CI)	Adjusted <sup>‡</sup> OR (95% CI)	Unadjusted OR (95% CI)	Adjusted <sup>‡</sup> OR (95% CI)	Unadjusted OR (95% CI)	Adjusted <sup>‡</sup> OR (95% CI)
<b>SCHOOL SMOKING POLICIES</b>								
<b>Policy banning smoking</b>								
No official policy	1	1	1	1	1	1	1	1
Policy exists for either of them	1.53 (1.17–2.01)	1.24 (0.92–1.67)	1.52 (0.94–2.48)	0.95 (0.55–1.64)	1.80 (1.37–2.38)	1.52 (1.12–2.07)	1.71 (1.22–2.40)	1.24 (0.86–1.80)
Policy exists for both	1.67 (1.27–2.18)	1.34 (0.99–1.80)	2.14 (1.36–3.36)	1.34 (0.81–2.23)	2.18 (1.66–2.87)	1.80 (1.33–2.45)	1.48 (1.05–2.09)	1.04 (0.72–1.52)
P-value	≤0.001	0.055	0.001	0.251	<0.001	<0.001	0.026	0.819
<b>Random part</b>								
School level variance (SE)	0.16 (0.08)	0.11 (0.07)	0.38 (0.20)	0.19 (0.15)	0.14 (0.07)	0.11 (0.07)	0.08 (0.07)	0.04 (0.05)
<b>Smoking restriction</b>								
No Official Policy	1	1	1	1	1	1	1	1
Complete restriction	1.52 (1.19–1.96)	1.24 (0.94–1.63)	2.17 (1.38–3.41)	1.32 (0.82–2.16)	1.66 (1.28–2.15)	1.36 (1.02–1.80)	1.42 (1.04–1.94)	1.04 (0.73–1.47)
Partial restriction	1.54 (1.13–2.10)	1.35 (0.96–1.90)	3.53 (2.18–5.73)	2.91 (1.68–5.02)	2.26 (1.65–3.09)	2.17 (1.54–3.06)	1.39 (0.94–2.06)	1.14 (0.74–1.75)
P-value	0.001	0.083	≤0.001	≤0.021	≤0.001	0.034	0.1	0.544
<b>Random part</b>								
School level variance (SE)	0.16 (0.07)	0.12 (0.08)	0.28 (0.17)	0.08 (0.10)	0.15 (0.08)	0.07 (0.06)	0.07 (0.06)	0.04 (0.05)
<b>EXPOSURE TO RESIDENTIAL SMOKING</b>								
Not exposed	1	1	1	1	1	1	1	1
Exposed	2.16 (1.75–2.68)	1.66 (1.31–2.10)	4.45 (2.95–6.69)	3.12 (1.98–4.92)	2.16 (1.74–2.68)	1.73 (1.36–2.21)	1.72 (1.31–2.26)	1.33 (0.98–1.80)
P-value	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	0.069
<b>Random part</b>								
School level variance (SE)	0.16 (0.08)	0.05 (0.05)	0.33 (0.19)	0.19 (0.14)	0.16 (0.08)	0.09 (0.06)	0.06 (0.06)	0.01 (0.04)

Variance of random effects (SE) for ever smoking (0.17 [0.08]), current smoking (0.38 [0.20]), Ever shisha (0.18 [0.09]) and Ever dipping tobak (0.07 [0.06]).  
‡Adjusted for age, sex and school level as a random effect.

**TABLE 4 |** Odds ratios (95% confidence intervals) for tobacco use on school premises during the prior 1-year by school smoking policies and exposure to residential smoking among smokers and tombak dippers; adjusted for age, sex, and school level as random effects.

	Smoking on school premises during prior 1-year <sup>a</sup> N = 163		Current smoking on school premises prior 1-year <sup>b</sup> N = 77		Ever dipping on school premises during the prior 1-year <sup>c</sup> N = 56	
	Unadjusted OR (95% CI)	Adjusted <sup>d</sup> OR (95% CI)	Unadjusted OR (95% CI)	Adjusted <sup>d</sup> OR (95% CI)	Unadjusted OR (95% CI)	Adjusted <sup>d</sup> OR (95% CI)
<b>SCHOOL SMOKING POLICIES</b>						
<b>Policy banning smoking (for school building and clinics)</b>						
No official policy	1	1	1	1	1	1
Policy exists for either	2.04 (1.36–3.08)	1.92 (1.23–3.01)	0.22 (0.07–0.65)	0.23 (0.08–0.67)	3.51 (1.73–7.14)	2.32 (1.06–5.12)
Policy exists for both	1.98 (1.31–2.99)	1.63 (1.04–2.59)	2.58 (1.50–4.44)	2.38 (1.34–4.25)	3.71 (1.86–7.41)	2.60 (1.22–5.56)
P-value	0.001	0.034	0.001	0.003	<0.001	0.013
<b>Random part</b>						
School level variance (SE)	0.13 (0.11)	0.14 (0.13)	1.59 (0.80)	1.54 (0.79)	0.22 (0.22)	6.84 (1.39)
<b>Smoking restriction</b>						
No official policy	1	1	1	1	1	1
Complete restriction	1.75 (1.20–2.59)	1.59 (1.04–2.43)	1.31 (0.74–2.30)	1.38 (0.77–2.47)	2.88 (1.56–5.30)	2.30 (1.16–4.53)
Partial restriction	1.61 (1.01–2.60)	1.63 (0.99–2.70)	1.33 (0.64–2.75)	1.30 (0.61–2.80)	1.62 (0.69–3.82)	1.60 (0.64–3.97)
P-value	0.046	0.055	0.441	0.489	0.001	0.311
<b>Random part</b>						
School level variance (SE)	0.18 (0.14)	0.13 (0.13)	1.46 (0.74)	1.40 (0.72)	0.22 (0.22)	4.48 (3.99)
<b>EXPOSURE TO RESIDENTIAL SMOKING</b>						
Not exposed	1	1	1	1	1	1
Exposed	2.10 (1.51–2.95)	1.45 (1.00–2.10)	0.94 (0.57–1.53)	0.85 (0.50–1.44)	2.18 (1.26–3.79)	1.35 (0.74–2.49)
P-value	<0.001	≤0.05	0.791	0.554	≤0.05	0.324
<b>Random part</b>						
School level variance (SE)	0.18 (0.14)	0.16 (0.14)	1.58 (0.78)	0.50 (0.38)	0.36 (0.31)	7.80 (1.66)

Variance of random effects [SE] Ever smoked at school (0.24 [0.16]) smoking in school prior 1-year (0.20 [0.14]), Current smoking in 1-year (1.39 [0.68]) Tombak (0.30 [0.28]).

<sup>a</sup>Included only those who smoked: students who either ever or current smokers (total = 513).

<sup>b</sup>Those were only current smokers who smoked on school premises = 77 students constitute 59.2 %, of all current smokers (total = 130 see **Table 2**).

<sup>c</sup>Those were only dippers who dipped on school premises = 56 students constitute 21.9% of all dippers (total dippers = 256 dippers, see **Table 2**).

<sup>d</sup>Adjusted for age and sex and school level as a random effect.

That might be because it is inconvenient to use shisha inside a school compared to cigarette smoking and dipping. The size of the shisha, the strong smell of fruit-flavored tobacco, and the fact that shisha is usually smoked in groups (35) would collectively hinder the use of shisha inside the school. In addition, there is lack of literature about policy concerning shisha use (36). In contrast, the “dip” can be hidden behind the lips and remain hidden for several minutes (14), which makes it easier for dippers to dip inside schools. Unlike smoking cigarettes or using shisha, dippers were more aware of smoking and restriction zones only if they reported being dual users (37).

With regard to smoking on school premises, 31.8% of all smokers and 21.8% of dippers have smoked or dipped on school premises (**Table 4**, footnote). Specifically, more than half of the current smokers (59.2%) have smoked inside the school they attend (**Table 4**, footnote). Results of multi-level analysis showed that despite knowing the existence of a non-smoking policy, students continued to smoke and dip on school premises, meaning that the awareness of the policy had no effect on their smoking or dipping, or they knew that it was not vigorously enforced.

Students’ reports about their school policy is quite ambiguous. Their responses varied greatly, despite the fact that they may

be in the same schools (31, 38). Awareness of the policy and enforcement are essential to help ensure compliance (39). Various researchers have shown that the relationship between school policies and students’ -smoking are mixed (20, 40). Some indicate a weak-to moderate relationship between policies and student smoking, while other studies indicate no effects (41). Other researchers suggest that changing a school environment represents a broader yet appropriate and effective factor in prevention and protection (26, 42).

More than half of ever smokers and 44% of shisha users; at least on 1 day of the previous week, were exposed to smoking in places where they are living, more among older male students (55%). Those exposed to residential smoking were more susceptible to start smoking, and they were more than three times at risk to be current smokers and twice as likely to be shisha users (14). Exposure to residential smoking did not affect a student’s risk of dipping tombak, and it was also not found to be related to smoking on school premises. Most researchers who examined smoking among young revealed that ever smokers initiated their smoking early in adolescence (43, 44), raising a question of the possibility of exposure to residential smoking perhaps some time before getting into their current university. Therefore, it made it crucial, in the present study, to consider the exposure to residential smoking as one of the main factors behind starting to use cigarettes when students were already



adults. Accordingly, this finding itself is an indicator of many other unmeasured influences on student tobacco use. Further research in the low- and middle-income countries is needed to explore other factors, possibly imitating friends (45) or socio-economic background (46), or exposure to smoking in places other than the places where they live.

Tombak dipping is a normative behavior among Sudanese. The product is cheap, easily available, and widely used. Some smokers have adopted it as an alternative to smoking tobacco (14). Results of the present study indicated that tombak is less used among Health Science students (16%) compared to the 45% prevalence of tombak among the adult population (47). This might be explained in that tombak is less prestigious among young university students and is less accepted, especially among females.

## Strengths and Limitations

This study makes an important contribution to researches about school tobacco policies in Africa. The findings could be taken as a baseline for school policies in Sudan and other Sub-Saharan countries targeting the same group, although it was carried out in a country which is now two separate countries. Several factors may cause different students in different schools in different countries to experience the effect of tobacco use in different ways, but a baseline is important for the future researchers to measure the effect of changes over time. One of the most important strengths of the present study is that the researcher considered different kinds of tobacco products, and similarly assessed use of those products. By understanding the use of varied tobacco products and their associations with school policy, the results can be used to target future policy programs that address use of different kinds of tobacco products in the developing world and in establishing a school-based tobacco policy. Another important strength of the present study was the use of a standardized questionnaire for data collection; it was based on the international core questionnaire. The original questionnaire was translated by expert persons, piloted, and back-translated by an independent professional person who was not part of the first translation or the study to minimize bias and misunderstanding. More questions were also asked about local tobacco products. The overall response rate of school was 100%, and 68% for students, yet non-response bias might have affected the results. Some researchers have found that non-respondents are more likely to be smokers than respondents (48), the author does not expect that non-response rate (32%) of the students had a major role on influencing the results of this study.

The most important limitations of this study included its cross-sectional design (49); therefore, a causal relationship cannot be determined. For instance, from the findings obtained in this study, the direction of causality of the association between tobacco use by students and their attitudes toward anti-smoking policy was not clear. Longitudinal studies are required to make the direction of this kind of causality clear. The data for this study were only collected from third year Health Sciences Students; therefore, it cannot be assumed that the sample is representative of other students at the same age at other universities or in other academic disciplines of study. Other measures, such as

school written policies from the schools, to validate the students' reports were not available. More information would be valuable in supporting the findings, since the official written policy and the students' perception of policy might be different. The data used in the present study were collected in 2007. To conduct another study; targeting the same study population would not be easy because the country has subsequently divided into two countries. However, findings from data collected among some Health Science students in the northern part of Sudan in 2013 and 2016 (32, 33), showed that situation about tobacco use is worse than in 2007.

## CONCLUSIONS

Despite the limitations, the results of this study provide important information as research about use of tobacco products continues. The present study was designed to examine the relationship between tobacco control activities and tobacco use prevalence among young adults, confirming the importance of continuous review of policies and prevention programs. Although school policies banning or restricting tobacco use seemed to be largely ignored, no specific elements with significant effects were found in the school context that would lead to specific suggestions for improvement of the policies. Yet, strategies for tobacco control must be extended to cover school, societal, and individual levels. From a research perspective, the high prevalence of tobacco use by the study population calls into question what other factors in the environment, including cultural norms, seem to promote smoking and result in such a high percentage of future health professional being tobacco users.

## RECOMMENDATIONS

Based on the findings from this study, opportunities for schools to have a significant role in preventing tobacco use should be pursued. Further work is needed with emphasis on students' tobacco use attitudes and behavior for every form of tobacco product. More attention should be given to enforcement of school smoking policies, to help dissuade smoking initiation. Future researchers who use the questionnaire from this study in school settings should include a random sample of students from preparatory to finalist classes, representing a wider life span and geographical representation than in the present study. Researchers studying tobacco use and prevention should examine all major kinds of tobacco products, as the results here indicated that use of different types of tobacco is associated with different individual characteristics and environmental contexts. Different stages in a student's life should also be considered, including the socio-cultural background of the student, the school environment, residential and neighborhoods' smoking, and financial accessibility that might have effect on a student's initiating or continuing use of any kind of tobacco product.

## DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

## AUTHOR CONTRIBUTIONS

SE conceived the study, collected the data, conducted the analysis, drafted, and finalized the manuscript.

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**Conflict of Interest:** The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# **PUBLICATION**

## **III**

### **Awareness and determinants of electronic cigarette use among Finnish adolescents in 2013: a population- based study**

Jaana Maarit Kinnunen, Hanna Ollila, Salma El-Tayeb El-Amin, Lasse  
Antero Pere, Pirjo Liisa Lindfors, Arja Hannele Rimpelä

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OPEN ACCESS

# Awareness and determinants of electronic cigarette use among Finnish adolescents in 2013: a population-based study

Jaana Maarit Kinnunen,<sup>1</sup> Hanna Ollila,<sup>2</sup> Salma El-Tayeb El-Amin,<sup>1</sup> Lasse Antero Pere,<sup>1</sup> Pirjo Liisa Lindfors,<sup>1</sup> Arja Hannele Rimpelä<sup>1,3</sup>

<sup>1</sup>School of Health Sciences, University of Tampere, Tampere, Finland

<sup>2</sup>Department of Alcohol, Drugs and Addiction, National Institute for Health and Welfare, Helsinki, Finland

<sup>3</sup>Department of Adolescent Psychiatry, Pitkämäki Hospital, Nokia, Tampere University Hospital, Tampere, Finland

## Correspondence to

Jaana Kinnunen, School of Health Sciences, University of Tampere, Tampere FI-33014, Finland; [jaana.m.kinnunen@uta.fi](mailto:jaana.m.kinnunen@uta.fi)

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## ABSTRACT

**Background** A wide range of electronic cigarettes (e-cigarettes) are now on the market. We studied e-cigarette awareness and use, determinants and sources of e-cigarettes, the e-liquids used in them and exposure to e-cigarette advertisements among adolescents in Finland. Among smokers, we studied the association of e-cigarette use and interest in smoking cessation.

**Method** Data were obtained from a national survey of 12–18-year-old Finnish adolescents in 2013 (N=3535, response rate 38%). Descriptive statistics and logistic regression analysis were used.

**Results** Of the respondents, 85.3% knew what e-cigarettes were; 17.4% had tried them. E-liquids with nicotine were used most often (65.7%); also those who had never tried conventional cigarettes had used them. Of e-cigarette ever users, 8.3% had never tried smoking. Parents' high level of education, being in employment, and intact family protected against children's e-cigarette use. In the final model, daily smoking (OR 41.35; 95% CI 25.2 to 67.8), snus use (2.96; 2.4–4.0), waterpipe use (2.21; 1.6–3.0), children's vocational education (2.06; 1.4–3.1) and poor school performance (1.92; 1.4–3.0) were associated with e-cigarette experimentation. Those smokers with most experience of e-cigarettes were least likely to consider smoking cessation.

**Conclusions** Awareness and experimentation with e-cigarettes are high among adolescents, especially in older age groups and boys. Nicotine e-liquids are easy to acquire for youth. Having similar risk factors, e-cigarette use seems to follow the model of conventional smoking initiation. Among adolescent smokers, use of e-cigarettes does not clearly relate to interest in smoking cessation. Preventive policies are needed to protect the youth.

## BACKGROUND

In recent years, the rise of a new tobacco-like product, the electronic cigarette (e-cigarette) or electronic nicotine delivery system (ENDS),<sup>1</sup> has raised concerns. Despite the name, these products do not contain tobacco or necessarily resemble a conventional cigarette, and there are also non-nicotine product lines, sometimes called e-shishas. These products vaporise liquid solution (e-liquid, 'e-juice') composed of propylene glycol and other chemicals, which is then inhaled.<sup>2</sup>

E-cigarettes are marketed with claims, so far unproven, of efficacy in smoking cessation.<sup>2–4</sup> Instead of mimicking the appearance of nicotine replacement therapy (NRT) products, e-cigarettes often use colour coding and flavours familiar from contemporary cigarette packets.<sup>5</sup> Recently, traditional tobacco

companies have emerged openly onto the market. Questions have been raised as to whether e-cigarettes are purely a new tactic for renormalising smoking in the context of declining use of conventional cigarettes.<sup>6</sup> The wide variety of e-cigarettes has drawn attention to their potential appeal for young people: the products come in multiple colours, shapes and flavours.

Regarding accessibility to youth, e-cigarettes have different legal status in different countries. Often they fall into a grey area of jurisdiction.<sup>1</sup> In Finland, selling tobacco products to individuals under 18 years old is prohibited, but as e-cigarettes are categorised as tobacco imitations, and e-liquids as substitute tobacco, minors can purchase them. E-cigarettes and e-liquids are treated as medicinal products if they contain nicotine. Products containing over 0.42 g nicotine/product or 10 mg/cartridge are treated as prescription medicines, while products with lower nicotine content are treated as over-the-counter medicines. No e-cigarette company holds a permit for selling nicotine-containing e-liquids in Finland because they have not demonstrated the required safety and efficacy evidence for medicinal products. However, consumers, including adolescents, can acquire nicotine-containing liquids from visits abroad or online cross-border distance sales.

The marketing of e-cigarettes is currently vast.<sup>6 7</sup> Lessons from conventional tobacco show that marketing is a risk factor for smoking initiation.<sup>8</sup> Active marketing efforts take place especially on the internet and social media—popular channels among youth, but challenging to supervising authorities.<sup>9</sup> In Finland, a legislative ban on direct and indirect advertising applies to e-cigarettes, but a point-of-sale display ban covers only tobacco products and their trademarks.

Little is known about the safety and health effects of these products, but the number of studies is growing. E-liquids have been shown to contain small amounts of harmful substances (eg, carcinogenic nitrosamines, toxic diethylene glycol).<sup>10</sup> The quality of e-liquids and electronic appliances has been shown to vary, and stated ingredient lists have not corresponded to actual ingredients.<sup>1 2 11 12</sup> As the business has grown, however, there is some evidence that the quality may have improved.<sup>13</sup> Some short-term negative health effects for the respiratory system have been reported,<sup>14</sup> but long-term effects remain uncertain.

For adolescents, use of nicotine-containing e-liquids constitutes a risk for developing dependence. Nicotine may have a lasting effect on the

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developing brain, due to its plasticity in adolescence.<sup>15</sup> Based largely on animal studies, adolescents may be expected to experience enhanced short-term positive and reduced aversive effects of nicotine, and fewer negative effects during nicotine withdrawal, compared with adults.<sup>16</sup> This is due to the brain being in a developmental phase, when dopamine-facilitating systems are overdeveloped and inhibitory systems underdeveloped,<sup>16</sup> which can explain why some adolescents show signs of nicotine dependence after brief intermittent use.<sup>17</sup>

There are only a few studies on use of e-cigarettes among adolescents. In 2011, 9.4% of South Korean adolescents reported having used e-cigarettes, 4.7% during the past 30 days and 1.4% without previous use of conventional cigarettes.<sup>18</sup> In Poland, 86.4% of students aged 15–24 years had heard about e-cigarettes in 2010–2011, and 23.5% of individuals aged 15–19 years had used e-cigarettes, 8.2% during the previous month.<sup>19</sup> Of never-smoking students, 3.2% had used them.<sup>19</sup> In the USA, the National Youth Tobacco Survey showed that e-cigarette ever use and recent use doubled among middle and high school students during 2011–2012.<sup>20</sup> The increase was strongest among high school students, in whom the ever use of e-cigarettes doubled from 4.7% to 10%. The same study showed that 20.3% of middle school e-cigarette users and 7.2% of high school users had never smoked a conventional cigarette.<sup>20</sup> Another US study showed that the prevalence of using an e-cigarette in the past 30 days more than doubled among high school students over a 16-month period, from 0.9% in 2010 to 2.3% in 2011.<sup>21</sup>

E-cigarette use in adolescence is strongly linked to ever or current tobacco smoking<sup>18–21</sup> and male gender.<sup>18–19</sup> In addition, associations have been found with older age and attempts to quit during the past year.<sup>18</sup> Interest in the product seems to relate to general attitudes towards smoking: non-smokers who have more negative beliefs about the typical smoker were less willing to try e-cigarettes.<sup>22</sup>

In general, awareness and use of e-cigarettes has increased rapidly in different parts of the world.<sup>23</sup> In Finland, the awareness of e-cigarettes among adults has been the highest (64%) in the EU, but actual use has remained marginal (current use 2%), including as an aid to smoking cessation (5%).<sup>24</sup> In this study, we publish the first results concerning awareness and use of e-cigarettes and types of e-liquids used among Finnish adolescents aged 12–18 years, based on nationally representative data. To deepen and extend previous findings, we also studied adolescents' sources of e-cigarettes, exposure to e-cigarette advertising, and the association of e-cigarette use with interest in smoking cessation among daily smokers. Furthermore, because e-cigarettes seem to relate strongly to concurrent conventional tobacco smoking in adolescence, we test the hypothesis that e-cigarette use relates to other tobacco use in general and shares similar risk factors to conventional smoking initiation.

## METHODS

### Sampling and participants

We used 2013 data from the nationwide monitoring system on adolescent health and health behaviours, the Adolescent Health and Lifestyle Survey. This is a cross-sectional postal survey, with an option to answer securely online, conducted biennially in Finland since 1977 by the University of Tampere. Nationally representative samples of individuals aged 12, 14, 16 and 18 years were obtained from the national Population Register Centre (<http://vrk.fi/default.aspx?site=4>). All Finns born on sample days in June, July or August in each age group were selected. This minimised the age variation within age groups.

The Ethics Committee of the Tampere region approved the study protocol: filling in the questionnaire was considered as adolescents' consent to participate. No parental consent was requested.

Self-administered questionnaires in official languages (Finnish/Swedish) were sent to 9398 adolescents in February, followed by three reminders to non-responders. The number of responders to the questionnaire was 3535 (response rate 38%; including 1405 boys and 2130 girls). A short questionnaire, including the main questions on tobacco, was sent with the third reminder to the non-responders, of whom 623 responded to the short questionnaire; these responses were used for comparison of responders and non-responders.

### Study measures

Awareness and use of e-cigarettes was assessed via the questions: 'Have you ever tried electronic cigarettes? How many times altogether?' Options were: 'I do not know what they are', 'No', 'I have tried once or twice', 'I have tried 20 times or less', 'I have tried more than 20 times'. The question on e-liquid content was: 'If you have used electronic cigarettes, what substance did they contain?', with the options 'Liquid with nicotine', 'Liquid without nicotine', 'I do not know'. The respondent could report several liquids. Sources of e-cigarettes were established via an open-ended question: 'If you have used electronic cigarettes, where did you get them?' The 29 different responses were categorised into six sources (see table 3). The question about exposure to e-cigarette advertising was: 'During the past month, have you seen an electronic cigarette advertisement in Finland?' The alternatives were 'No', 'Yes'. Those who answered 'Yes' were asked 'Where?' Thirty different responses were categorised into six groups: Facebook, other internet pages, traditional media, shops, the street, and elsewhere. Interest in quitting smoking was assessed by asking current smokers: 'Have you thought about trying to quit smoking in the near future?', with the options 'No', 'Yes'.

Smoking status was divided into three groups: never-smokers (never tried conventional cigarettes), experimenters (tried but did not smoke daily), and daily smokers (reported daily smoking and smoked >50 cigarettes in lifetime). Snus and waterpipe use were dichotomised (tried, not tried). Parents' smoking was asked separately and categorised as neither smokes, only mother smokes, only father smokes, both smoke. Attitude towards conventional cigarette smoking was assessed by posing the statement: 'Smoking is for losers' (which has been used previously in the survey), with the options definitely agree, agree to some extent, difficult to say, slightly disagree, definitely disagree. School type was categorised as comprehensive, general upper secondary, vocational upper secondary, combined general and vocational upper secondary, other schools, not in school. (The last two categories were combined due to their small sizes.) School performance was based on the respondent's subjective assessment of school performance compared with the class average: 'much or slightly better', 'about class average', and 'slightly or much poorer'. Family structure was dichotomised according to whether the respondent lived with both parents (intact family) or not (other). Parents' education was asked separately and categorised into one variable (highest educational level of either parent): 'high' (over 12 years of education), 'middle' (9–12 years), and 'low' (9 years or less). Father's and mother's work situations were dichotomised: 'working', 'not working', the latter including both unemployed and retired. The proportion of missing answers was small for all variables (0.4–7.9%).



**Table 1** Distribution of e-cigarette use among adolescents in Finland in 2013 by sex and age, %. The total columns are adjusted for age or age and sex

Use of e-cigarettes   Age	Girls					Boys					All Total
	12	14	16	18	Total	12	14	16	18	Total	
Do not know what they are	43.8	13.3	7.2	3.2	16.9	29.3	9.9	4.9	5.8	12.5	14.7
Never tried	55.9	74.5	72.7	73.2	69.1	68.4	70.6	66.6	62.8	67.1	68.1
Have tried once or twice	0.3	9.1	15.3	18.4	10.8	1.6	15.3	19.5	20.6	14.3	12.6
Have tried 20 times or less	–	2.5	3.2	3.7	2.4	0.8	3.2	3.7	5.1	3.2	2.8
Have tried more than 20 times	–	0.7	1.7	1.6	1.0	–	1.0	5.3	5.8	3.0	2.0
Total	100	100	100	100		100	100	100	100		
N	288	596	596	626	2106	256	405	431	277	1369	3475

### Analysis of non-responders

Boys were underrepresented among the responders (40.6%) compared with the sample (50.7%). For age, adolescents aged 12 years were overrepresented (16.3% vs 13.5%) and those aged 18 years underrepresented (25.7%; 30.4%) while differences were small for those aged 14 years (27.6%; 28.9%) and 16 years (28.5%; 29.2%). The impact of non-response was assessed by comparing those who responded to the full questionnaire (n=3535) with those who responded to the short questionnaire (n=623) which was sent to three-time non-responders. (It was assumed that this latter group closely represented all non-responders.) E-cigarette use did not differ between the groups (Pearson's  $\chi^2$  test,  $p=0.502$ ), neither did age ( $p=0.216$ ), but boys were more likely to be non-responders ( $p=0.01$ ). For boys, school type ( $p=0.323$ ) and school performance ( $p=0.926$ ) did not differ between the groups. Girls studying in vocational upper secondary school were more likely to be classed as non-responders compared with girls in general upper secondary school ( $p=0.000$ ), as were those with average or worse school performance ( $p=0.001$ ).

### Data analysis

Awareness and use of e-cigarettes and e-liquids were cross tabulated with age, sex, tobacco use and socioeconomic background. Age-adjusted and sex-adjusted prevalence was calculated using direct adjustment giving equal weights to each group. For 12-year-old adolescents, only results for use and awareness are presented because their e-cigarette use was rare. Sources of e-cigarettes are presented for those who had used e-cigarettes, and advertisement locations for those who had seen them. Interest in smoking cessation in relation to e-cigarette use was analysed among daily smokers.

Factors associated with ever use of e-cigarettes were analysed using stepwise logistic regression analysis. The analysis was first conducted separately for all independent variables, adjusting for age and sex. All independent variables were then included in a multivariate model. Results are presented as ORs and 95% CIs. The Pearson  $\chi^2$  test was used to test for statistical significance. Data were analysed using IBM SPSS Statistics, V20.

## RESULTS

### Awareness and use of e-cigarettes

Awareness of e-cigarettes was high: 85.3% of 12–18-year-old adolescents reported knowing what e-cigarettes are. Awareness was lowest among the youngest and highest among the oldest age groups (table 1). Overall, 17.4% of the respondents had tried e-cigarettes, although most of them (12.6%) had experimented only once or twice. The proportion who had used e-cigarettes more than 20 times was 2.0%. Experimentation with e-cigarettes increased by age for both sexes, and in each age group experimentation was more common among boys.

### Content of e-liquids

Use of nicotine e-liquids was common: 65.7% of e-cigarette ever users reported this (table 2). Every fourth ever user had used only liquids without nicotine, and every tenth person did not know the content of the liquid.

Of those who had used e-cigarettes more than two times, 83.6% had used liquids containing nicotine. Of those who had tried e-cigarettes only once or twice, the proportion was 59.4%. All those who had used e-cigarettes more than 20 times knew what e-liquids they had used: the highest proportion (14.3%) of those who did not know the content of e-liquids was among those who had tried e-cigarettes only once or twice.

**Table 2** E-cigarette ever users by type of e-cigarette liquid, and the proportion of e-cigarette ever users in each e-liquid category who had never tried conventional cigarettes

	Type of e-liquid					
	With nicotine		Without nicotine		Did not know	
	n	% 95% CI	n	% 95% CI	N	% 95% CI
E-cigarette ever users, all	411	65.7% 61.8 to 69.3%	147	23.5% 20.3 to 27.0%	68	10.9% 8.7 to 13.5%
Proportion of e-cigarette ever users who had never tried conventional cigarettes in each e-liquid category	12	2.9% 1.7 to 5.0%	31	21.1% 15.3 to 28.4%	9	13.2% 7.1 to 23.3%

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**Table 3** Sources of e-cigarettes among adolescent e-cigarette ever users who reported a source, % (95% CI) (N=517)\*

Source of e-cigarettes	%	(95% CI)
Friends	79.9	(76.2 to 83.1%)
Internet	7.2	(5.2 to 9.7%)
Family	5.0	(3.5 to 7.3%)
Abroad	3.3	(2.1 to 5.2%)
Shop	1.7	(0.9 to 3.4%)
Other place	4.1	(2.7 to 6.5%)

\*A person may have reported more than one source.

Of all e-cigarette ever users, 8.3% had never tried tobacco smoking. Of those who used nicotine-containing e-liquids, 2.9% were never smokers (table 2). Of those 8.3% (n=52) of e-cigarette users who had never tried tobacco smoking, 12 had used nicotine-containing e-liquid, 31 had used only liquids without nicotine and 9 did not know what the liquid was.

### Sources of e-cigarettes and exposure to e-cigarette advertising

E-cigarette ever users were asked about the source of their e-cigarettes (table 3). Almost 80% reported friends as their primary source, with acquisition from the internet (7.2%) as the second most common source.

During the previous month, 10.5% of respondents had seen e-cigarette advertisements. Of those, 21.8% had seen them on Facebook, 41.4% on other internet pages, 14.7% in shops, 7.4% in magazines or on television, 4.9% in the street and 7.1% elsewhere.

### Interest in quitting smoking

Among adolescent daily smokers, 74.1% had considered quitting smoking in the near future. Adolescents aged 14–18 years with more frequent e-cigarette experimentation were less likely to consider quitting smoking (table 4). Among daily smokers who had tried e-cigarettes more than 20 times, 55.3% had considered quitting tobacco smoking; this dropped to 48.6% among heavier smokers (10 or more cigarettes per day). Of those daily smokers who had tried e-cigarettes only once or twice, three out of four had considered quitting.

### Factors associated with e-cigarette use

In model 1 (adjusted for age and sex), all tobacco-related and socioeconomic background variables had a significant association with e-cigarette experimentation (table 5). The strongest

associations were observed for daily smoking, followed by snus and waterpipe use.

Parents' smoking, exposure to e-cigarette advertisements and having a positive attitude towards conventional smoking were all positively associated with e-cigarette experimentation. Among socioeconomic characteristics, type of school and school performance were more strongly related to e-cigarette use than family structure, parents' education and parents' work situation. High parental education, being in employment and intact family protected against children's e-cigarette use.

In the final model (model 2, table 5), adjusting for all variables, e-cigarette use showed the strongest association with conventional smoking, followed by snus and waterpipe use. Among socioeconomic characteristics, only vocational education and having poor school performance retained a significant association with e-cigarette use.

### DISCUSSION

The results of our study demonstrate that awareness and ever use of e-cigarettes are high among adolescents, especially in older age groups and boys. E-cigarettes are also used by those who have never smoked conventional tobacco, although the majority of ever users are daily smokers. E-liquids used by adolescents typically contain nicotine. Friends are the main source of acquisition, followed by the internet. Despite the advertisement ban, every 10th adolescent reported having seen e-cigarette advertisements, mostly on Facebook. Use of other tobacco products, parents' smoking and lower socioeconomic background, and the adolescents' vocational education and poor school performance were associated with ever use of e-cigarettes. Among daily smokers, interest in smoking cessation was least common among those with the highest level of e-cigarette experimentation.

Our study found levels of e-cigarette awareness comparable to a recent Polish study, in which nearly nine out of ten adolescents had heard of e-cigarettes.<sup>19</sup> The proportion of Finnish adolescents who had tried e-cigarettes was comparable to that in Poland,<sup>19</sup> but higher than that reported in Korea and the USA.<sup>18 20 21</sup> Previous studies have reported significant increases in adolescents' e-cigarette use over the short term.<sup>18 20 21</sup> These findings are likely to reflect the rapid growth in product availability and marketing in recent years,<sup>6 7 9</sup> but also different regulatory approaches in these countries.

Our results showing higher use of e-cigarettes in male adolescents, conventional smokers and older age groups are in line with previous studies.<sup>18 19</sup> The finding that those adolescents with positive attitudes towards conventional smoking have higher ever use of e-cigarettes also supports previous results regarding willingness to try e-cigarettes.<sup>22</sup> In addition, the

**Table 4** Percentage and 95% CI of those who had considered quitting tobacco smoking in the near future, according to e-cigarette use, among all 14–18-year-old daily smokers and among those who smoke ≥10 cigarettes daily

Use of e-cigarettes	Considered quitting smoking			Daily smokers, ≥10 cigarettes daily		
	All daily smokers					
	n	%	95% CI (%)	n	%	95% CI (%)
Do not know what they are/Have not tried	78	80.8	70.7 to 88.0	26	65.4	46.2 to 80.6
Have tried once or twice	151	76.8	69.5 to 82.8	73	76.7	65.8 to 84.9
Have tried 20 times or less	68	73.5	62.0 to 82.6	43	67.4	52.5 to 79.5
Have tried more than 20 times	47	55.3	41.2 to 68.6	37	48.6	33.4 to 64.1
All	255	74.1	69.3 to 78.5	179	67.0	59.9 to 73.5

**Table 5** Age and sex adjusted prevalence (%) of e-cigarette ever use and ORs and the 95% CI for e-cigarette use by tobacco-related and socioeconomic factors, among adolescents aged 14–18 years

Characteristics	Ever use of e-cigarettes, %	Model 1* OR (95% CI)	Model 2† OR (95% CI)
<i>Tobacco-related factors</i>			
Smoking status			
Never (n=1604)	3.6	1.00	1.00
Experimenter (n=994)	32.9	<b>14.17</b> (10.35 to 19.41)	<b>8.09</b> (5.56 to 11.78)
Daily smoker (n=350)	81.1	<b>120.86</b> (81.72 to 178.74)	<b>41.35</b> (25.22 to 67.79)
Snus use			
Never (n=2373)	11.7	1.00	1.00
Ever (n=586)	63.0	<b>12.05</b> (9.69 to 14.98)	<b>2.96</b> (2.18 to 4.00)
Waterpipe use			
Never (n=2402)	15.6	1.00	1.00
Ever (n=531)	56.0	<b>6.54</b> (5.27 to 8.12)	<b>2.21</b> (1.62 to 3.02)
Parents' smoking			
Neither of them smokes (n=1974)	18.6	1.00	NS
Only mother smokes (n=180)	31.4	<b>2.23</b> (1.58 to 3.16)	
Only father smokes (n=381)	28.4	<b>1.84</b> (1.42 to 2.38)	
Both of them smoke (n=237)	33.2	<b>2.69</b> (1.99 to 3.62)	
Has seen e-cigarette advertisement			
No (n=2542)	22.0	1.00	NS
Yes (n=335)	30.5	<b>1.54</b> (1.19 to 1.99)	
Statement 'Smoking is for losers'			
Agree (n=1841)	17.2	1.00	NS
Hard to say (n=679)	30.4	<b>2.14</b> (1.74 to 2.64)	
Disagree (n=374)	36.5	<b>2.72</b> (2.12 to 3.50)	
<i>Socioeconomic background</i>			
School			
General upper secondary (n=1165)	18.1	1.00	1.00
Comprehensive (n=1077)	19.5	1.38 (0.77 to 2.46)	1.36 (0.98 to 1.89)
Vocational upper secondary (n=520)	51.3	<b>3.29</b> (2.60 to 4.17)	<b>2.06</b> (1.43 to 2.97)
Combined general and vocational upper secondary/other schools (n=116)	25.4	<b>1.98</b> (1.28 to 3.05)	1.31 (0.69 to 2.48)
Not in school (n=66)	46.9	<b>2.18</b> (1.26 to 3.76)	1.40 (0.16 to 12.38)
School performance			
Much or slightly better (n=1431)	16.2	1.00	1.00
About class average (n=1132)	25.1	<b>1.78</b> (1.45 to 2.17)	1.27 (0.95 to 1.69)
Slightly or much poorer (n=319)	41.7	<b>3.89</b> (2.96 to 5.12)	<b>1.92</b> (1.28 to 2.90)
Family structure			
Intact family (n=2308)	20.4	1.00	NS
Other family type (n=650)	29.6	<b>1.73</b> (1.41 to 2.11)	
Parents' educational level			
High (n=1009)	16.7	1.00	NS
Middle (n=1667)	26.0	<b>1.78</b> (1.45 to 2.19)	
Low (n=64)	24.7	1.74 (0.96 to 3.18)	
Father's work situation			
Working (n=2446)	21.5	1.00	NS
Not working (n=357)	27.5	<b>1.42</b> (1.09 to 1.83)	
Mother's work situation			
Working (n=2570)	22.0	1.00	NS
Not working (n=310)	28.6	<b>1.58</b> (1.21 to 2.07)	

\*Model 1: logistic regression, adjusted for age and sex.

†Model 2: stepwise forward logistic regression; includes all variables in model 1. Note: OR is given in boldface when it indicates a statistically significant ( $p < 0.005$ ) difference from the odds of the reference category.

NS, non-significant.

finding that every 12th adolescent among the e-cigarette ever users was a never-smoker corresponds to evidence from the USA.<sup>20</sup>

E-cigarettes are marketed as a tool for smoking cessation.<sup>2–3</sup> Despite a growing number of studies among adults, only one study from Korea has previously reported associations between

e-cigarette use and smoking cessation in adolescence.<sup>18</sup> This study found that e-cigarette use was more common among those with a history of recent quit attempts.<sup>18</sup> Our results suggest a different pattern: e-cigarette use was most common among those tobacco smokers who were least interested in smoking cessation. Further studies are needed to understand the

## Research paper

relationship between e-cigarette use and smoking cessation in adolescence.

E-liquids containing nicotine are a potential source of nicotine addiction. The use of different types of e-liquids among adolescents has not been previously reported. In our study, most adolescent users of e-cigarettes used e-liquids containing nicotine. A small proportion of nicotine e-liquid users had never tried conventional cigarettes. The possibility of developing nicotine addiction through e-cigarettes cannot be excluded. Further, users may also be exposed to toxic levels of nicotine when refilling cartridges or misusing e-liquids.<sup>2</sup> Substances other than nicotine could be used, thus delivering drugs with a new device.<sup>25</sup> Since the majority of e-cigarette users were current daily smokers, concurrent use seems likely to lead to higher nicotine consumption. Dual use is an important topic for further research.

Our results show that adolescents can easily obtain nicotine and non-nicotine e-liquids, despite the prohibition of nicotine e-liquid sales inside Finland. This indicates that more attention should be paid to cross-border distance sales. The main source for e-cigarettes is friends, which may mean purchasing on behalf of friends or sharing. This has not been reported previously. Social sources, particularly friends, are also known to be the most common source for conventional cigarettes.<sup>26</sup>

Despite the Finnish ban on advertising, every 10th adolescent had seen e-cigarette advertisements, mostly on the internet. Several e-cigarette companies have relocated their place of business outside Finland, where they continue advertising to Finnish consumers. Facebook was the only social media website that adolescents mentioned. Advertisements on Facebook can be versatile, ranging from paid commercials to informal groups promoting a specific brand. Interestingly, ever use of e-cigarettes was most common among those who reported seeing an e-cigarette advertisement. Adolescents' knowledge of e-cigarettes can be partly based on marketing messages, which can be misleading.<sup>3</sup>

These results confirm our hypotheses that e-cigarette use is related to tobacco use, with associated factors resembling those of conventional smoking initiation. E-cigarette use was associated with familial socioeconomic disadvantage, vocational school career and poor school performance, which are also risk factors for conventional tobacco smoking.<sup>27</sup> The meaning of e-cigarettes in adolescents' everyday life may be similar to that of conventional cigarette use since they share similar features. The similarity with patterns of waterpipe and snus use (the first a newcomer, and the second a product with sales prohibition in Finland) suggest that e-cigarettes may appeal to adolescents with novelty-seeking or sensation-seeking characteristics. Another interpretation could be that e-cigarettes appeal to adolescents in the process of forming a smoker identity, a known risk factor for smoking escalation.<sup>28</sup>

Some limitations of our study should be noted. Our data are cross sectional, allowing no causal conclusions. The brief measures of our key constructs may be seen as a limitation since our measures do not capture frequent use of e-cigarettes—only ever use and total episodes of experimentation. Our results are based on adolescents' self-reports, and we cannot know how accurately they answered questions concerning this new phenomenon. The low response rate may compromise the generalisability of the study, although the Finnish arm of the Global Youth Tobacco Survey (conducted a few months earlier among 13–15-year-old adolescents) showed similar age-specific and sex-specific prevalence of e-cigarette use.<sup>29</sup> Furthermore, our comparison of responders and non-responders found no meaningful difference in use of e-cigarettes.

## CONCLUSIONS

E-cigarette experimentation in adolescence is linked with conventional cigarette use, positive attitudes towards smoking, and experimentation with other tobacco products—indicating novelty-seeking behaviour. E-liquids used by adolescents typically contain nicotine. Factors associated with e-cigarette use are similar to those for conventional smoking initiation. Among smokers, e-cigarette use is associated with lower interest in smoking cessation; never smokers are also shown to use e-cigarettes. These findings challenge claims that the product's sole function is as an adult-oriented smoking cessation or harm reduction tool. Further research is needed to understand adolescents' e-cigarette use in different parts of the world. It will be important to monitor the development of this new phenomenon during the coming years and to develop appropriate policy measures to protect young people from the risks of nicotine addiction. The Framework Convention on Tobacco Control obliges parties to adopt and implement effective measures for preventing and reducing tobacco consumption, and for preventing nicotine addiction.<sup>30</sup> The new European Tobacco Products Directive sets out important steps for EU-level regulation of e-cigarettes and their marketing. Nevertheless, member states retain responsibility for regulating availability of non-nicotine e-cigarettes and e-liquids, flavours, age limits and use of e-cigarettes in smoke-free environments. For youth protection, additional preventive policies should include age limits, regulation of e-liquid flavours, and efforts to reduce cross-border distance sales.

## What this paper adds

- Awareness and ever use of e-cigarettes appear high among Finnish adolescents, especially in older age groups and boys. E-liquids used in adolescence typically contain nicotine.
- Factors associated with e-cigarette use and sources for e-cigarettes appear similar to those for conventional cigarettes among adolescents.
- Among adolescent smokers, e-cigarette use was the most common among those who were the least interested in smoking cessation. E-cigarettes, even those containing nicotine e-liquid, are also used by those who have never tried conventional tobacco products. These argue against claims that the product is only an adult-oriented smoking cessation or harm reduction tool.

**Contributors** JK, HO and SEA had the main responsibility for the conduct of this paper. JK, LP, PL and AR were responsible for the planning of the study and for the data collection. LP was responsible for the preparation of the data for analysis. JK and LP were responsible for the statistical analyses. All authors made a substantial contribution to the design and the discussion of the results. All authors participated in writing this paper.

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**Ethics approval** The Ethics Committee of the Tampere region, Finland.

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## Awareness and determinants of electronic cigarette use among Finnish adolescents in 2013: a population-based study

Jaana Maarit Kinnunen, Hanna Ollila, Salma El-Tayeb El-Amin, Lasse Antero Pere, Pirjo Liisa Lindfors and Arja Hannele Rimpelä

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# **PUBLICATION IV**

## **Transmission of smoking across three generations in Finland**

Salma E. T. El-Amin, Jaana M. Kinnunen, Hanna Ollila, Mika Helminen,  
Joana Alves, Pirjo Lindfors, Arja H. Rimpelä

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Article

# Transmission of Smoking across Three Generations in Finland

Salma E. T. El-Amin <sup>1</sup>, Jaana M. Kinnunen <sup>1,\*</sup>, Hanna Ollila <sup>2</sup>, Mika Helminen <sup>1,3</sup>, Joana Alves <sup>4</sup>,  
Pirjo Lindfors <sup>1,5</sup> and Arja H. Rimpelä <sup>1,5,6</sup>

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- <sup>1</sup> School of Health Sciences, University of Tampere, 33014 Tampere, Finland; salma.el.amin@staff.uta.fi (S.E.T.E.-A.); mika.helminen@uta.fi (M.H.); pirjo.lindfors@uta.fi (P.L.); arja.rimpela@uta.fi (A.H.R.)
  - <sup>2</sup> Tobacco, Gambling and Addiction Unit, National Institute for Health and Welfare, 00271 Helsinki, Finland; hanna.ollila@thl.fi
  - <sup>3</sup> Science Centre, Pirkanmaa Hospital District, 33521 Tampere, Finland
  - <sup>4</sup> National School of Public Health, Lisbon NOVA University, P-1600-560 Lisbon, Portugal; joana.alves@ensp.unl.pt
  - <sup>5</sup> PERLA—Tampere Centre for Childhood, Youth and Family Research, University of Tampere, 33104 Tampere, Finland
  - <sup>6</sup> Department of Adolescent Psychiatry, Pitkänieki Hospital, Tampere University Hospital, 33380 Nokia, Finland
- \* Correspondence: jaana.m.kinnunen@staff.uta.fi; Tel.: +358-40-190-1667

**Abstract:** The influence of parents' smoking on children's smoking is well known, but few studies have examined the association between grandparents' and grandchildren's smoking. We studied the association between paternal and maternal grandparents' smoking and their grandchildren's tobacco use and assessed whether parents' smoking is a mediator in this process. Data were obtained from a national survey of 12–18-year-old Finns in 2013 ( $N = 3535$ , response rate 38%). Logistic regression and mediation analyses were used. Both boys and girls had higher odds for smoking experimentation, daily smoking and other tobacco or tobacco-like product use if their mother, father or any of the four grandparents were current or former smokers. When parents' and grandparents' smoking status were included in the same model, grandparents' smoking generally lost statistical significance. In the mediation analysis, 73% of the total effect of grandparents' smoking on grandchildren's daily smoking was mediated through parents' smoking, 64% on smoking experimentation and 63% on other tobacco or tobacco-like product use. The indirect effect of a mother's smoking was higher than that of a father's. To conclude, paternal and maternal grandparents' smoking increases grandchildren's tobacco use. The influence is mainly, but not completely, mediated through parents' smoking.

**Keywords:** smoking; tobacco use; adolescents; intergenerational transmission; parents; grandparents

## 1. Introduction

Family has an important role in providing models of behaviors and shaping the tobacco practices, values, beliefs and attitudes of children and adolescents [1–3]. Children learn to construct their reality based on early experiences in their environment, peer behaviors and cultural norms [2,4]. The effect of parental smoking on children's smoking has been well documented [5], but there have been differences found regarding whether a mother's or father's smoking is a more important risk factor and regarding whether the effect varies based on the child's gender [6–10]. In their systematic review and meta-analysis, Leonardi-Bee *et al.* [5] concluded that having two smoking parents increases the child's smoking risk compared to having just one smoking parent. They also concluded that a mother's

smoking is a slightly more prominent risk factor than a father's smoking (OR 2.19 *vs.* OR 1.66). They also provided some evidence of a sex-specific effect in which boys were more substantially influenced by paternal smoking, while girls were influenced more by maternal smoking.

Despite the vast evidence of the parental influence on smoking initiation, the influence of grandparents' smoking and the intergenerational transmission of smoking behavior beyond two generations have rarely been studied [6,7]. However, the increased life expectancy of both men and women in industrialized countries [11] means that grandparents live longer and have more opportunities to witness their grandchildren's development from early childhood to adolescence and even adulthood and thus their smoking may play a role in the initiation of smoking among their grandchildren. Escario and Wilkinson [12] showed that smoking by at least one grandparent living in the same family as grandchildren increases the odds of smoking for boys but not for girls. A study from the U.S. examined the smoking behavior across three generations and showed that smoking behaviors are transferred from preceding generations to later generations and that parents have a mediating role in this process [8]. There are no published studies in which the effects of maternal and paternal grandparents' smoking on grandchildren's smoking have been studied separately; nor have there been studies on the use of tobacco or tobacco-like products other than cigarettes. In this study, other tobacco or tobacco-like products include snus, water pipes and electronic cigarettes, and the shorter term "other tobacco products" will be used to encompass these products, although electronic cigarettes do not actually contain tobacco.

In this study, we addressed the transmission of smoking across three generations. The research questions were as follows:

- (1) Are maternal and paternal grandmothers' and grandfathers' smoking related to their grandchildren's smoking and use of other tobacco products?
- (2) Is the influence of grandparents' smoking independent of parents' smoking or is it mediated through parental smoking behavior?

In addition, we studied the relationship of mother's and father's smoking to their children's smoking and use of other tobacco products as well as differences between genders.

## 2. Methods

### 2.1. Sampling and Participants

Data from the 2013 Adolescent Health and Lifestyle Survey (AHLS), the nationwide monitoring system on adolescent health and health behaviors in Finland was used. AHLS is a cross-sectional postal survey, with an option to answer securely online. It has been conducted biennially since 1977. A nationally representative sample of individuals aged 12, 14, 16 and 18 years was obtained from the national Population Register Centre. All Finns born on sample days in June, July or August in each age group were selected to minimize the age variation within age groups. The Ethics Committee of the Tampere region approved the study protocol. Filling in the questionnaire was considered an adolescent's consent to participate, and no parental consent was needed according to the Ethics Committee. In January 2013, self-administered questionnaires in Finnish were sent to 9398 adolescents. They were followed by three reminders to non-responders. The number of responders to the questionnaire was 3535, indicating a response rate of 38% (including 1405 boys and 2130 girls).

### 2.2. Measures

#### 2.2.1. Children's Smoking

Children's smoking status was assessed with the questions: "Have you ever tried smoking?" with the options "No" and "Yes"; "How many cigarettes have you smoked during your life-time until now?" with the options "None", "Only one", "Approximately 2–50" and "More than 50"; and "Which of the

following options best describes your current smoking?” with the options “I smoke once per day or more often”, “I smoke once per week or more often but not daily”, “I smoke less than once per week”, “I have stopped smoking” and “I don’t smoke”. Based on the answers, the smoking status was divided into three groups: Never smokers (never tried smoking), experimenters (tried but did not smoke daily) and daily smokers (reported daily smoking and had smoked >50 cigarettes during their lifetimes). For the analyses, dichotomization was conducted for tried smoking (experimenting) and daily smoking (No/Yes) based on the smoking initiation process where “tried smoking” represents the first steps and “daily smoking” represents regular smoking where nicotine addiction has a stronger role (See Table 1).

**Table 1.** Distribution of children’s smoking experimentation, daily smoking and other tobacco product use \* and parents’ and grandparents’ smoking by gender.

Smoking	Girls	Boys	All
	(n = 2130)	(n = 1405)	(N = 3535)
	% (n)	% (n)	% (n)
Children			
<i>Tried smoking</i>			
No	59.8 (1267)	61.6 (852)	60.5 (2120)
Yes	40.2 (851)	38.4 (531)	39.5 (1382)
<i>Daily smoking</i>			
No	89.4 (1901)	91.0 (1277)	90.0 (3178)
Yes	10.6 (226)	9.0 (126)	10.0 (352)
<i>Other tobacco product use *</i>			
No	72.6 (1547)	67.2 (939)	70.5 (2486)
Yes	27.4 (583)	32.8 (458)	29.5 (1041)
Parents			
<i>Father’s smoking status</i>			
Never smoker	56.6 (1153)	56.1 (749)	56.4 (1902)
Ex-smoker	19.9 (406)	22.7 (303)	21.0 (705)
Current smoker	23.4 (477)	21.1 (282)	22.5 (759)
<i>Mother’s smoking status</i>			
Never smoker	70.0 (1451)	71.7 (962)	70.7 (2413)
Ex-smoker	13.9 (288)	14.8 (199)	14.3 (487)
Current smoker	16.1 (333)	13.5 (181)	15.1 (514)
Paternal grandparents			
<i>Grandfather’s smoking status</i>			
Never smoker	75.5 (1070)	73.2 (736)	74.5 (1806)
Ex-smoker	14.4 (204)	17.0 (171)	15.5 (375)
Current smoker	10.2 (144)	9.8 (99)	10.0 (243)
<i>Grandmother’s smoking status</i>			
Never smoker	83.7 (1427)	85.8 (975)	84.5 (2402)
Ex-smoker	7.8 (133)	7.2 (82)	7.6 (215)
Current smoker	8.5 (145)	7.0 (80)	7.9 (225)
Maternal grandparents			
<i>Grandfather’s smoking status</i>			
Never smoker	71.0 (1132)	71.4 (761)	71.1 (1893)
Ex-smoker	17.1 (273)	17.6 (188)	17.3 (461)
Current smoker	11.9 (190)	11.0 (117)	11.5 (307)
<i>Grandmother’s smoking status</i>			
Never smoker	81.3 (1484)	82.9 (979)	81.9 (2463)
Ex-smoker	8.5 (155)	8.6 (102)	8.5 (257)
Current smoker	10.2 (186)	8.5 (100)	9.5 (286)

\* Snus, water pipe and electronic cigarettes.

The use of other tobacco or tobacco-like products was assessed with the following questions: “Have you ever tried snus?” with the options “Have not tried”, “Tried once”, “Have used 2–50 times” and “Have used more than 50 times”; and “Have you ever tried water pipe?” and “Have you ever tried electronic cigarettes?” with the options for both questions “I don’t know what this is”, “No”, “I have tried this product once or twice”, “I have tried this product 20 times or fewer” and “I have tried this product more than 20 times”. For the analyses, these three questions were combined as one dichotomized variable “other tobacco product use” such that reporting a trial of at least one of these products was coded as “Yes”, and otherwise the response was coded as “No”.

### 2.2.2. Parents’ and Grandparents’ Smoking

Data on parents’ and grandparents’ smoking were assessed with the questions “Have your parents smoked during your lifetime?” and “Have your grandparents smoked during your lifetime?” separately for father and mother, paternal grandfather and grandmother, and maternal grandfather and grandmother. The options were “Never”, “Has stopped”, “Smokes currently”, and “I don’t have one or I don’t know”. In the analyses, the answers for the option “I don’t have one or I don’t know” were included in the category “Never”. The proportion of missing values was 2.8% for father, 1.5% for mother, 28.9% for paternal grandfather, 16.6% for paternal grandmother, 22.3% for maternal grandfather, and 12.4% for maternal grandmother. Additionally, a combined variable was created for parents’, paternal grandparents’ and maternal grandparents’ smoking with categories “Neither of them smokes”, “One or both has stopped”, “One of them smokes” and “Both of them smoke”.

### 2.2.3. Other Variables

Parents’ employment status was assessed and categorized separately for fathers and mothers as “Working”, “Unemployed” and “Other” (retired or on a long sick leave). Parents’ education was assessed separately and combined into one variable according to the highest level that the parents had achieved with the categories “high” (more than 12 years of education), “middle” (9–12 years) and “low” (9 years or fewer).

## 2.3. Analysis of Non-Response

Boys were underrepresented among the respondents (40.6%) compared with the overall sample (50.7%). For age, adolescents aged 12 years were overrepresented (16.3% *vs.* 13.5%), and those aged 18 years were underrepresented (25.7% and 30.4%, respectively), while differences were small for those aged 14 years and 16 years. Boys were more likely to be non-responders ( $p = 0.01$ ), but the differences between age groups were not significant ( $p = 0.216$ ). The impact of non-response on the reports of parents’ and grandparents’ smoking was assessed by dividing the responders into four groups according to how promptly they had answered the survey. It was assumed that the later the person answered, the more he/she resembled a non-responder. There were no systematic differences between the groups that had answered early or late that would have suggested an over- or underrepresentation of parental or grandparental smoking among the non-respondents (Appendix Table A1).

## 2.4. Data Analysis

Logistic regression analysis was used to study the association of parents’ and grandparents’ smoking with children’s smoking and other tobacco product use. Results are presented as odds ratios (ORs) and 95% confidence intervals (CIs). First, age-adjusted ORs and 95% CIs for boys’ and girls’ tobacco use variables were calculated according to the mother’s, father’s, and each of the four grandparent’s smoking statuses (Table 2). Second, ORs and 95% CIs were calculated for children’s tobacco use variables according to each grandparent’s smoking status, adjusting first for age and sex (Model 1, Table 3) and then for parents’ smoking status, employment status and education (Model 2, Table 3). Third, logistic regression analysis was conducted for children’s tobacco use according to the number of smokers among parents, maternal grandparents and paternal grandparents (Model 1,

Table 4), adjusting for age and sex. Finally, all three variables were included in the analysis at the same time, adjusting for age, sex, parents' education, and employment status (Model 2, Table 4).

The Pearson  $\chi^2$  test was used to examine the statistical significance;  $p$ -values in Tables 2–4 represent the statistical significance of the relationship between children's tobacco use and parents'/grandparents' smoking variables (Wald test). The logistic regression analyses were conducted with IBM SPSS Statistics v. 20.0 software (IBM Inc. Armonk, NY, USA).

The mediation analysis [13] was performed to assess how much of the effect of the exposure to grandparents' smoking on children's smoking is mediated through mothers' and fathers' smoking. Grandparents' smoking was assumed to have an effect on both mothers' and fathers' smoking and also on children's smoking (Figure 1). Mothers' and fathers' smoking was assumed to have effect only on children's smoking. All the dependent, independent and mediator variables were coded as binary (No = 0, Yes = 1). For the mother and father, the categorization was 0 = Never smoker and 1 = Smoker or ex-smoker, and for grandparents, 0 = All grandparents never smokers and 1 = One or more grandparents smokers or ex-smokers. STATA (version 13.1) software with a "binary-mediation" program was used for mediation analyses, together with a "bootstrap" command for producing the confidence intervals [14].

### 3. Results

#### 3.1. Smoking among Children, Their Parents and Grandparents

Overall, 39.5% of the 12–18-year-old respondents had tried smoking, and 10.0% of them smoked daily (Table 1). Smoking, both experimentation and daily smoking, was somewhat more prevalent among girls, but the difference was not significant. Of all respondents, 29.5% had tried other tobacco products, boys more often than girls ( $p < 0.001$ ). In total, 15.1% of mothers and 22.5% of fathers smoked currently, compared to less than 12% of all grandparents.

#### 3.2. Association of Parents' and Grandparents' Smoking Statuses with Children's Tobacco Use

When analyzing boys and girls separately and adjusting for age, fathers' and mothers' current smoking was associated with children's smoking experimentation and daily smoking as well as with other tobacco product use (Table 2). The associations were somewhat stronger among girls; the strongest association was found between mothers' current smoking and girls' daily smoking. Additionally, fathers' and mothers' former smoking were associated with the children's smoking experimentation and daily smoking as well as with other tobacco product use (See also Appendix Table A2).

**Table 2.** Age-adjusted ORs and 95% CIs for boys’ and girls’ smoking experimentation, daily smoking and other tobacco product use \* by parents’ and grandparents’ smoking statuses.

Smoking Status of Parents and Grandparents	Tried Smoking			Daily Smoking			Other Tobacco Product Use *		
	Girls	Boys		Girls	Boys		Girls	Boys	
	OR (95% CI)	OR (95% CI)		OR (95% CI)	OR (95% CI)		OR (95% CI)	OR (95% CI)	
Parents									
<i>Father’s smoking status</i>									
Never smoker	1.00	1.00		1.00	1.00		1.00	1.00	
Ex-smoker	<b>1.73</b> (1.35–2.22)	<b>1.92</b> (1.44–2.57)		<b>2.27</b> (1.56–3.30)	<b>2.64</b> (1.66–4.21)		<b>1.45</b> (1.11–1.90)	<b>1.53</b> (1.14–2.05)	
Current smoker	<b>2.14</b> (1.70–2.71)	<b>1.90</b> (1.41–2.55)		<b>3.16</b> (2.25–4.44)	<b>2.32</b> (1.43–3.76)		<b>1.99</b> (1.55–2.54)	<b>1.50</b> (1.11–2.03)	
<i>p</i> -value	<0.001	<0.001		<0.001	<0.001		<0.001	0.009	
<i>Mother’s smoking status</i>									
Never smoker	1.00	1.00		1.00	1.00		1.00	1.00	
Ex-smoker	<b>1.88</b> (1.43–2.48)	<b>2.06</b> (1.49–2.86)		<b>2.33</b> (1.55–3.50)	<b>1.55</b> (0.90–2.66)		<b>1.96</b> (1.46–2.62)	<b>1.44</b> (1.03–2.01)	
Current smoker	<b>2.71</b> (2.08–3.52)	<b>1.56</b> (1.11–2.18)		<b>5.18</b> (3.72–7.22)	<b>2.91</b> (1.81–4.68)		<b>2.85</b> (2.18–3.72)	<b>1.46</b> (1.04–2.05)	
<i>p</i> -value	<0.001	<0.001		<0.001	<0.001		<0.001	0.010	
Paternal grandparents									
<i>Grandfather’s smoking status</i>									
Never smoker	1.00	1.00		1.00	1.00		1.00	1.00	
Ex-smoker	<b>1.42</b> (1.03–1.97)	1.36 (0.96–1.94)		1.29 (0.79–2.09)	<b>2.19</b> (1.24–3.85)		<b>1.44</b> (1.02–2.03)	1.35 (0.94–1.93)	
Current smoker	<b>1.84</b> (1.26–2.70)	1.34 (0.90–2.18)		<b>2.63</b> (1.59–4.33)	1.74 (0.85–3.57)		<b>2.40</b> (1.61–3.57)	1.17 (0.74–1.85)	
<i>p</i> -value	0.005	0.210		0.002	0.006		<0.001	0.291	
Grandmother’s smoking status									
Never smoker	1.00	1.00		1.00	1.00		1.00	1.00	
Ex-smoker	<b>2.47</b> (1.67–3.64)	0.71 (0.43–1.17)		<b>1.93</b> (1.14–3.25)	1.23 (0.53–2.82)		<b>1.92</b> (1.28–2.86)	0.76 (0.45–1.28)	
Current smoker	1.25 (0.86–1.83)	<b>1.73</b> (1.06–2.81)		<b>1.71</b> (1.01–2.90)	<b>3.02</b> (1.50–6.09)		1.38 (0.92–2.06)	<b>1.84</b> (1.14–2.99)	
<i>p</i> -value	<0.001	0.055		0.005	0.001		0.005	0.054	

Table 2. Cont.

Smoking Status of Parents and Grandparents	Tried Smoking		Daily Smoking		Other Tobacco Product Use *	
	Girls	Boys	Girls	Boys	Girls	Boys
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Maternal grandparents						
<i>Grandfather's smoking status</i>						
Never smoker	1.00	1.00	1.00	1.00	1.00	1.00
Ex-smoker	1.26 (0.95–1.68)	<b>1.72</b> (1.23–2.42)	1.11 (0.71–1.73)	<b>2.41</b> (1.42–4.08)	1.21 (0.89–1.65)	<b>1.48</b> (1.05–2.08)
Current smoker	<b>1.41</b> (1.00–1.97)	<b>1.84</b> (1.22–2.78)	1.31 (0.78–2.20)	<b>1.99</b> (1.02–3.89)	1.23 (0.85–1.79)	1.28 (0.84–1.96)
<i>p</i> -value	0.004	0.001	0.111	0.004	0.219	0.112
<i>Grandmother's smoking status</i>						
Never smoker	1.00	1.00	1.00	1.00	1.00	1.00
Ex-smoker	<b>1.58</b> (1.10–2.27)	1.03 (0.67–1.59)	1.47 (0.85–2.53)	1.60 (0.84–3.06)	<b>2.07</b> (1.42–3.03)	1.18 (0.76–1.82)
Current smoker	<b>1.66</b> (1.19–2.32)	1.47 (0.95–2.29)	<b>2.86</b> (1.88–4.36)	<b>2.03</b> (1.00–4.10)	<b>1.66</b> (1.16–2.36)	0.97 (0.60–1.55)
<i>p</i> -value	<0.001	0.205	<0.001	0.078	<0.001	0.895

\* Snus, water pipe and electronic cigarettes; Note: OR is given in boldface when it indicates a statistically significant ( $p < 0.05$ ) difference from the odds of the reference category.

**Table 3.** Adjusted ORs and 95% CIs for children’s smoking experimentation, daily smoking and other tobacco product use \* by grandparents’ smoking status in two models †.

Grandparents’ Smoking Status	Tried Smoking		Daily Smoking		Other Tobacco Product Use *	
	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)
<b>Paternal grandparents</b>						
<i>Grandfather’s smoking status</i>						
Never smoker	1.00	1.00	1.00	1.00	1.00	1.00
Ex-smoker	<b>1.40</b> (1.10–1.78)	1.16 (0.91–1.49)	<b>1.59</b> (1.10–2.28)	1.20 (0.82–1.76)	<b>1.40</b> (1.09–1.79)	1.21 (0.94–1.57)
Current smoker	<b>1.61</b> (1.20–2.14)	1.23 (0.91–1.66)	<b>2.27</b> (1.51–3.41)	1.50 (0.97–2.31)	<b>1.69</b> (1.25–2.28)	1.35 (0.99–1.84)
<i>p</i> -value	<0.001	0.072	<0.001	0.189	<0.001	0.035
<i>Grandmother’s smoking status</i>						
Never smoker	1.00	1.00	1.00	1.00	1.00	1.00
Ex-smoker	<b>1.52</b> (1.13–2.05)	1.14 (0.84–1.56)	<b>1.68</b> (1.08–2.61)	1.10 (0.69–1.75)	1.32 (0.97–1.81)	1.03 (0.75–1.43)
Current smoker	<b>1.40</b> (1.04–1.89)	1.07 (0.79–1.46)	<b>2.07</b> (1.36–3.15)	1.34 (0.86–2.09)	<b>1.54</b> (1.13–2.09)	1.20 (0.87–1.66)
<i>p</i> -value	<0.001	0.842	<0.001	0.441	0.007	0.515
<b>Maternal grandparents</b>						
<i>Grandfather’s smoking status</i>						
Never smoker	1.00	1.00	1.00	1.00	1.00	1.00
Ex-smoker	<b>1.44</b> (1.16–1.80)	1.21 (0.97–1.51)	<b>1.49</b> (1.07–2.09)	1.14 (0.80–1.62)	<b>1.33</b> (1.06–1.67)	1.13 (0.89–1.43)
Current smoker	<b>1.56</b> (1.20–2.02)	1.26 (0.96–1.65)	<b>1.53</b> (1.02–2.30)	0.99 (0.64–1.53)	1.24 (0.94–1.64)	0.99 (0.74–1.33)
<i>p</i> -value	<0.001	0.203	0.019	0.831	0.052	0.529
<i>Grandmother’s smoking status</i>						
Never smoker	1.00	1.00	1.00	1.00	1.00	1.00
Ex-smoker	1.30 (0.99–1.72)	1.01 (0.76–1.35)	<b>1.54</b> (1.02–2.34)	1.03 (0.66–1.59)	<b>1.57</b> (1.18–2.04)	1.26 (0.94–1.69)
Current smoker	<b>1.58</b> (1.21–2.06)	1.14 (0.86–1.51)	<b>2.60</b> (1.81–3.73)	<b>1.47</b> (1.00–2.17)	<b>1.35</b> (1.02–1.79)	0.99 (0.73–1.33)
<i>p</i> -value	<0.001	0.383	<0.001	0.260	0.002	0.163

\* Snus, water pipe and electronic cigarettes; † Model 1: adjusted for age and sex; Model 2: parents’ and grandparents’ smoking simultaneously in the model, adjusted for age, sex and parents’ education and employment status; Note: OR is given in boldface when it indicates a statistically significant ( $p < 0.05$ ) difference from the odds of the reference category.



**Table 4.** Adjusted ORs and 95% CIs for children’s smoking experimentation, daily smoking and other tobacco product use \* by number of smoking parents and grandparents in two models <sup>†</sup>.

Smoking Status of Parents and Grandparents	Tried Smoking		Daily Smoking		Other Tobacco Product Use *	
	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)
<b>Parents’ smoking</b>						
Both never smokers	1.00	1.00	1.00	1.00	1.00	1.00
One or both ex-smokers	<b>2.04</b> (1.71–2.42)	<b>1.93</b> (1.57–2.38)	<b>2.79</b> (2.11–3.69)	<b>2.77</b> (1.96–3.91)	<b>1.73</b> (1.45–2.07)	<b>1.70</b> (1.37–2.19)
One smoker	<b>1.87</b> (1.50–2.33)	<b>1.97</b> (1.50–2.58)	<b>2.20</b> (1.54–3.15)	<b>2.36</b> (1.52–3.68)	<b>1.78</b> (1.42–2.24)	<b>2.02</b> (1.52–2.67)
Both smokers	<b>2.55</b> (1.93–3.37)	<b>2.60</b> (1.82–3.71)	<b>5.63</b> (3.93–8.07)	<b>5.65</b> (3.55–9.02)	<b>2.42</b> (1.82–3.20)	<b>2.51</b> (1.74–3.63)
<i>p</i> -value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Paternal grandparents’ smoking</b>						
Both never smokers	1.00	1.00	1.00	1.00	1.00	1.00
One or both ex-smokers	<b>1.42</b> (1.15–1.75)	1.04 (0.82–1.32)	<b>1.76</b> (1.28–2.41)	1.17 (0.81–1.71)	<b>1.35</b> (1.08–1.68)	0.98 (0.76–1.27)
One smoker	1.22 (0.93–1.60)	1.10 (0.81–1.49)	<b>1.85</b> (1.24–2.78)	1.50 (0.95–2.38)	1.28 (0.97–1.70)	1.16 (0.84–1.60)
Both smokers	<b>2.92</b> (1.65–5.15)	<b>1.97</b> (1.05–3.68)	<b>3.45</b> (1.73–6.86)	2.05 (0.95–4.42)	<b>3.16</b> (1.80–5.55)	<b>2.34</b> (1.42–4.91)
<i>p</i> -value	<0.001	0.198	<0.001	0.129	<0.001	0.018
<b>Maternal grandparents’ smoking</b>						
Both never smokers	1.00	1.00	1.00	1.00	1.00	1.00
One or both ex-smokers	<b>1.34</b> (1.10–1.64)	1.19 (0.95–1.49)	<b>1.57</b> (1.14–2.14)	1.21 (0.85–1.73)	<b>1.38</b> (1.12–1.70)	1.18 (0.93–1.50)
One smoker	<b>1.50</b> (1.18–1.92)	1.67 (0.88–1.55)	<b>2.02</b> (1.40–2.91)	1.05 (0.67–1.66)	1.28 (0.99–1.67)	0.96 (0.70–1.30)
Both smokers	<b>2.00</b> (1.22–3.23)	1.58 (0.92–2.71)	<b>2.67</b> (1.33–5.33)	1.40 (0.64–3.04)	1.50 (0.88–2.58)	1.07 (0.59–1.95)
<i>p</i> -value	<0.001	0.185	<0.001	0.656	0.008	0.524

\* Snus, water pipe and electronic cigarettes; <sup>†</sup> Model 1: adjusted for age and sex; Model 2: parents’ and grandparents’ smoking statuses included simultaneously in the model, adjusted for age, sex and parents’ education and employment status; Note: OR is given in boldface when it indicates a statistically significant (*p* < 0.05) difference from the odds of the reference category.

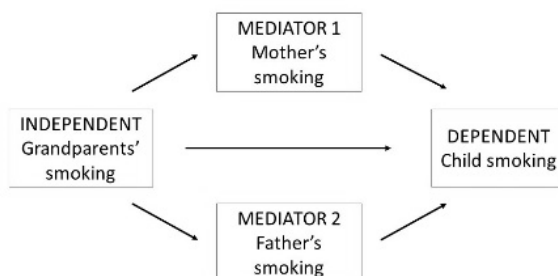
Grandparents' current smoking and former smoking were related to the grandchildren's smoking experimentation, daily smoking and other tobacco product use; however, the associations were not as strong as for parents' smoking (Table 2). Some of these relationships were not significant (e.g., boys' other tobacco product use with maternal grandfather and maternal grandmother; girls' daily smoking and other tobacco product use with maternal grandfather). The strongest association was found between paternal grandmothers' current smoking and boys' daily smoking (3.02; 1.50 to 6.09).

As shown in Table 3, the grandparents' current and former smoking statuses were associated with the grandchildren's smoking experimentation, daily smoking and other tobacco product use in the age- and sex-adjusted Model 1. Most associations were significant, excluding maternal grandmother's former smoking with smoking experimentation and paternal grandmothers' former smoking and maternal grandfathers' current smoking with other tobacco product use. When adjusting for parents' smoking, employment status and education (Table 3, Model 2), the associations remained but were weakened, and significance was lost because of the strong association of parents' smoking with grandparents' and children's smoking.

Children with two smoking parents or two smoking paternal or maternal grandparents had higher odds for smoking experimentation, daily smoking and other tobacco product use compared to when only one was a smoker or when parents or grandparents were former smokers (Table 4, Model 1). With all the variables from Model 1 along with the parents' employment status and education in Model 2, the associations with grandparents' smoking lost significance, with the exceptions of the relationships between two paternal grandparents' current smoking and the grandchildren's smoking experimentation and other tobacco product use.

### 3.3. Mediation Analysis

A mediation analysis was used to test whether the effect of grandparents' smoking on the grandchildren's smoking was mediated through mothers' and fathers' smoking (Figure 1). The total effect is a summary of the direct effect (grandparents' smoking) and the indirect effects (mother's and father's smoking) and it can be seen as a correlational measure between grandparents' smoking and grandchildren's smoking. Only about 10% (0.097) of grandchildren's smoking experimentation, about 14% (0.137) of daily smoking and about 9% (0.086) of other tobacco product use is explained by the transmission of smoking from the grandparents to the grandchildren (Table 5). The total effect of grandparents' smoking was mainly mediated through mothers' and fathers' smoking (indirect effects) for all three indicators of children's smoking. The proportion of the total effect that is mediating through parents' smoking was calculated by dividing the sum of the indirect effect by the total effect. Of the total effect of grandparents' smoking, 64% of smoking experimentation, 73% of daily smoking, and 63% for other tobacco product use was mediated through parents' smoking; and approximately one third (36%, 27% and 37%) of the total effect of grandparents' smoking on grandchildren's tobacco use was direct.



**Figure 1.** The relationships between grandparents' smoking, mother's and father's smoking and child's smoking.

**Table 5.** Coefficients and their confidence intervals from mediation analysis of the association between grandparents' smoking and grandchildren's smoking experimentation, daily smoking and other tobacco product use \*, considering mother's and father's smoking as mediators.

Effect	Tried Smoking	Daily Smoking	Other Tobacco Product Use *
<b>Indirect Effects</b>			
<i>Mother's smoking</i>	0.036 (0.021–0.049)	0.066 (0.042–0.087)	0.041 (0.02–0.055)
<i>Father's smoking</i>	0.026 (0.012–0.038)	0.034 (0.015–0.053)	0.013 (0.00–0.027)
<b>Direct effect</b>			
<i>Grandparents' smoking</i>	0.035 (−0.015–0.073)	0.037 (−0.03–0.111)	0.032 (−0.01–0.074)
<b>Total effect</b>	0.097 (0.049–0.135)	0.137 (0.07–0.209)	0.086 (0.04–0.125)
Proportion of the total effects mediated through parents	64%	73%	63%
Proportion of the total effect that is direct from grandparents to grandchildren	36%	27%	37%

\* Snus, water pipe and electronic cigarettes.

#### 4. Discussion

The results of this study demonstrate the association between grandparents' smoking and their grandchildren's tobacco use. The association was noted for both paternal and maternal grandparents and for experimentation, daily smoking and use of other tobacco or tobacco-like products. The transmission of smoking from grandparents to grandchildren was mainly mediated through mother's and father's smoking, which were also strongly related to children's tobacco use. One-third of the effect from grandparents was direct, not mediated through the parents. Children having two smoking parents or paternal or maternal grandparents were more likely to smoke, as were those with formerly smoking parents or grandparents.

The association between children's and their grandparents' smoking and the mediation effect of parents' smoking are consistent with the study by Vandewater *et al.* [8], which is the only report studying three generations and all grandparents and not only those who live in the same family with their grandchildren. Our study adds to the previous knowledge by showing that there seems to be a direct effect of grandparents on adolescent smoking behavior and that both the paternal and maternal grandparents are important.

A number of mechanisms, both social, psychological, and genetic, have been proposed to explain the influence of parents' smoking on their children's smoking. These mechanisms are likely to be valid, at least partly, in explaining the influence of grandparents' smoking behavior as well. The social and psychological mechanisms include direct modeling of behavior, in which parents and grandparents serve as role models, the transmission of norms and attitudes towards smoking, and (grand)parenting styles like a home smoking ban and controlling access to tobacco products and to certain friendship networks [15,16]. Genetics and biological pathways have also been shown to have a role in smoking behavior and nicotine addiction [17,18] and the role of second-hand smoke should not be forgotten [19]. Both genetic and environmental factors can explain smoking initiation and quantities of cigarettes smoked and environmental factors can regulate the expression of genetic predisposition [18,20]. Interestingly, non-biological stepparents' smoking has been shown to influence adolescents' smoking as significantly as parents' smoking [21], supporting the important role of social and environmental factors.

With the increasing life expectancy, children have more possibilities to spend time with their grandparents, explaining why their influence on different aspects of children's life is likely to be

higher than in previous decades. In Finland, where this study was conducted, 30% of 12-year-old children had all four grandparents alive in 2011 [22]. A majority of grandparents actively provide childcare for their grandchildren in Finland [23]. The evidence also suggests that the intergenerational influences and transmission of values, attitudes, and patterns of behavior between grandchildren and grandparents today are strong, despite changes in the society as a whole and in terms of family structure and socioeconomic context [24–26]. Grandparents' possible role in adolescent smoking prevention programs is worth studying because family interventions have been shown to have positive effects [27].

Finland is an interesting context to study the effect of family smoking because of its strict smoking prevention legislation [28]. All advertisement and sales promotion are forbidden, sales of tobacco products to minors under the age of 18 is forbidden, tobacco products are not displayed in retail sales, and smoking is not allowed in public places, restaurants, cafés, workplaces, schools and in places which minors can access. This means that the exposure within the family may be more influential in a Finnish society than in a society where smoking and tobacco products are easily seen and accessed by minors, and where tobacco industry can advertise their products. Cross-country comparisons could bring valuable insights into the mechanisms of the intergenerational transmission of smoking and into the actions needed to prevent it. In countries with strong tobacco control policies, family smoking could be one of the remaining issues to tackle and mostly with other means than legislative bans and restrictions (e.g., family interventions and smoking cessation support in health care). Countries with less comprehensive tobacco control policies could benefit from stronger implementation of the Framework Convention on Tobacco Control (FCTC) as the first-stage prevention.

Some limitations of our study should be noted. The data are based on adolescents' self-reports, and we cannot know how accurately they have reported their grandparents' smoking. Conversely, adolescents' reports reflect their perceptions of their grandparents' smoking, which can be considered even more important than the actual grandparent's smoking status. We also do not know what close contact, if any, the children had with their grandparents; this information would have provided more insight into the role of grandparents and may have modified the observed effects. When children or grandchildren are asked about grandparents'/parents' smoking, the exposure to environmental tobacco smoke during early childhood may be omitted, which may dilute the effects in our study. We did not have information on the age of parents or grandparents which may have been relevant because smoking has diminished in these age groups. On the other hand, we have shown that the strength of the association between the parents' and child's smoking did not change over a period of three decades [29] which is why the lack of age information hardly produces any bias. Important factors in the initiation and continuation of smoking are siblings' and peers' smoking [5] which were not available in our data. The low response rate may alter the generalizability of this study, although the indirect non-response analysis did not suggest any bias in the adolescents' reports of their grandparents' smoking.

## 5. Conclusions

Paternal and maternal grandparents' smoking is associated with grandchildren's tobacco use. The influence is mainly, but not completely, mediated through parents' smoking, suggesting an independent role of grandparents in smoking initiation. The role of grandparents in the prevention of adolescent smoking is worth considering in future prevention programs. Implementation of strong tobacco control policies is essential in order to reduce smoking among adults and the elderly population—which are the sources of the intergenerational transmission of smoking. Understanding the relationships between children and their grandparents' smoking statuses in different settings as well as the type and quality of contacts between children and their grandparents would help us to understand the role of grandparents more thoroughly.

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**Author Contributions:** Salma El-Amin had the main responsibility of producing this paper. Jaana M. Kinnunen, Pirjo Lindfors and Arja Rimpelä were responsible for the planning of the study and for the data collection. Salma El-Amin drafted the manuscript and developed the analysis. Salma El-Amin and Mika Helminen were responsible for the statistical analyses. Hanna Ollila and Joana Alves contributed by reviewing the drafts, providing comments and editing the manuscript. All authors made substantial contributions to the design and critically revised the manuscript. All authors read and approved the final manuscript.

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## Appendix

**Table A1.** Distribution of children’s smoking experimentation, daily smoking and other tobacco product use \* and parents’ and grandparents’ smoking by mailing order and the *p*-value.

Smoking	Round 1, %	Round 2, %	Round 3, %	Round 4, %	<i>p</i> -Value
Parents					
<i>Father’s smoking status</i>					0.289
Never smoker	57.7	57.3	53.5	53.2	
Ex-smoker	19.8	22.4	22.5	22.4	
Current smoker	22.5	20.3	24.0	24.4	
<i>Mother’s smoking status</i>					0.869
Never smoker	70.4	71.5	71.0	70.2	
Ex-smoker	14.9	13.3	13.9	12.8	
Current smoker	14.7	15.1	15.0	17.0	
Paternal grandparents					
<i>Grandfather’s smoking status</i>					0.198
Never smoker	73.4	74.3	78.7	72.9	
Ex-smoker	15.6	17.5	12.7	16.9	
Current smoker	11.0	8.1	8.7	10.1	
<i>Grandmother’s smoking status</i>					0.341
Never smoker	83.2	87.5	85.5	85.1	
Ex-smoker	8.4	5.3	7.2	7.6	
Current smoker	8.4	7.2	7.4	7.2	
Maternal grandparents					
<i>Grandfather’s smoking status</i>					0.008
Never smoker	72.2	66.5	75.6	64.3	
Ex-smoker	16.7	21.3	14.4	19.8	
Current smoker	11.2	12.3	10.0	15.9	
<i>Grandmother’s smoking status</i>					0.596
Never smoker	82.8	80.3	82.0	79.8	
Ex-smoker	7.7	9.6	9.4	10.1	
Current smoker	9.6	10.1	8.5	10.1	

\* Snus, water pipe and electronic cigarettes.

**Table A2.** ORs and 95% CIs for boys’ and girls’ smoking experimentation, daily smoking and other tobacco product use \* by parents’ smoking statuses, adjusted for age, parents’ education and employment status.

Smoking Status of Parents and Grandparents	Tried Smoking		Daily Smoking		Other Tobacco Product Use *	
	Girls	Boys	Girls	Boys	Girls	Boys
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Parents						
<i>Father’s smoking status</i>						
Never smoker	1.00	1.00	1.00	1.00	1.00	1.00
Ex-smoker	<b>1.60</b> (1.23–2.07)	<b>1.88</b> (1.39–2.55)	<b>1.86</b> (1.26–2.77)	<b>2.39</b> (1.45–3.93)	<b>1.51</b> (1.14–1.99)	<b>1.41</b> (1.04–1.91)

Table A2. Cont.

Smoking Status of Parents and Grandparents	Tried Smoking		Daily Smoking		Other Tobacco Product Use *	
	Girls	Boys	Girls	Boys	Girls	Boys
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Current smoker	<b>1.99</b> (1.55–2.56)	<b>1.89</b> (1.38–2.58)	<b>2.61</b> (1.83–3.73)	<b>2.11</b> (1.26–3.54)	<b>1.92</b> (1.48–2.50)	<b>1.41</b> (1.02–1.94)
<i>p</i> -value	<0.001	<0.001	<0.001	0.001	<0.001	0.031
<i>Mother's smoking status</i>						
Never smoker	1.00	1.00	1.00	1.00	1.00	1.00
Ex-smoker	<b>1.86</b> (1.40–2.48)	<b>1.84</b> (1.30–2.59)	<b>2.30</b> (1.51–3.49)	1.17 (0.65–2.11)	<b>2.11</b> (1.56–2.86)	1.41 (0.99–2.00)
Current smoker	<b>2.44</b> (1.84–3.23)	1.41 (0.98–2.03)	<b>4.50</b> (3.15–6.44)	<b>2.30</b> (1.36–3.88)	<b>2.80</b> (2.10–3.73)	1.39 (0.96–2.00)
<i>p</i> -value	<0.001	0.001	<0.001	0.007	<0.001	0.067

\* Snus, water pipe and electronic cigarettes; Note: OR is given in boldface when it indicates a statistically significant ( $p < 0.05$ ) difference from the odds of the reference category.

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