ICT use and mental health in young adults

Effects of computer and mobile phone use on stress, sleep disturbances, and symptoms of depression

Sara Thomée

Occupational and Environmental Medicine
Department of Public Health and Community Medicine
Institute of Medicine
at Sahlgrenska Academy
University of Gothenburg

UNIVERSITY OF GOTHENBURG

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sara.thomee@amm.gu.se

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Sara Thomée

Department of Public Health and Community Medicine, Institute of Medicine, University of Gothenburg, Gothenburg, Sweden

Abstract

The overall aim of this thesis was to explore possible associations between information and communication technology (ICT) use and mental health symptoms among young adults. By "ICT" in this context is meant mainly computer and mobile phone use. The thesis contains three longitudinal cohort studies using self-report questionnaires and one qualitative interview study. Study I was performed in a cohort of medical and computer science students (19–25 years old, n=1127). Prospective associations were found between ICT use at baseline and stress, sleep disturbances, and symptoms of depression at 1 year follow-up. Study II explored possible explanations for the associations between ICT and mental health symptoms by means of qualitative interviews with 32 high ICT users (20–28 years old). The concepts and ideas of the young adults generated a model showing several possible paths for associations between ICT exposure and mental health symptoms. In studies III and IV, parts of this model were tested in a population-based cohort of young adults (20–24 years old, n=4163). In Study III, a high frequency of mobile phone use at baseline was a risk factor for reporting sleep disturbances in the men and symptoms of depression in both sexes at 1 year follow-up. The risk for reporting mental health symptoms at follow-up was greatest among those who reported that they perceived accessibility via mobile phones as stressful. In Study IV, duration of computer use was prospectively associated with sleep disturbances in the men while for the women often using the computer without breaks was a prospective risk factor for stress, sleep disturbances, and symptoms of depression, at follow-up. High duration of emailing and chatting at leisure was a risk factor for sleep disturbances in the men and for most mental health outcomes in the women. Daily computer gaming for 1–2 hours was associated with an increased risk for symptoms of depression in the women. Often using the computer late at night and consequently losing sleep was associated with several mental health outcomes in both sexes. These findings suggest that sleep is an important mediating factor to focus on in future studies. Public health prevention strategies aimed at young adults could include information and advice about healthy ICT use, for example, advice about the importance of taking breaks and ensuring recovery when using e.g., computers intensively, and advice to set limits for own (and others) accessibility.

In conclusion, the main findings in the thesis suggest that intensive ICT use can have an impact on mental health in young adults. Frequent mobile phone use was a prospective risk factor for reporting sleep disturbances in the men and symptoms of depression in both sexes. Intensive computer use ("intensive" in terms of duration of use or continuous use without breaks) was a prospective risk factor for reporting sleep disturbances in the men and stress, sleep disturbances, and symptoms of depression in the women. Combined intensive computer and mobile phone use enhanced associations with mental health symptoms.

Keywords: computer, mobile phone, mental health, stress, sleep, depression, performance, young adults, qualitative, prospective, epidemiology

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Sammanfattning på svenska

Det övergripande syftet var att undersöka möjliga samband mellan användning av informations- och kommunikationsteknik (ICT) och symtom på psykisk ohälsa bland unga vuxna. ICT i detta sammanhang handlar främst om användning av dator och mobiltelefon. Avhandlingen innehåller tre longitudinella enkätstudier och en kvalitativ intervjustudie. Studie I utfördes i en kohort av läkar- och datavetarstudenter (19-25 år, n = 1127). Vi fann samband mellan hög användning av ICT vid första undersökningstillfället och rapportering av stress, sömnbesvär och depressionssymtom ett år senare. Studie II undersökte möjliga förklaringar till sambanden genom kvalitativa intervjuer med 32 unga vuxna (20-28 år) med hög ICT-användning och rapporterad psykisk ohälsa. De unga vuxnas idéer och beskrivningar ledde fram till en modell över flera möjliga vägar för samband mellan ICT-exponering och mental symtom. I studierna III och IV, testades delar av denna modell i ett slumpvis urval bestående av 4163 unga vuxna (20-24 år) som besvarade en enkät vid två tillfällen med ett års mellanrum. I studie III, utforskades effekter av både kvantitativa och kvalitativa aspekter av mobilanvändning på mentala symtom. Hög frekvens av mobilanvändning vid första undersökningstillfället ökade risken för sömnbesvär hos männen och depressionssymtom hos både männen och kvinnorna vid uppföljning efter ett år. Risken för att rapportera mentala symtom vid uppföljningen var störst bland dem som uppfattade tillgängligheten via mobiltelefon som stressande. I studie IV, undersöktes samband mellan datoranvändning och mentala symtom. En daglig hög användning av dator vid första undersökningstillfället ökade risken för att rapportera sömnbesvär efter ett år hos männen. Att ofta använda dator utan paus ökade risken för stress, sömnbesvär och depressionssymtom hos kvinnorna. Hög användning av e-post och chatt på fritiden var en riskfaktor för sömnbesvär hos männen och för de flesta mentala hälsoutfallen hos kvinnorna. Dagligt datorspelande om 1-2 timmar ökade risken för att rapportera depressionssymtom hos kvinnorna. Att ofta använda datorn sent på natten och därmed förlora sömn var associerat med de flesta mentala hälsoutfallen hos både männen och kvinnorna. Resultaten tyder på att sömn kan vara en viktig faktor att fokusera på i framtida studier. Förebyggande strategier inom folkhälsoområdet riktade till unga kan omfatta råd och information om hälsosam användning av ICT; t ex om vikten av att ta pauser och säkerställa återhämtning vid intensiv användning av exempelvis dator, och att sätta gränser för egen (och andras) tillgänglighet.

Sammanfattningsvis tyder resultaten i avhandlingen på att intensiv ICT-användning kan påverka den psykiska hälsan hos unga vuxna. Frekvent användning av mobiltelefon ökade risken för att rapportera sömnbesvär hos männen och depressionssymtom hos både männen och kvinnorna. Intensiv datoranvändning ökade risken för att rapportera sömnbesvär hos männen och stress, sömnbesvär och depressionssymtom hos kvinnorna. En kombination av intensiv dator- och mobilanvändning förstärkte sambanden.

List of papers

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Thomée, S., Eklöf, M., Gustafsson, E., Nilsson, R., Hagberg, M.
Prevalence of perceived stress, symptoms of depression and sleep disturbances in relation to information and communication technology (ICT) use among young adults – an explorative prospective study.
Computers in Human Behavior 2007; 23: 1300-1321.

II. Thomée, S., Dellve, L., Härenstam, A., Hagberg, M.
Perceived connections between information and communication technology use and mental symptoms among young adults – a qualitative study.
BMC Public Health 2010; 10:66

III. Thomée, S., Härenstam, A., Hagberg, M.
Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults – a prospective cohort study.
BMC Public Health 2011; 11:66

IV. Thomée, S., Härenstam, A., Hagberg, M.
Computer use and stress, sleep disturbances, and symptoms of depression among young adults – a prospective cohort study.
Submitted manuscript.

List of abbreviations

CI	Confidence Interval
CU	Computer Use
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, fourth edition
EEG	Electroencephalography
EMF	Electromagnetic Field
H24	Health 24 (cohort)
ICT	Information and Communication Technology
IRL	In Real Life
IT	Information Technology
Md	Median
PBSE	Performance-Based Self-Esteem
PC	Personal Computer
PDA	Personal Digital Assistant
PR	Prevalence Ratio
REM	Rapid Eye Movement
SEK	Swedish Krona
SMS	Short Message Service
WAYA	Work Ability Young Adults (cohort)

Contents

1. Introduction

The development of information and communication technology (ICT) has had considerable effects on our lives, affecting how we work, communicate, and interact. It has speeded up processing of many tasks; we can do more in less time, we can access enormous quantities of information, we can be reached at any time and anywhere, and we can engage in several lines of communication simultaneously. The rapid advances in technology and popularization of different devices and applications have implied rapid changes in the exposure profiles in the population at work, at school, at home, and in leisure over only a few decades. Therefore, it is important to examine potential health effects of this exposure. This thesis focuses on possible negative effects of ICT use on mental health in young adults. The term *ICT* in this context mainly refers to the use of computers and mobile phones. Moreover, it concerns self-reported total use, i.e., both occupational and leisure use.

1.1 ICT use

Computerization in the work field has taken place on a wide front since the 1970s. In 2009, 75% of the Swedish working population used computers at work [1]. Computers have also been increasingly used at home and at leisure. A significant shift in people's lives is the development and widespread use of the Internet. Sweden is among the top countries in Europe regarding the use of the Internet, being second only to Norway [2]. In 2010, 91% of the Swedish population between the ages of 16 and 74 had access to the Internet at home and almost 88% used the Internet on a regular basis [2]. The young adult age group of 16–24-year-olds were the most frequent users, with 99% reporting regular use of the Internet [2]. In addition to frequency, the duration of Internet use has also increased several-fold. Among 15–24-year-olds, average daily Internet use has increased from 38 minutes in 1998 to 167 minutes in 2010 [3], as can be seen in Figure 1. The time spent on the Internet has surpassed the time spent watching TV for this age group [3].

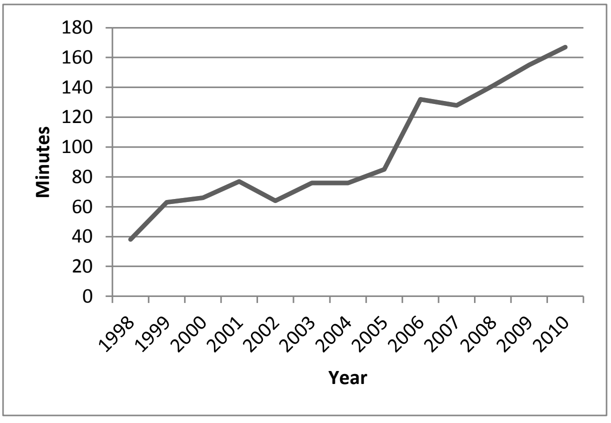

Figure 1. Average number of minutes per day spent on the Internet among 15–24-year-old users in 1998–2010. Data from Nordicom [3].

Internet usage is more common among those with a higher educational level compared to those with lower education, and students are the most frequent users [2, 3]. Internet usage is also higher in the three major cities in Sweden compared to the rest of the country [3].

The mobile phone has evolved from being exclusive, costly, and large to being small, affordable, and portable. In 2011, almost all (97%) Swedes aged 16–75 years had a mobile phone [4]. There were more than 13 million mobile phone subscriptions (and 4.6 million stationary subscriptions) in a nation of 9.5 million inhabitants [5]. Mobile phones are steadily replacing stationary phones. The duration of outgoing traffic on mobile phones has surpassed that of stationary phones (the level of total telephone traffic seems to be relatively constant) [5]. In addition, the use of Short Message Service (SMS) has had an enormous impact. First popular among the young because of low costs in comparison to the cost of mobile phone calls in Sweden, SMS use has spread rapidly and text messaging is now widely used. In the first 6 months of 2011, 9.2 billion SMS messages were sent in Sweden [6]. In the young age groups (9–24 years old), SMS use has surpassed regular calls on the mobile phone [3]. The rapid increase in the average number of SMSs sent per private subscription and month can be seen in Figure 2; from 8 SMSs per month in 2000, to 164 SMSs per month in 2010.

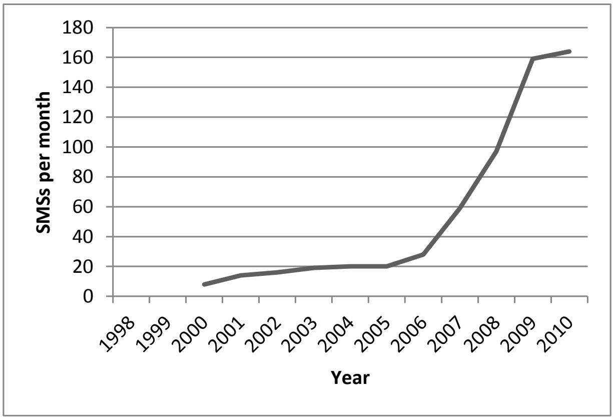

Figure 2. Average number of Short Message Service messages (SMSs) sent from mobile phones per private subscription and month in Sweden in the years 2000–2010. Data from the Swedish Post and Telecom Agency [6].

However, there may be a break in the trend. According to media reports on January 1, 2012, for the first time in years, the number of SMSs sent on New Year's Eve had decreased [4]. The use of social media and other new channels for sending messages were suggested to explain this decrease.

The mobile phone is increasingly used to access the Internet. This has been a breakthrough development taking place in just the past few years. Internet access by mobile phone was rare in 2009 but has rapidly increased since [7]. In 2011, 16–25-year-olds were the most frequent users of mobile Internet [8]. Another major shift over the past few years has been the increased involvement in social media. The most active users are 15–24-year-olds [3], with just about all 15–24-year-olds (96%) using social networks such as Facebook and Twitter, but other age groups are also becoming increasingly active in social media [7]. Among children and adolescents, the use of emails and chatting has decreased over the past few years, probably due to, e.g., Facebook use [9].

There are some gender differences in ICT use. The differences in Internet usage between the sexes seem to be negligible in the younger age groups, but in the older age groups (55+), men still have more access to the Internet than women [2, 3]. In 2010, among 16–24-year-olds, more women than men (91% and 85%, respectively) reported using the Internet every day or almost every day [3]. However, among children, boys more often than girls have their own computer [9].

Contents of Internet use may differ. For example, young men seem to use the Internet to listen to music and watch video clips to a larger extent than women, while young women more often visit blogs [7]. However, social media use and emailing are equally common among 15–24-year-old men and women [3]. Playing computer games is more common among men and boys than among women or girls [3, 10-12]. In 2010, 44% of the men but only 15% of the women in the age group 15–24 years old played computer, video, or Internet games on an average day [3]. Gaming had about doubled since 2004; online gaming had increased eightfold [3].

Using the mobile phone for regular phone calls was equally common among men and women in 2010, but SMSing was more common among the women [3]. Approximately 10% of the general population played mobile phone games on an average day in 2010 [3], men more than women. Mobile Internet access is generally more common among men than women [2, 3], but seems to be approximately equally common for both sexes in the young age groups up to 25 [7].

1.2 Health aspects of ICT use

Use of ICT involves both physical and psychosocial exposure that can have effects on health [13]. Physically, computers and mobile phones can be seen as separate, but they also have several psychosocial aspects in common. Perceptions about health risks of information technology (IT) use have been studied among young adults [14] and the general Swedish population [15]. In both studies cited, the respondents were generally quite positive to IT use, but were also aware of physical and psychosocial health risks.

In the following, a brief review of research concerning health aspects of computer and mobile phone use, respectively, is presented. This is followed by a discussion of the more general aspects of ICT use, including stress induced by ICT (i.e., information, communication, and technology stress), and research relating ICT use to sleep disturbances and depression.

1.2.1 Computer use at work

Research on health and ergonomics associated with the use of computers and different input devices has been performed in the context of working life, in line with the increasing computerization of work in the past decades. Musculoskeletal symptoms have been reported among computer workers, including mostly non-specific symptoms from the neck, shoulders, and upper extremities [16-19]. There is a wide variety of what constitutes computer work. At one end of the spectrum, there are monotonous and tedious data entry tasks, implying long duration of static work postures and repetitive movements. Psychosocial factors in this type of work situation often include low decision latitude in combination with high psychological demands (e.g., time pressure), leading to a stressful situation (job strain), as defined by Karasek & Theorell [20]. A combination of these psychosocial factors and physical factors has been found to increase the risk of developing musculoskeletal symptoms in relation to computer use [17, 18, 21]. According to Griffiths et al [21], this can be explained in that high workload and deadlines can encourage long duration of mentally demanding work at a hectic pace without adequate breaks, resulting in long duration of heightened muscle tension [21].

Computer work, such as call center work, has been likened to industrial assembly line work, but with the difference that computer work requires prolonged concentration and mental presence and is therefore a risk for cognitive overload and fatigue [22]. In one study of call center operators (a profession heavily dependent on computers at work), the most important risk factors for perceived stress were time pressure, limited support from colleagues and supervisors, and low decision latitude [23]. At the other end of the spectrum of computer work, there are work situations with high complexity in tasks and with high decision latitude, sometimes yielding limitless work hours and tight deadlines, whether it concerns programming, system designs, or creative work (or writing a thesis, for that matter), i.e., work situations also associated with stress [24].

Physical symptoms, such as skin complaints, were reported in connection with visual display terminal use in the 1980s and gave rise to worries concerning possible electromagnetic hypersensitivity. However, it was suggested that these symptoms were psychophysiological stress reactions due to occupational strain (termed technostress) in persons who are dependent on computers in their work, and that these reactions can become conditioned to the computer work environment [25, 26]. Technostress is discussed further in section 1.2.3.

Besides physical symptoms and stress, mental health symptoms, such as depressive symptoms and sleep disturbances, have also been associated with intensive computer use at work [27, 28] or at work and home [29]. It is possible that there are critical thresholds for exposure in relation to incidence of symptoms. For example, in a cross-sectional study, Aronsson et al [28] found critical limits (5–6 hours/day) for computer use in relation to physical and mental symptoms. Nakazawa et al [27] found a linear relationship between daily hours of computer use and physical symptoms, while reporting an apparent threshold effect concerning mental symptoms (at >5 hours/day).

1.2.2 Mobile phone use

The use of small keyboards, as when texting on a mobile phone, has also been acknowledged as an important phenomenon to study [30, 31] as musculoskeletal symptoms due to intensive texting on a mobile phone have been reported [32]. Other physical symptoms reported in relation to mobile phone use include headaches, earache, and warmth sensations [33-35], but also perceived concentration difficulties and fatigue including worries about possible sensitivity to electromagnetic fields (EMFs) related to mobile phones [33]. Perceived electrosensitivity is associated with reporting symptoms of depression and worse general health compared to controls [36]. However, the existence of such sensitivity has not been confirmed in scientific settings, e.g., in double-blind provocation studies [37]. There is some evidence that, e.g., electroencephalography (EEG) and slow wave sleep can be affected by exposure to radiofrequency fields [38] and effects on attention have been shown [39, 40]. Increased headaches have also been reported [41]. However, EMF exposure due to mobile phone use is not currently known to have any major health effects [42]. It is important to point out that this thesis takes a predominantly psychosocial and behavioral perspective on mobile phone exposure.

1.2.3 ICT stress

Today, ICT makes it possible to work from places other than the actual workplace, e.g., from home or from the bus, within or outside of the work schedule. Many people handle work-related emails in leisure time or are expected to be accessible via the mobile phone outside of work. Likewise, the private sphere can enter the work or study situation by means of ICT accessibility. The blurring of boundaries between work and private life can cause role stress, role conflicts, and role overload for the individual [43, 44]. Furthermore, stress connected to ICT use can be described as stress referring to the components of ICT, i.e., Information, Communication, and Technology.

Information and communication overload

ICT allows a never ending flood of information, in the form of messages, emails, updates, etc. We can also personally search for information in a way that was not possible a few decades back. The enormous and overwhelming quantities of information on the Internet are probably impossible to grasp. Being exposed to large amounts of information is mentally demanding and may imply difficulties separating important from unimportant information, and lead to uncertainty and decision-making difficulties [45]. Furthermore, it is time-consuming and can consequently be productivity-reducing [46].

In terms of information overload, both the quantity and the quality of information can be of significance as a high proportion of external stimulation has been associated with fatigue, and the association has been reported to be strengthened if the information is considered unattractive [47]. An aspect of ICT is that we can communicate by several means simultaneously, e.g., via chats, mobile phones, emails, etc, which can be mentally demanding and potentially stressful since distractions and dual-tasking are demanding on working memory [48, 49]. Frequent ringing of mobile phones has been shown to enhance allergic responses in patients with atopic eczema/dermatitis syndrome [50], implying that this exposure is stressful. Furthermore, the use of mobile phones has been found to distract attention and affect driving, bicycling, and pedestrian safety [51-54].

Emails can be seen as stressful and contribute to information and communication overload. In a study among employees in an engineering company, time spent emailing was associated with feeling overloaded, and the overload was not dependent on the hours worked [55]. Participants felt that while they spent time on other activities their emails accumulated, and email use also implied interference between work and private life. It was concluded that emailing became a symbol of stress, as it seemed to be experienced as stressful regardless of the amount of work it generated, and even made the participants overlook other aspects of work that contributed to overload [55]. Furthermore, incoming emails create interruptions that are time-consuming, productivity-reducing, and possibly also creativity-reducing [46]. It may therefore be a matter of urgency for organizations to employ strategies for handling email communication in order to decrease information or communication overload. For example, quantity of emails can be reduced by technical filters as well as changed cultural norms [46].

Technostress

Technological stress in terms of frustration and stress due to hardware or software problems, slow response times, and computer breakdowns, is well known to most of us, and is associated with heightened stress [56-58] and increased blood pressure [59]. The generally increased dependency on ICT may also make this type of stress a greater problem. Higher levels of computer dependency were associated with higher levels of “technostress” in a study by Shu et al [57]. The construct *technostress* refers to stress reactions in persons who are heavily dependent on computers at work [25, 26, 44, 57]. Inability to deal with the complexity of technology and the uncertainty that comes with constant development, changes, and upgrades in ICT have also been suggested as components of technostress [44]. Constantly having to learn new hard- and software can certainly be experienced as stressful, and the introduction of new computer systems in the work situation adds to mental workload [28]. Self-efficacy seems to be an important factor in terms of stress relating to the technological aspects of ICT. The confidence we have in our own capacity to handle ICT affects how we will respond to ICT-related problems, in terms of burnout [60], stress [57], and depression [61]. In this context, constructs such as *computer anxiety* and *computer attitudes* have also been associated with stress [62].

1.2.4 ICT and sleep disturbances

Computer use at work [27], as well as general computer use [29], has been associated with sleep disturbances. The round the clock society implies that activities can take place at any time of the day – or night. During the decade of the 1990s, average sleep time in Sweden decreased by 13 minutes [63]. Negative effects of ICT use on sleeping habits have been found in studies [10, 64, 65]. In a study among Finnish adolescents, intensive computer use among the boys was a risk for poor perceived health through negative effects on sleeping habits and daytime tiredness [10]. For the girls, intensive mobile phone use was directly associated with poor perceived health, but also through negative effects on sleeping habits and daytime tiredness [10]. In a study among South Korean university students, about one-third of those who had insufficient sleep reported that visual media including computers were the primary reason [65]. Mobile phone use at night was common among Belgian adolescents in a longitudinal study [66] and was associated with increased tiredness a year later. In a Norwegian population survey, the use of computer and mobile phones in the bedroom was associated with poor sleep habits, but seemed to be unrelated to insomnia [64]. Excessive Internet use has been associated with sleep problems [67, 68], as has excessive mobile phone use [69].

1.2.5 ICT and depression

Questions concerning potential negative effects of Internet usage arose when Internet access increased among the general public in the 1990s. In 1998, Kraut et al [70] reported negative effects on social involvement and psychological wellbeing among new Internet users. Use of the Internet was associated with a decline in participants' communication with family members in the household, a decline in the size of the social circle, and an increase in depression and loneliness. These findings of course caused some alarm. It was later argued by LaRose et al [61] that the causal link between Internet use and depression may have been specific to novice Internet users. In a follow-up study, Kraut et al [71] also found that negative effects dissipated with time, and in a second longitudinal survey, respondents generally experienced positive effects of Internet use on communication, social involvement, and wellbeing. However, it was concluded that personality variables have an influence on effects of Internet use. For extroverts, psychological wellbeing increased with time spent on the Internet, while for introverts, it declined [71]. Since then, several studies have continued to explore possible connections between Internet use, social interaction, and depression.

For example, emailing and chatting online/instant messaging have been found to be associated with decreased depressive symptoms [61, 72-74], while Internet time spent on shopping, playing games, or research has been associated with increased depressive symptoms [72]. Also, Internet use for health purposes, i.e. searching for medical information, increased depression in a longitudinal study [73]. Furthermore, Internet use has been associated with loneliness, in that lonely individuals use the Internet and email more than others [75]. In one study of high school seniors, low Internet users, as compared to high users, were found to report better relationships with their mothers and friends [76]. A meta-analysis of 43 studies of the relationship between Internet use and various measures of psychological wellbeing indicated only a very small detrimental effect [77]. Most studies in the meta-analysis were cross-sectional and the results were heterogeneous.

Computer game playing has also been associated with depression. In a longitudinal study among youths, pathological gaming (defined similar to other addiction disorders) predicted higher levels of depression, anxiety, social phobia, and poor school performance [78]. It seemed to be a long-term exposure, as most (84%) of the youths who were pathological gamers at baseline were still pathological gamers after 2 years. Furthermore, in a cross-sectional study of a population of Internet game players, habitual gaming at night was related to an increase in depression scores in adolescents and emerging adults (13–22 years old), but not among young adults (23–30 years old) [79]. The association with depression was not dependent on total time spent playing and was not mediated by sleep problems.

There has been a growing number of publications concerning ICT addiction [80]. "Internet addiction" has been associated with depressive symptoms among adults [67] and adolescents [68, 81]. Constructs such as *Internet addiction*, and *problematic* or *pathological Internet use* have been used to describe a syndrome consisting of preoccupation with using the Internet, compulsive use, excessive amounts of time spent online, and negative emotions when not online [82]. Internet addiction has been proposed as a specific psychiatric illness by Young [83], who applied the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV) criteria for pathological gambling, on Internet use. However, another view holds that problematic Internet use shares elements with impulse control disorders and is related to the specific activities (like gambling or compulsively accessing pornography) rather than the Internet in itself [82, 84-86]. In a Norwegian cross-sectional adult population sample, the prevalence of Internet addiction was 1% and that of at risk users was approximately 5% [67].

In the same line of thought, criteria for addiction diagnoses have been used to define problematic use [69, 87-92] including compulsive SMS use [89]. In this context, heavy or problem mobile phone use has been associated with depression [69, 92], but also with somatic complaints, anxiety, and insomnia [69], psychological distress [90], and an unhealthy lifestyle [93].

1.3 Young adults' mental health

Young adults are in focus in this thesis, an age group leaving adolescence and entering working life or higher education, and societal life. The definition of *young adults* varies in different contexts; one definition, used by the United Nations [94], is 20–24 years. Young adults 20–24 years old are the most frequent users of ICT compared to all other age groups [3]. The young are often trendsetters, implying that their exposure today is tomorrow's exposure in the general population. Health status in this group is also important for the future health of the population. It is therefore relevant to study possible negative health effects of ICT use in young adults.

Young adulthood is generally the healthiest period of adult life, but recent health reports concerning this group have caused some alarm. Over the past few decades, mental health symptom reports have increased among the general Swedish population, but the highest increase has been seen in adolescents and young adults [63, 95, 96]. The symptom reports are generally higher among women than among men [95, 97]. Besides self-reported symptoms, also increased hospitalization because of depression, anxiety disorders, suicide attempts, and alcohol-related diagnoses have been reported among the young [96]. Mental health problems seem to have been increasing among young people around the world and account for a large proportion of the disease burden in young people in all societies [95, 98].

In the Swedish National Survey of Public Health in 2010 [97], diminished mental wellbeing was reported by 29% of women and 13% of men in the 16–29-year age group. About one-quarter of the young women in the survey reported that they were stressed and had sleeping problems. Of the young men, approximately one out of ten perceived stress and one in five reported sleeping problems. Although the increase has been alarming over the past decades, fortunately these symptom reports have decreased slightly since 2004 [97].

In Figure 3, data on reported sleeping problems among 16–24-year-olds in the years 1980–2010 is presented from the Living Conditions Survey by Statistics Sweden [99].

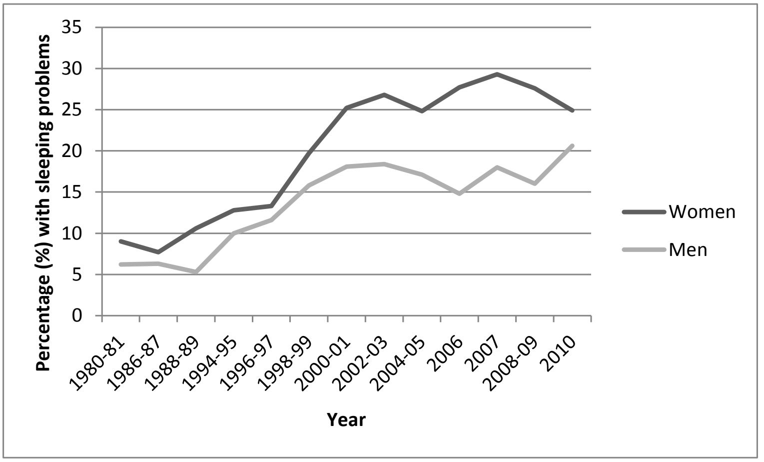

Figure 3. Reported sleeping problems (%) among Swedish 16–24-year-olds in the years 1980–2010. Data from the Living Conditions Survey, Statistics Sweden [99].

The causes of mental disorders are generally considered to be multifactorial. For example, gender, sociodemographic factors, general health, and major life events, as well as individual factors such as coping skills, are all related to the incidence of depression among young people [100-102]. In addition, family life stress and academic stress are related to depression and insomnia [103].

Cultural and societal changes in terms of increased materialism and individualism have been discussed in relation to the increase in mental health problems among the young [63, 104, 105], including a decreased stigma attached to mental illness, improved screening for mental illness, and increased help-seeking behavior [106]. Factors that have been discussed within the Swedish context are economic factors, including unemployment, related to the economic recession in the 1990s [63, 107]. Also, the cultural developments, with increased individualism, leading to an increased load and responsibility on the individual for making choices in the face of multiple or infinite opportunities, have been discussed as a cause of increased mental health problem among the young [63].

2. Aims

The overall aim of the thesis was to explore possible associations between information and communication technology (ICT) use and mental health symptoms among young adults.

Specific aims:

To examine if intensive computer use is a risk factor for mental health symptoms in young adults (studies I and IV)

To examine if intensive mobile phone use is a risk factor for mental health symptoms among young adults (studies I and III)

To explore possible explanations for associations between high ICT use and mental health symptoms among young adults in order to propose a model of possible pathways that can be tested epidemiologically (study II).

To examine if the combination of intensive mobile phone use and intensive computer use is a risk factor for increased mental health symptoms (studies I and IV)

3. Methods

In this section, the study designs, populations, and data collection methods are presented, study by study. This is followed by a presentation of the exposure variables in studies I, III, and IV, including reported exposure at the baseline of each study. Thereafter, the mental health variables used in the studies are presented together with the prevalence of reported symptoms. In the Analysis section, the statistical methods used in the thesis will be presented, as well as the qualitative analytical method. The Methods section ends with a dropout analysis for studies III and IV.

3.1 Study designs, populations, and data collections

The studies were performed in two cohorts of young adults: the Health 24 years (H24) cohort, a selected cohort of students aged 19–25 years, and the Work Ability Young Adults (WAYA) cohort, a population-based sample of young adults 20–24 years old. Studies I, III, and IV were epidemiological prospective cohort studies, and Study II was a qualitative interview study.

Table 1. Overview of study designs, study populations, and data collections

Study	Study design	n	Cohort	Study population	Data collection
I	Prospective cohort study	1127	H24	Medical and IT students, 19–25 years old	Questionnaire at baseline and 1 year follow-up
II	Qualitative interview study	32	H24	Medical, IT, and nurse students, 20–28 years old	Semi-structured interviews
III	Cross-sectional and prospective cohort study	4156	WAYA	Population-based sample, 20–24 years old	Questionnaire at baseline and 1 year follow-up
IV	Prospective cohort study	4163	WAYA	Population-based sample, 20–24 years old	Questionnaire at baseline and 1 year follow-up

3.1.1 Study I

Study I was an explorative prospective cohort study examining associations between computer and mobile phone use and mental health symptoms among the college and university students in the H24 cohort, by means of a questionnaire administered at baseline in 2002 and at 1 year follow-up in 2003.

The H24 cohort

The H24 cohort was recruited in 2002 with the aim to identify risk and health factors in relation to ICT use among young adults, and consisted of a selected population of students enrolled in medical and computer science programs at college/university or in vocational upper secondary schools, and aged 18–25 years at baseline [108, 109]. The goal had been to recruit 1800 participants (600 medical students, 600 computer science students, and 600 vocational upper secondary school students) with an even gender distribution. Annual follow-ups of the cohort were made from 2002 to 2007. The cohort was enlarged in 2004 with additional members (medical, computer science, and nurse students). Only data from baseline and the 1 year follow-up were used in Study I. The upper secondary school students were excluded from the studies in this thesis, because of a high dropout rate and also in order to form a slightly less heterogeneous study group, and are not further accounted for. The study population was recruited from student records at universities and colleges in the south-west of Sweden (in Gothenburg, Lund, Linköping, Borås, and Skövde).

Altogether 1728 college/university students were invited by post to participate in the study (Figure 4). Two cinema tickets were offered for participation. After registering for the study, either by post or on a website, a password to the web-based questionnaire was sent by email. The number of reminders sent out (from no reminder to three reminders) differed for the sub-groups, the goal being to reach the aimed-for participation rates. At baseline, the study population consisted of 1204 university students, aged 19–25 years (response rate 70%)[1]. After 1 year, the baseline participants received another invitation by post, with a password and a link to a questionnaire, to a large extent identical to the one at baseline. Four reminders were posted to non-respondents. Response rate at follow-up was 94% (n=1127) of the baseline population. Only respondents who had responded at baseline and follow-up were included in Study I. The study population consisted of 48% men and 52% women. Forty-seven percent were medical students, and 53% were computer science students (Figure 4).

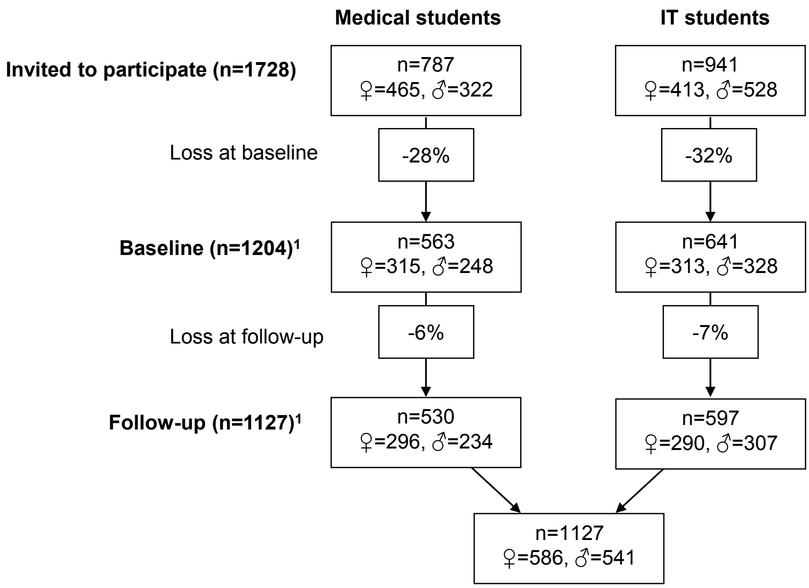

Figure 4. Study population in Study I.

The H24 questionnaire

The web-based questionnaire contained questions about ICT exposure, creativity, health, and psychosocial and demographic factors. It contained 45 items and had an estimated response time of less than 20 minutes. The questionnaire was developed by a broad research group at the Occupational and Environmental Medicine Unit, University of Gothenburg, and included

[1] It was later found that four participants should have been excluded from the study, two due to misclassifications of educational level and two due to double registrations [110]. The study population should thus have been 1200 at baseline (response rate 69%), and consequently, 1123 at follow-up. This was not known at the time of Study I and has not been corrected in the thesis.

validated items as well as items that were constructed by the research group. The questionnaire was piloted and validated before launching, as described in Herloff et al [108]. Only selected items from the questionnaire were used in Study I, to be described later.

3.1.2 Study II

Study II was a qualitative study based on semi-structured interviews with 32 respondents who had reported high ICT use prior to reporting mental health symptoms in the annual H24 cohort questionnaire. The purpose was to explore possible explanations for associations between high ICT use and mental health symptoms among young adults in order to propose a model of possible pathways connecting ICT use and mental health symptoms that could be tested epidemiologically.

Study population

Sixteen women and 16 men, 20–28 years old, were recruited among those who had responded to the H24 questionnaire in 2004 and 2005 (n=1843). Inclusion criteria for the interview study were: living in south-western Sweden, having reported high ICT use in 2004, and having reported at least two of the following mental symptoms in 2005: continuous stress, depressive symptoms, and sleep disturbances (described in 3.4). *High ICT use* was defined as the highest ranking reports (for men and women separately) of estimated total duration of computer use during the past week, number of mobile phone calls and text messages per day in the past week, or both. Participants must also have reported that this exposure was representative of their typical use. Furthermore, ten subjects were strategically included because, in response to a direct question in the cohort questionnaire, they had reported a perceived connection between mental symptoms and IT use. This was done to enhance the potential for identifying factors or conditions connecting ICT use with mental symptoms.

Participants were recruited consecutively until 32 individuals had been enlisted. Potential participants received a postal letter of invitation with information about the study. A week later they were telephoned by the author and asked to participate. Monetary compensation was offered to make up for loss of time or salary. A total of 44 individuals were contacted. Of these, eleven declined to participate: six due to lack of time, three due to current travels abroad, and two for no specified reason. One person agreed to participate, but dropped out without further contact.

Study group demographics

The high ICT users formed two subgroups: high computer users (n=28) and high mobile phone users (n=20) (Table 2). Response in the upper half for exposure to the technology in question was considered sufficient to qualify for each subgroup. Sixteen participants qualified for both groups. The high computer use group comprised 15 men and 13 women, aged 21–28. Of these, 75% had reported regular weekly computer use in the upper quartile of the total cohort. Twenty-four of 28 had reported all three mental symptom items, and the remaining four had reported two of the mental symptoms. All 15 men and ten of the women had a background in computer science; two of the other women were nurses and one was a medical doctor. Six men and four women had reported a perceived connection between IT use and subjective mental symptoms in the cohort questionnaire (Table 2).

The high mobile phone use group comprised eight men and twelve women, aged 22–28. Of these, 14 had reported regular daily mobile phone use in the upper quartile of the total cohort. Seventeen had reported all three mental symptoms, and the remaining three had reported two of the mental symptoms. Seven men and six women had a background in computer science, one man and four women were doctors or medical students, and two women were nurses (Table 2).

Table 2. Study group demographics in Study II

	All		High computer users[1]		High mobile phone users[1]	
	N=32		N=28		N=20	
	n	%	n	%	n	%
Gender						
Women	16	50	13	46	12	60
Men	16	50	15	54	8	40
Study background						
Computer science	25	78	25	89	13	65
Medical doctor or nurse	7	22	3	11	7	35
Upper quartile regular exposure in 2004						
Computer use[2]	21	66	21	75	10	50
Mobile phone use[3]	14	44	10	36	14	70
Reported mental symptoms in 2005[4]						
Three symptoms	28	88	24	86	17	85
Two symptoms	4	12	4	14	3	15
Reported connection between mental symptoms and IT use in 2005	10	31	10	36	6	30

n=number of participants in each category.
[1]Inclusion criteria for the groups were a reported minimum exposure in the upper half of the larger c o-hort in 2004 of the technology in question. Lowest exposure in High computer use group was for women 10 and for men 26 hours per week. Lowest exposure in High mobile phone use group was for women 8 and for men 7 calls or SMS messages per day. Sixteen subjects participated in both groups.
[2]For women: > 20 hours per week. For men: > 40 hours per week.
[3]For women: > 11 calls or SMS messages per day. For men: > 12 calls or SMS messages per day.
[4]Mental symptoms were *continuous stress; sleep disturbances; symptoms of depression* (see 3.3)

Interview procedure

Individual, semi-structured interviews were performed by the author. The interviews took place from October 2005 to April 2006 at the Sahlgrenska University Hospital Clinic of Occupational and Environmental Medicine, in Gothenburg, Sweden. The participants were asked open-ended questions about possible connections between the use of computers and mobile phones, and stress, depression, and sleep disturbances, e.g., "Do you think there is a connection between the use of computers and stress? If so, how? Have you experienced this yourself? What about people in general?" In addition, direct questions were asked about the participants' own worries about personal ICT use, their experiences of problematic or destructive ICT use, and the impact of ICT use on their sleep. The interviews lasted between 40 and 90 minutes and were tape-recorded. After answering the main research questions the participants also filled in questionnaires (concerning Internet addiction, loneliness, and attitudes towards computer and mobile phone use) in connection with the interviews. The results of these questionnaires are not presented here. Furthermore, in parallel with, and blinded to, the explorative interviews, a physician performed psychiatric assessments of the participants. Psychiatric disorders were diagnosed in six men and six women [Edlund, M, unpublished data]. Mild depression was diagnosed in four participants, moderate depression in two, anxiety disorder in four, mixed anxiety in one, and unspecified mood syndrome in one participant.

3.1.3 Studies III and IV

Studies III and IV were prospective cohort studies performed in a population-based sample of young adults, 20–24 years old, the WAYA cohort, with a questionnaire at baseline in 2007 and at 1 year follow-up in 2008. The purpose was to epidemiologically test parts of the model proposed in Study II. In Study III, we explored if intensive mobile phone use (including frequency, availability issues, and subjective overuse) is a risk factor for mental health symptoms among young adults. In Study IV we explored if intensive computer use (including duration of total use, email/chat use, computer gaming, computer use without breaks, and computer use late at night causing lost sleep) is a risk factor for mental health symptoms. Also, in both studies we examined if ICT exposure was associated with perceived social support.

The WAYA cohort

The WAYA cohort was recruited in 2007 with the objective to identify factors relating to health and physical and mental work ability among young adults, with focus on modern exposures and lifestyle patterns. Ten thousand men and 10 000 women, born between 1983 and 1987, were randomly selected from the general population from a registry held by the Swedish Tax Agency, 50% living in Västra Götaland County, Sweden, and 50% in the rest of the country. The age span 20–24 years corresponds to the United Nations definition of young adults [94]. In October 2007, a questionnaire [110] containing questions about health, work- and leisure-related exposure factors, demographic factors, and psychosocial factors was sent by post. Besides returning the postal questionnaire it was also possible to respond to the questionnaire via the web if desired. A lottery ticket (value 10 SEK) was attached to the cover letter and could be used regardless of participation in the study. Two reminders were sent by post. The response rate at baseline was 36% (n=7125, 2778 men and 4347 women). The response rate was slightly higher in the Västra Götaland sample (36% compared to 35%) at the cohort baseline. Twelve months later, those respondents who had indicated that they agreed to be invited to participate in future studies (n=5734) were asked to respond to an identical questionnaire, this time administered via the web. The data collection process was in other aspects similar to that at baseline, but with the addition of a third reminder offering a paper version of the questionnaire and two cinema tickets to respondents. The response rate at follow-up was 73% (n=4163, 1458 men and 2705 women).

Study groups

Only those who remained at follow-up (n=4163) were included in studies III and IV. In Study III, in addition, those who failed to respond to both questions concerning frequency of mobile phone calls and SMSs were excluded from the study group, leaving n=4156, 1455 men and 2701 women. This, however, had little practical implication, compared to defining the study group as n=4163, because other missing values also affected the number of subjects in the analysis. In Study IV, the study group was considered to be all those who remained at follow-up: n=4163. In the thesis, when conjointly accounting for factors appertaining to both studies III and IV, the number of participants is defined as 4163 (see Figure 5).

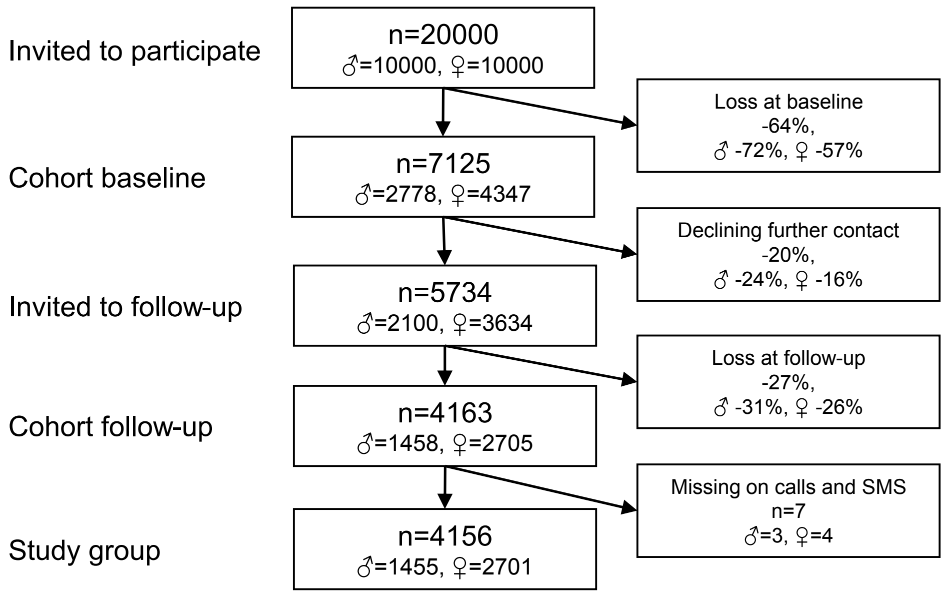

Figure 5. Study population of studies III and IV; the WAYA cohort.

The WAYA questionnaire

The WAYA questionnaire contained questions about health, work- and leisure-related exposure factors, psychosocial factors, and demographic factors [110]. It was developed by a broad research group at the Occupational and Environmental Medicine Unit, and contained validated items as well as items constructed specifically for the study. In order to keep the questionnaire to a reasonable size, single items were preferred as indicators instead of using full versions of established measures. The questionnaire contained 78 items, and was developed and tried out in two pilot studies (n=36 and n=31), the latter a test–retest reliability study [110]. In the reliability study, 100 randomly selected 20–24-year-olds in Västra Götaland County were invited to respond to the exact same questionnaire twice, 2 weeks apart. Test–retest reliability was calculated, and validating feedback was received, leading to some modifications of the questionnaire. Only selected items from the WAYA questionnaire were used in studies III and IV, and are described below and in sections 3.2–3.3 below.

Study group demographics

In studies III and IV, sociodemographic factors were collected from the WAYA questionnaire, to describe the study group, and to adjust for as potential confounders, including relationship status: *single* or *in a relationship*; highest completed educational level: *elementary school* (basic schooling for 6–16-year-olds), *upper secondary school*, or *college or university studies*; and occupation: *working*, *studying*, or *other* (*other* included being on longterm sick leave, or on parental or other leave, or being unemployed).

Half of the men and a third of the women in studies III and IV were single at baseline (Table 3). The majority of the respondents had completed upper secondary school, 13% of the men and 16% of the women had finished college or university studies, while 5% of the men and 6% of the women only had elementary schooling. A higher proportion of the men worked rather than studied, while the opposite applied to women. Eight percent of the men and 12% of the women neither worked nor studied. Fifty-two percent of the study group lived in Västra Götaland County and 48% in the rest of Sweden.

Social support

The variable *social support* was based on the questionnaire item, *When I have problems in my private life I have access to support and help*. The item had been constructed for the WAYA questionnaire as a single item adaptation of the social support scale in the Karasek-Theorell job content questionnaire [20], here relating to private life (rather than work life). Response categories were: a = *applies very poorly*; *b = applies rather poorly*; c = *applies rather well*; d = *applies very well.* The responses were categorized as *low* (response categories a and b), *medium* (response category c), and *high* (response category d). More women than men were categorized as having high social support in private life (Table 3).

Table 3. Study group demographics at baseline in studies III and IV

	MEN N=1458		WOMEN N=2705	
	n	%	n	%
Relationship status				
Single	722	52	848	34
In a relationship	659	48	1682	66
Education				
Elementary	72	5	150	6
Upper secondary	1188	82	2076	78
University	188	13	437	16
Occupation				
Working	741	51	1081	41
Studying	582	40	1258	48
Other	118	8	309	12
Geographical region				
Västra Götaland	760	52	1399	52
The rest of Sweden	698	48	1306	48
Social support				
High	626	43	1501	56
Medium	595	41	853	32
Low	228	16	339	13

3.2 Exposure variables

Information about ICT exposure was collected from the H24 baseline questionnaire for study I and from the WAYA baseline questionnaire for studies III and IV.

Table 4. Overview of exposure variables

Study	Exposure variables	Categories used in study
I	Computer use; mobile phone use; ICT use (computer+mobile use); emailing; chatting online; Internet surfing; mobile phone calls per day; SMSs per day	High, low (medium excluded)
III	Mobile phone use (calls + SMSs) per day; awakened at night; availability demands; accessibility stress; overuse	High, medium, low
IV	Computer use, email/chat use, computer gaming, computer use without breaks, computer use causing lost sleep, mobile phone use	High, medium, low

3.2.1 Study I

The exposure variables were based on the respondents' reports of estimated time spent on different types of ICT equipment during the past 7 days, including estimated daily frequency of mobile phone calls and SMS messages sent and received. Time spent on Internet surfing, emailing, and online chatting was also included as more specific aspects of computer exposure. The items had been constructed for the study, after validating interviews in a pilot study [108]. Those who, in response to a direct question, claimed that the estimate of the previous week's exposure did not represent their regular use of the computer or mobile phone were excluded from further analyses concerning that type of exposure. The exclusion rate for exposure variables concerning computers was 22%, while for mobile phones, it was 13%, and for the combination of the two, 29%, leaving n=883 in computer-based variables, n=978 in mobile phone-based variables, and n=799 in the combined variable "ICT" (i.e., sum of computer and mobile phone use hrs/wk) (Figure 6). Of the remaining participants, 99% of both women and men reported computer use during the past 7 days, and 93% of the women and 91% of the men reported mobile phone use.

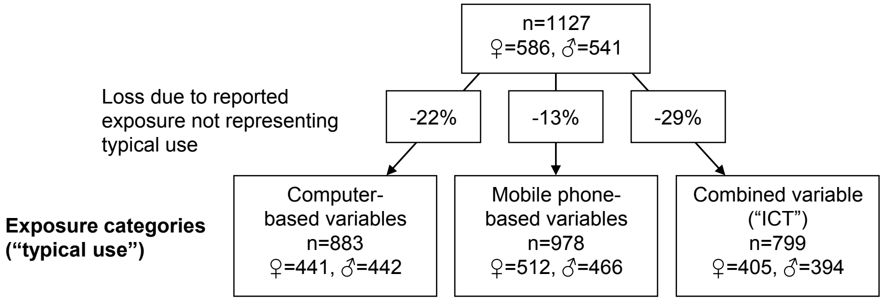

Figure 6. Remaining participants in Study I, after exclusion due to non-typical use

Exposure at baseline

Reported total computer use (personal computer, laptop, personal digital assistant, and e-book use) ranged from 0 to 150.5 hours per week (hrs/wk) for the men and from 0 to 100 hrs/wk for the women (Table 5). Median (Md) computer use was higher for the men (Md 19.5 hrs/wk) than for the women (Md 8.0 hrs/wk). The women generally reported higher duration of mobile phone use (Md 1.5 hrs/wk) compared to the men (Md 0.5 hrs/wk), while frequency of mobile phone calls per day was about the same for both sexes (Md 2 calls per day). The use of SMSs seemed to be somewhat more frequent among the women (Md 2 SMSs per day) than among the men (Md 1 SMS per day). The median of reported total ICT use was more than twice as high for the men compared to that of the women (Md 20.3 and 9.0 hrs/wk, respectively). Furthermore, the men reported more time on Internet surfing and somewhat more time chatting online, compared to the women. The time spent on emailing was about the same in both sexes (Table 5).

For further analysis, the continuous response data was divided into three categories: *high*, *medium*, and *low*, with cutoffs at the upper and lower quartiles based on the univariate analysis for the total group. The exception was the variable *chatting online*, where the 25th percentile value was 0, and we therefore arbitrarily chose to categorize all values >0 and ≤ the 75th percentile value as *medium chatting.* Some of the reported values may seem unreasonable, but were still included in the study. In Table 5, only exposures for men and women separately are presented, except for the upper and lower quartile values (Q3 and Q1, respectively) for the total group. For a full presentation of exposures of the total group, see Table 1 in Paper I.

Table 5. Exposure at baseline for the men and women in Study I

	MEN						WOMEN						TOTAL	
Exposure variables	n	Mean	Md	Max[1]	Q1	Q3	n	Mean	Md	Max[1]	Q1	Q3	Q1	Q3
PC hrs/wk	442	19.85	15.00	150.5	6.00	30.00	441	11.72	7.00	100	2.00	15.00	3.00	25.00
Laptop hrs/wk	442	1.48	0.00	50	0.00	0.00	441	1.29	0.00	70	0.00	0.00	0.00	0.00
PDA hrs/wk	442	0.20	0.00	20	0.00	0.00	441	0.07	0.00	8	0.00	0.00	0.00	0.00
Ebooks hrs/wk	442	0.03	0.00	10	0.00	0.00	441	0.01	0.00	5	0.00	0.00	0.00	0.00
Total computer hrs/wk[2]	442	21.56	19.50	150.5	7.00	30.00	441	13.09	8.00	115	2.83	20.00	4.00	26.00
Mobile phone hrs/wk	466	1.98	0.50	168	0.25	1.00	512	3.69	1.50	40	0.25	1.00	0.25	1.00
Total ICT hrs/wk[3]	394	23.88	20.29	218	7.25	35.00	405	14.67	9.00	118	3.50	21.50	4.33	29.00
Internet surfing hrs/wk	442	6.11	4.00	30.33	1.57	8.00	441	3.69	1.50	80	0.50	4.50	0.83	6.00
Emailing hrs/wk	442	1.56	1.00	30.25	0.42	2.00	441	2.17	1.00	50	0.50	2.00	0.50	2.00
Chatting online hrs/wk	442	2.42	0.00	168	0.00	2.00	441	1.66	0.00	80	0.00	0.75	0.00	1.00
Mobile calls per day	466	3.02	2.00	40	1.00	4.00	512	2.44	2.00	15	1.00	3.00	1.00	3.00
SMSs per day	466	2.57	1.00	50	0.30	3.00	512	3.27	2.00	100	1.00	4.00	1.00	4.00

hrs/wk = hours per week; n = subjects reporting that the exposure represented typical use; Md = Median; PC = personal computer; PDA = personal digital assistant; Q1 = 25th percentile value; Q3 = 75th percentile value; SMSs = text messages sent/received by mobile phone.

[1]Minimum value in all exposure variables = 0.00.

[2]Total computer hrs/wk = PC hrs/wk + laptop hrs/wk + PDA hrs/wk + ebooks hrs/wk.

[3]Total ICT hrs/wk = total computer use hrs/wk + mobile phone use hrs/wk.

3.2.2 Studies III and IV

Information about ICT exposure was collected from the WAYA baseline questionnaire. Several items had been developed based on the results of Study II. For Study III, besides frequency of mobile phone use (average number of calls and SMSs sent and received per day), more qualitative aspects relating to mobile phone use were also assessed. These included how often the respondent was awakened at night by the mobile phone, to what extent he or she was expected to be accessible via the mobile phone, and whether he or she perceived the accessibility offered by mobile phones to be stressful, as well as perceptions regarding personal overuse of the mobile phone. For Study IV, computer use variables included average duration of general computer use per day, average duration of emailing or chatting at leisure, average duration of computer gaming, how often the computer was used for more than 2 hours without breaks, and how often sleep was lost because of getting stuck late at night by the computer.

Response data for mobile phone and computer exposure variables were categorical, and were further divided into *high*, *medium*, and *low* categories (except for the mobile phone variable *overuse*, which was categorized according to number of items confirmed). A combined quantitative *mobile phone use* variable was constructed by merging the variables *calls* and *SMSs*. The *mobile phone use* variable correlated well with the original *calls* and *SMSs* variables ($r=0.73$ and 0.84, respectively, $p<0.0001$). Mobile phone (Study III) and computer (Study IV) variables, including questionnaire items, response categories, and response classifications, are presented in Tables 6 and 7, respectively.

Mobile phone use at baseline

A little more than half of the participants were categorized as having *low mobile phone use* (i.e., five or fewer calls and five or fewer SMS messages per day), while 22% of the men and 24% of the women were categorized as having *high use* (eleven or more calls and/or SMS messages per day, or between six and ten calls and between six and ten SMSs per day) (Table 6). A massive majority reported that they were expected to be available on a daily basis, and one out of four reported having to be available around the clock. Only a few percent found accessibility via mobile phones very stressful, while about half of the participants did not find it stressful at all. Most participants were never, or only on rare occasions, woken up by the mobile phone, and only a few reported being woken by the mobile phone on a weekly basis. Thirteen percent of the men and 22% of the women indicated that they themselves, or someone close to them, thought that they used the mobile phone too much, and 6% and 14%, respectively, had tried, but failed, to cut down on mobile phone use (Table 6).

Computer use at baseline

Almost 40% of the men and 30% of the women were categorized as having *high computer use* (>4 hours per day) (Table 7). The majority spent less than 1 hour per day on leisure time *email/chat use*, while about 20% spent 1-2 hours, and 10% spent more than 2 hours per day. More than four times as many men as women spent >1 hour per day on computer game playing (*medium* or *high computer gaming*). Lost sleep because of late night computer use (*CU causing lost sleep*) was more common among men than among women (Table 7).

Table 6. Mobile phone exposure at baseline in Study III

Variables and categories	Questionnaire items and response categories		MEN N=1455 n	%	WOMEN N=2701 n	%
CALLS	*How many mobile phone calls on average have you made and received per day in the past 30 days?*					
Low	0 per day		69	5	51	2
Low	1–5 per day		952	65	1946	72
Medium	6–10 per day		301	21	543	20
High	11–20 per day		97	7	108	4
High	>20 per day		36	2	47	2
SMS	*How many SMS messages on average have you sent and received per day in the past 30 days?*					
Low	0 per day		126	9	58	2
Low	1–5 per day		906	62	1609	60
Medium	6–10 per day		262	18	634	23
High	11–20 per day		98	7	259	10
High	>20 per day		60	4	140	5
MOBILE PHONE USE	(*Calls* and *SMS* combined)					
Low	0–5 calls + 0–5 SMSs per day		804	55	1433	53
Medium	0–5 calls + 6–10 SMSs, or vice versa		326	22	616	23
High	>11 calls and/or >11 SMSs, or 6–10 calls + 6–10 SMSs per day		323	22	645	24
AWAKENED AT NIGHT	*How often have you been awakened by the mobile phone at night in the past 30 days?*					
Low	Never		600	41	989	37
Medium	Only occasionally		657	45	1248	46
High	A few times per month		164	11	386	14
High	A few times per week		27	2	68	3
High	Almost every day		6	0	9	0
AVAILABILITY DEMANDS	*To what extent are you expected by those around you to be accessible via the mobile phone?*					
Low	Never		23	2	12	0
Low	Now and then, but not daily		82	6	86	3
Low	Daily, but not all day		278	19	828	31
Medium	All day		680	47	1127	42
High	Around the clock		388	27	642	24
ACCESSIBILITY STRESS	*To what extent do you perceive accessibility via mobile phones as stressful?*					
Low	Not at all stressful		892	61	1229	46
Medium	A little bit stressful		418	29	1083	40
High	Rather stressful		115	8	311	12
High	Very stressful		28	2	75	3
OVERUSE	Item 1: *Do you or someone close to you think that you use the mobile phone too much? (Yes/No)*	Yes	184	13	587	22
	Item 2: *Have you tried, but failed, to cut down on your use of the mobile phone? (Yes/No)*	Yes	87	6	371	14
Low	No item		1199	84	1898	71
Medium	One item		183	13	579	22
High	Both items		41	3	187	7

n = number of respondents in each category

Table 7. Computer exposure variables at baseline in Study IV

Variables and categories	Questionnaire items[1] and response categories	Men N=1458 n	%	Women N=2705 n	%
COMPUTER USE (CU)	*On average, how much time per day have you used on a computer (total use)?*				
Low	<2 hours per day	382	26	993	37
Medium	2–4 hours per day	505	35	950	35
High	>4 hours per day	564	39	748	28
EMAIL/CHAT USE	*On average, how much time per day have you used on a computer for emailing and chatting (leisure/private use)?*				
Low	None at all	120	8	162	6
Low	<1 hour per day	906	62	1732	64
Medium	1–2 hours per day	277	19	558	21
High	>2 hours per day	151	10	236	9
COMPUTER GAMING	*On average, how much time per day have you spent on computer gaming (e.g., computer games or online games, private/leisure use)?*				
Low	None at all	655	45	2050	76
Low	<1 hour per day	427	29	468	17
Medium	1–2 hours per day	204	14	114	4
High	>2 hours per day	168	12	61	2
CU WITHOUT BREAKS	*How often have you used a computer for more than 2 hours without taking a break longer than 10 minutes?*				
Low	Never	202	14	565	21
Low	Only occasionally	314	22	832	31
Medium	A few times per month	247	17	526	20
Medium	A few times per week	324	22	445	17
High	Almost every day	366	25	323	12
CU CAUSING LOST SLEEP	*How often have you lost sleep because of sitting late at night at the computer?*				
Low	Never	410	28	1128	42
Low	Only occasionally	490	34	920	34
Medium	A few times per month	316	22	393	15
High	A few times per week	181	12	206	6
High	Almost every day	57	4	46	2

[1]Time span for all items was “in the past 30 days.”; n=number of respondents in each category.

3.3 Mental health outcomes

Information about perceived mental health symptoms was collected from the H24 and WAYA questionnaires at baseline and follow-up. Mental health outcomes included stress, sleep disturbances, symptoms of depression, and also perceived reduction in performance due to mental symptoms. The questionnaire items, response categories, and categories used in the studies are presented in Table 9. Prevalence of mental health symptoms in the studies is presented in Table 10. In the prospective analyses, prevalence of new cases of the mental health symptoms at 1 year follow-up (among participants who were free from the symptom at baseline) constituted the outcomes.

Table 8. Overview of mental health outcomes studies I, III, and IV

Study	Mental health outcomes
I	Current stress; continuous stress; difficulties falling asleep; repeated awakenings; symptoms of depression (one item); symptoms of depression (two items); reduced productivity
III	Current stress; sleep disturbances; symptoms of depression (one item); symptoms of depression (two items)
IV	Current stress; sleep disturbances; symptoms of depression (one item); symptoms of depression (two items); reduced performance

3.3.1 Stress

Stress was assessed by two variables, *current stress* (investigated in studies I, III, and IV) and *continuous stress* for more than 7 days during the past 12 months (included in Study I). *Current stress* was constituted of a single item, a general indicator of stress considered to have satisfactory content, criterion, and construct validity for group level analysis [111]. For the studies, the response categories were divided into *Yes* and *No.* The second stress variable, *continuous stress*, was an adaptation of the first, intended to represent a prolonged state of stress.

3.3.2 Sleep disturbances

In Study I, we used two items from the Karolinska Sleep Questionnaire [112], *difficulties falling asleep* and *repeated awakenings with difficulties going back to sleep.* In studies III and IV, the single item s*leep disturbances* was constructed by including the most common sleep disorders (insomnia, fragmented sleep, and premature awakening) into one question, but with the same response categories as adapted from the Karolinska Sleep Questionnaire [112]. Responses were divided into *Yes* and *No*, with *several times per week* used as a clinically significant cutoff.

3.3.3 Symptoms of depression

The H24 and WAYA questionnaires included the two depressive mood items from the Primary Care Evaluation of Mental Disorders (Prime-MD) screening form [113], and were used in all three epidemiological studies. It has been proposed that if one of the two items is confirmed in screening, to go forward with clinical assessment of mood disorder [113]. This procedure is considered to have high sensitivity for diagnosis of major depression in primary care populations [113, 114]. However, the depressive symptom reports in the cohorts in the thesis were alarmingly high; for example, in the WAYA cohort, approximately 50% of the men and almost 65% of the women confirmed at least one of the two depressive items. This indicates that although the instrument is sensitive the specificity is probably low in the study groups. Therefore, we constructed two separate outcomes: *symptoms of depression (one item)* and *symptoms of depression (two items)*, the latter presumably with higher specificity.

3.3.4 Reduced productivity/performance

In the H24 questionnaire, there was an item that referred to a reduction in general performance over the previous 30 days because of anxiety/depressed mood, an adaptation of a question validated for studying reduced productivity due to musculoskeletal symptoms [115]. The variable was named *reduced productivity* in Study I. In the WAYA cohort questionnaire, the question was rephrased, and now concerned performance at work or in studies, with the time span changed to *over the past 14 days*. There were two items regarding mental symptoms: *performance affected by stress/depressed mood* and *performance affected by fatigue*. Moreover, the number of response categories was expanded in the WAYA questionnaire (Table 9). In Study IV, the variable was named *reduced performance.* It was sufficient for respondents to confirm that one of the two items affected performance “quite a lot” to consider the response a *Yes* on *reduced performance*. The outcome was not analyzed in Study III, but was added as an outcome in the analysis of mobile phone exposure in the thesis.

3.3.5 Prevalence of mental health symptoms

Two of the mental health variables, *current stress* and *symptoms of depression*, were identical in both cohorts and were consequently used in all three epidemiological studies. The prevalence of current stress was about the same in the two cohorts, as can be seen in Table 10. Less than 20% of the men and almost 30% of the women reported experiencing *rather much* or *very much* current stress. Almost half of the men and 65% of the women had experienced continuous stress for more than 7 days in the past year (only Study I). Confirming symptoms of depression seemed to be more common in the WAYA cohort: about half of the men and 65% of the women confirmed at least one of the two depressive items, compared to 40% and 50%, respectively, in the H24 cohort. Sleep disturbances were also more commonly reported in the WAYA cohort compared to the H24 cohort, with about a quarter of the men and one-third of the women reporting sleep disturbances several times per week. However, the sleep disturbance items were not comparable over the two cohorts. The single item used in the WAYA cohort was probably more inclusive as it concerned general sleeping problems, and apart from difficulties falling asleep and repeated awakenings, also included premature awakening. Reduced productivity (due to anxiety/depressed mood) was reported by almost 20% of the men and 30% of the women in Study I. In Study IV, about 10% of the men and 20% of the women were categorized as having reduced performance due to stress, depressed mood, or fatigue. These variables were not comparable over the cohorts. Overall, the women reported higher prevalence of all mental symptoms compared to the men.

Table 10 also accounts for the prevalence of new cases of mental health symptoms at 1 year follow-up among participants who at baseline were free from the symptom investigated. New cases constitute the actual outcomes in the prospective analyses. In addition, the prevalence of multiple symptoms is presented in Table 10 (not shown in the papers). Only about one-quarter of the women and 41% percent of the men (in both cohorts) were categorized as reporting neither stress, sleep disturbances, nor symptoms of depression, at baseline. Reporting all three mental health symptoms was twice as common among the women as among the men in both cohorts.

Table 9. Mental health variables, questionnaire items, response categories, and categories in the studies

Variable	Cohort questionnaire item	Response categories	Categories in study *Yes*	Categories in study *No*
STRESS				
Current stress Studies I, III, IV	*Stress means a situation when a person feels tense, restless, nervous, or anxious or is unable to sleep at night because his/her mind is troubled all the time. Are you currently experiencing this kind of stress?*	a = *not at all*; b = *just a little*; c = *to some extent*; d = *rather much*; e = *very much*	d–e	a–c
Continuous stress Study I	*Have you continuously, for more than 7 days, during the past 12 months experienced this kind of stress?*	H24, baseline: *Yes* or *No* H24, follow-up: *Yes*	*Yes*	*No* or missing
SLEEP DISTURBANCES				
Difficulties falling asleep Study I	*During the past 6 months, have you been bothered by: (a) difficulties falling asleep? (b) repeated awakenings with difficulties going back to sleep?*	*a = never; b = a few times per year; c = a few times per month; d = several times per week; e = every day*	d–e	a–c
Repeated awakenings Study I	*During the past 6 months, have you been bothered by repeated awakenings with difficulties going back to sleep?*	*a = never; b = a few times per year, c = a few times per month; d = several times per week; e = every day*	d–e	a–c
Sleep disturbances Studies III, IV	*How often have you had problems with your sleep these past 30 days (e.g., difficulties falling asleep, repeated awakenings, premature awakening)?*	*a = never; b = a few times per month; c = several times per week; d = every day*	c–d	a–b
SYMPTOMS OF DEPRESSION				
Symptoms of depression **· one item** **· two items** Studies I, III, IV	*During the past month, have you often been bothered by:* (a*) little interest or pleasure in doing things? (b) feeling down, depressed, or hopeless?*	H24 baseline: *Yes* or *No* H24 follow-up: *Yes* WAYA: *Yes* or *No*	One item: (a) *Yes* or (b) *Yes* Two items: (a) *Yes* and (b) *Yes*	One item: (a) *No*[1] and (b) *No*[1] Two items: (a) *No*[1] and (b) *No*[1]
REDUCED PRODUCTIVITY/PERFORMANCE				
Reduced productivity Study I	*Have the following complaints influenced your performance in general over the past 30 days: anxiety/depressed mood?*	Yes	Yes	Missing
Reduced performance Study IV (+ thesis)	*Have the following complaints influenced your performance at work or in studies over the past 14 days: (a) stress/depressive feelings; (b) tiredness?*	a = *No*; b = *Yes, negligibly*; c = *Yes, a little*: and d = *Yes, quite a lot*	(a) d or (b) d	(a) a–c and (b) a–c

[1]In Study I, *No* includes the missing values. The follow-up H24 questionnaire did not include the category *No*; hence, all *No* responses are based on missing values. In order to treat missing data the same way for the two measurements, missing values at baseline were also categorized as *No* in Study I. In the WAYA studies, missing values were not categorized as responses.

Table 10. Prevalence of mental health symptoms in studies I, III, and IV

VARIABLE	Study I – H24 cohort								Studies III and IV – WAYA cohort							
	MEN N=541				WOMEN N=586				MEN N=1458				WOMEN N=2705			
	Baseline prevalence		Follow-up: new cases[1]		Baseline prevalence		Follow-up: new cases[1]		Baseline prevalence		Follow-up: new cases[1]		Baseline prevalence		Follow-up: new cases[1]	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	**%**
Stress																
Current stress	97	18	37	8	166	28	61	15	233	16	127	10	779	29	369	19
Continuous stress	247	46	99	34	383	65	81	40	–	–	–	–	–	–	–	–
Sleep disturbances																
Difficulties falling asleep	69	13	29	6	81	14	28	6	–	–	–	–	–	–	–	–
Repeated awakenings	17	3	8	2	34	6	39	7	–	–	–	–	–	–	–	–
Sleep disturbances	–	–	–	–	–	–	–	–	332	23	168	15	911	34	358	20
Symptoms of depression																
Symptoms of depression: one item	134	25	60	18	160	27	67	23	388	27	166	24	806	30	269	28
Symptoms of depression: two items	81	15	26	8	136	23	40	14	352	24	84	12	902	34	171	18
Reduced performance																
Reduced productivity	99	18	61	14	174	30	56	14	–	–	–	–	–	–	–	–
Reduced performance	–	–	–	–	–	–	–	–	140	11	75	7	486	20	244	14
Mental health symptoms[2,3]																
0	221	41	–	–	139	24	–	–	598	41	–	–	754	28	–	–
1	171	32	–	–	206	35	–	–	526	36	–	–	930	34	–	–
2	139	26	–	–	216	37	–	–	223	15	–	–	595	22	–	–
3	10	2	–	–	25	4	–	–	111	8	–	–	426	16	–	–
3 + reduced productivity/performance	7	1	–	–	16	3			39	3			192	7		

n=number of respondents reporting mental health symptoms.
[1]new cases= prevalence of mental health symptoms at follow-up among participants who were symptom-free (in outcome concerned) at baseline.
[2]Mental health symptoms in H24= stress (*current stress* and/or *continuous stress*); sleep disturbances (*difficulties falling asleep* and/or *repeated awakenings*); symptoms of depression (*one* or *two items*).
[3]Mental health symptoms in WAYA= current stress; sleep disturbances; symptoms of depression (*one* or *two items*).

3.4 Ethics

The studies were approved by the Regional Ethic Review Board in Gothenburg, Sweden. Registry numbers were: Study I Ö491-01; Study II: 191-05; Studies III and IV: 191-05 and 876-11. In study I consent was implied by registering for the study. In study II, all subjects gave written consent to participate. In studies III and IV, informed consent was implied by responding to the questionnaire. All data in the studies were anonymized.

3.5 Analysis

First, statistical methods in the three epidemiological studies, including the additional analyses in the thesis, are described, followed by a section defining how missing data was handled. Thereafter, the qualitative analysis is described, followed by the dropout analysis of the studies III and IV population.

Table 11. Overview of main analyses used in this thesis

Study	Study design	Analysis and procedure	Estimate / result
I	Prospective cohort study	Univariate, Mantel-Hanzel	PR, 95% CI
II	Qualitative interview study	Qualitative content analysis	Model
III	Cross-sectional and prospective cohort study	Multivariate (adjusting for confounders), Cox proportional hazard with robust variance	PR, 95% CI
IV	Prospective cohort study	Multivariate (adjusting for confounders), Cox proportional hazard with robust variance	PR, 95% CI

95% CI = 95% confidence interval; PR = prevalence ratio.

3.5.1 Statistical methods

Conventional descriptive statistics of exposure, mental health symptoms, and sociodemographic factors were calculated in the studies. In all three epidemiological studies, prospective analyses were conducted to calculate prevalence ratios (PRs) with a 95% confidence interval (CI). Study III also involved cross-sectional analyses.

In Study I, unadjusted PRs were computed based on exposure categories *high* and *low* (using the Mantel-Hanzel procedure), with the *low* category as reference, and mental health outcomes (*yes* or *no*). The *medium* exposure category was omitted for the sake of contrast. In studies III and IV, adjusted PRs were calculated based on exposure categories *high*, *medium*, and *low* (reference level) and mental health outcomes (*yes* or *no*), using the Cox proportional hazard model (the PHREG procedure, with time set to 1). The robust variance option (COVS) was used to produce adequate CIs [116, 117]; however, in Study III, it was used only in the cross-sectional analysis. The CIs in the prospective analyses in Study III are therefore conservative. Prospective analyses in all studies were based on exposure at baseline and new cases of mental health symptoms at 1 year follow-up. Therefore, in the prospective analyses, participants who reported symptoms at baseline were excluded from the analysis of the mental health outcome concerned. For example, when analyzing sleep disturbances, subjects with sleep disturbances at baseline were excluded. It is possible that the included subjects had one or more of the other mental health symptoms at baseline; however, these were not accounted for in the analysis of sleep disturbances.

In studies III and IV, sociodemographic factors were collected from the WAYA questionnaire to adjust for as potential confounders in the multivariate analysis; including relationship status, educational level, and occupation. These potential confounders were chosen based on theoretical hypotheses, and were tested separately and added to the analyses if statistically significant (i.e., with a p-value of ≤0.10). The confounders were not consistently significant across all analyses. However, instead of adjusting for different factors in different analyses, we used the same confounders in all analyses. Age was not considered a confounder because of the limited age span of the study group. Missing values (due to non-responses to items) were excluded from the analyses, which means that *n* varied in the analyses.

Furthermore, in studies III and IV, Spearman correlation analysis was used to examine associations between the exposure variables and social support. For analysis of dropout from the initial cohort at baseline to the final study group in Study IV (and in the thesis), Wilcoxon's (two-sided) two-sample test was used. Furthermore, in Study IV, some computer use variables were analyzed in combination with mobile phone use, by using all nine possible category combinations of the two variables used in the analysis. Multivariate analyses were then performed to calculate PRs using the Cox procedure, as described earlier, with the "*low–low*" category combination as reference.

All analyses were done for men and women separately (in Study I also for the group as a whole). When interpreting the size of correlation coefficients, we used the "rule of thumb" as in Hinkle et al [118]. The rounding rule used overall was "half to even." A PR with a 95% CI not including 1.00 before rounding was considered statistically significant. All analyses were performed using the statistical software package SAS (version 8e in Study I, and version 9.2 in studies III and IV) (SAS Institute, Cary, NC, USA).

Additional analysis in the thesis

The components of *mobile phone use*, i.e., *calls* and *SMSs*, were analyzed and accounted for separately in the thesis. *Reduced performance* was analyzed as an outcome for the mobile phone variables, which was not done in Study III. In addition, in the thesis (but not in Study III), the robust variance option was used in the prospective analysis of mobile phone exposure. Furthermore, the dropout analysis for Study IV was broadened to encompass variables used in Study III as well. Cross-sectional analysis of computer use and mental health outcomes is presented in the thesis (but not in Study IV).

Additional analyses include Spearman correlation analyses of the exposure variables, and the mental health variables, in all studies. Finally, mobility from baseline to follow-up in the exposure variables and the mental health outcomes in studies III and IV was examined.

Missing data

In the questionnaire responses, data was missing (due to non-responses to items) to a varying extent. The H24 web-based questionnaire contained many items that were mandatory to complete in order to proceed in the form; consequently these contained no missing data. This did not apply to the exposure items in Study I, nor to some of the mental health items. Missing values in exposure items were given the value 0. The mental health items *continuous stress* and *symptoms of depression* included a *Yes* and *No* response in the baseline questionnaire, but in the follow-up questionnaire they only included a *Yes* response category, with the *No* category implicit in the missing data. In order to treat missing data the same across the two measurements, missing data were categorized as *No* also at baseline. At H24 baseline, *continuous stress* had eleven missing values, while *symptoms of depression* had eight missing values, that were categorized as *No*. The outcome *reduced productivity* only included a *Yes* category at both measurements, and consequently, all missing values were categorized as *No*.

In studies III and IV in the WAYA cohort, there were no mandatory items and a *No* category was always available to the *Yes/No* items. Missing values were not categorized as responses. The missing values for variables were (for n=4163): *relationship status*: 252; *education*: 52; *occupation*: 74; *calls*: 13; *SMSs*: 11; *mobile phone use*: 16; *awakened at night*: 6; *availability demands*: 14; *accessibility stress*: 9; *overuse*: 71; *computer use*: 21; *email/chat use*: 21; *computer gaming*: 16; *CU without breaks*: 19; *CU causing lost sleep*: 16; *current stress*: 9; *sleep disturbances*: 26; *symptoms of depression*: 43; *reduced performance*: 387; and *social support*: 21. The instruction for the *reduced performance* item was to skip the question if not working or studying, which means that those who were unemployed or on sick leave, for example, did not respond, which explains the fairly large amount of missing data. However, we do not know why *relationship status* contained so many missing values. Eighty-nine percent of the men and 86% of the women had responded to all items at baseline (not including *reduced performance*) used in studies III and IV. Missing values were not entered into the analysis; for this reason, the number of subjects in the analyses varies.

3.5.2 Qualitative analysis

All interviews in study II were tape-recorded and transcribed verbatim to enable qualitative content analysis [119-121]. Initially, the texts were handled using Nvivo7 software (QSR International Pty Ltd, Australia). The interview texts were sorted at topic level to form thematic domains, mainly following the interview structure. Only data from high users of the technology in question (computer or mobile phone) was used in the analysis of each domain. A stepwise conventional qualitative content analysis [119, 120] of the data was performed by the author (also the interviewer), which was facilitated by entering the text into regular MS Word tables. The text was first condensed and coded; codes were then sorted and categories formed based on the factors and conditions described by the respondents in each domain. The process focused on a low level of interpretation of the manifest content, closely following the statements of the interviewees [121].

In the next step, the categories were compared and sorted across thematic domains to generate overall categories. Patterns and relations among the categories were sought in an iterative process, using the original interview texts as additional verification. Preliminary results were discussed and validated by a reference group of specialists in student psychiatry, child psychiatry, stress medicine, and sleep medicine. Finally, a model was developed to illustrate and describe the categories and their relations, in order to present central features connecting ICT and mental symptoms while accounting for just about all factors mentioned by the subjects [121].

3.5.3 Dropout analysis

No dropout analysis was performed for Study I. (A dropout analysis (n=27) had been done among the upper secondary school students of the H24 cohort, who were not included in this thesis [108].) Furthermore, the dropout rate from baseline to follow-up was very low (6%), and analysis of this did not seem meaningful. Nor was a dropout analysis considered relevant for the qualitative study.

A non-respondent analysis of the WAYA cohort at baseline was performed by Ekman [110]. The non-respondents in the initial cohort at baseline were more often male (a difference of 17 percentage points), were somewhat younger (an age difference of <0.1 years), and were more often married (a difference of 1.4 percentage units) and foreign-born (8 percentage units difference) compared to the study population invited to participate.

Further analysis (for Study IV and the thesis) showed that the dropout group (n=2962) from the initial cohort baseline (n=7125) to 1 year follow-up (n=4163), also contained a higher proportion of men, resulting in almost twice as many women as men (65% vs. 35%) in the final study group in studies III and IV (n=4163).

Only statistically significant results are presented ($p < 0.05$), unless otherwise stated. The dropout analysis shows that both men and women in the study group had a slightly higher educational level and differed by up to 10 percentage units in occupation (not statistically significant for women) in that the participants were less often working and more often studying at baseline compared to the dropout group. The level of *computer use* and *CU without breaks* was slightly higher, while *mobile phone use* was lower, and the participants were less often awakened at night by the mobile phone compared to the dropout group. These ICT exposure categories differed by up to 10 percentage units. Furthermore, the study group men reported *overuse* of the mobile phone less often compared to those in the dropout group (a difference of 4 percentage units). The study group women were less often single (34% compared to 37%) and reported a slightly higher level of *social support* (differences of up to 3 percentage units). With the exception of a lower prevalence of sleep disturbances among the men in the study group (23% compared to 27%), the prevalence of mental health symptoms at baseline was about the same among the dropouts and those who remained in the study.

4. Results

The results are presented, study by study, followed by the results of the additional analyses in the thesis.

4.1 Study I: Prospective associations

Neither high duration of computer nor high duration of mobile phone use at baseline was clearly associated with any of the mental health outcomes at follow-up. However, a high total computer and mobile phone use, i.e., *high ICT use*, was prospectively associated with reports of continuous stress and symptoms of depression (two items) in the women (Table 12). Furthermore, high emailing and chatting online increased the risk for symptoms of depression among the women, and chatting online was also associated with continuous stress. In addition, much time spent on surfing the Internet was associated with increased risks of sleep disturbances in the form of repeated awakenings in the women.

High frequency of mobile phone calls and SMS messaging was associated with developing difficulties falling asleep in the men. Moreover, high SMS use was associated with reporting symptoms of depression (two items) in the men, and continuous stress in the women (Table 12).

There were no clear associations between any of the exposure variables at baseline and the outcomes current stress, symptoms of depression (one item), or reduced productivity due to anxiety/depressed mood at 1 year follow-up for either sex; nor was there any clear association between exposure and continuous stress for the men.

Only statistically significant associations are presented in Table 12. For a full presentation of results, see Paper I (Tables 3–9 and the Results section).

Table 12. Summary of results: prospective associations between ICT use at baseline and mental health outcomes at 1 year follow-up in Study I. A prevalence ratio (PR) with a 95% confidence interval (CI), not including 1.00 before rounding, was considered statistically significant. For full presentation of results, see Tables 3-9 in Paper I.

MEN		WOMEN	
Stress		**Stress - Continuous stress (> 7 days)**	
-		ICT	PR 1.9 (1.2-3.2)
		SMS	PR 2.0 (1.3-3.0)
		Chatting online	PR 2.1 (1.4-3.1)
Sleep disturbances (difficulties falling asleep)		**Sleep disturbances (repeated awakenings)**	
Mobile phone calls	PR 2.5 (1.0-6.0)	Internet surfing	PR 2.9 (1.1-7.7)
SMS	PR 2.6 (1.1-6.3)		
Symptoms of depression (two items)		**Symptoms of depression (two items)**	
SMS	PR 3.5 (1.2-10.2)	ICT	PR 2.5 (1.0-6.4)
		Emailing	PR 2.7 (1.1-6.6)
		Chatting online	PR 2.4 (1.2-4.6)

ICT = information and communication technology (sum of duration of computer and mobile phone use); SMS = short message service.

4.2 Study II: Perceived connections

In the following, the results of the qualitative content analysis of the interview data are summarized. Thereafter, a comparison of the results concerning computer and mobile phone use is presented. Finally, a model of possible paths of associations between ICT use and mental health symptoms is presented. For a full presentation of results, see the Results section in Paper II.

4.2.1 Computer use and mental health

High quantitative use was a central link between computer use and stress, sleep disturbances, and depression, described by the young adults. It was easy to spend more time than planned at the computer (e.g., working, gaming, or chatting), and this tended to lead to time pressure, neglect of other activities and personal needs (such as social interaction, sleep, physical activity), as well as bad ergonomics, and mental overload. The main causes of high quantitative use were personal dependency and perceived demands for and expectations of achievement and availability that originated from several domains: from work or study, from the social network or broader society, or from the participants themselves. Social isolation and addiction was proposed as consequences of high computer use, which, in a negative loop, could lead to even higher use. Besides the quantitative aspects of computer use, some qualitative aspects were perceived as important links to mental health symptoms. These included destructive information or communication and user problems (problems relating to the technology) that led to feelings of frustration or inadequacy.

Reversed pathways between computer use and mental health symptoms were also perceived, in that ill mental health could lead to altered computer use. Computer use was also considered, in some respects, to protect against, or decrease, mental health problems.

4.2.2 Mobile phone use and mental health

High quantity of use due to demands and expectations for availability at all times was a central area of concern. Demands for availability originated not only from work and the social network, but also from the individual's own ambitions or desires. This resulted in disturbances when busy or resting, the feeling of never being free, and difficulties separating work and private life. Unreturned calls or messages led to overload and feelings of guilt. Personal dependency was an area of concern, as was worry about possible hazards associated with exposure to EMFs. User competence issues as well as costs were mentioned. Bad quality of communication was another aspect mentioned, with the mobile phone perceived to increase the risk of receiving or sending negative messages. The major stressor for many, however, was not being available.

4.2.3 Comparison of results

There were several similarities in the factors identified as linking computer and mobile phone use, respectively, to mental health symptoms. Issues concerning high quantity of use, demands of availability, dependency, disturbed recovery, and mental and communication overload seemed to be common to both technologies. Concerns about the quality of communications were also prevalent in relation to both. Work-related demands for tasks and achievement were more highly related to computer use, while demands for availability, regardless of time and space, were more related to mobile phone use. Thoughts about increased social isolation were more evident in relation to computer use. Worry about EMFs was present in relation to both technologies, but more obvious in relation to mobile phones. User problems or competence issues were prevalent in both areas, although computers seemed to generate more general frustration.

There were sufficient similarities between the perceived effects of the two technologies to allow the proposal of a combined model of ICT, encompassing computer use, mobile phone use, and the perceived connections to mental health symptoms.

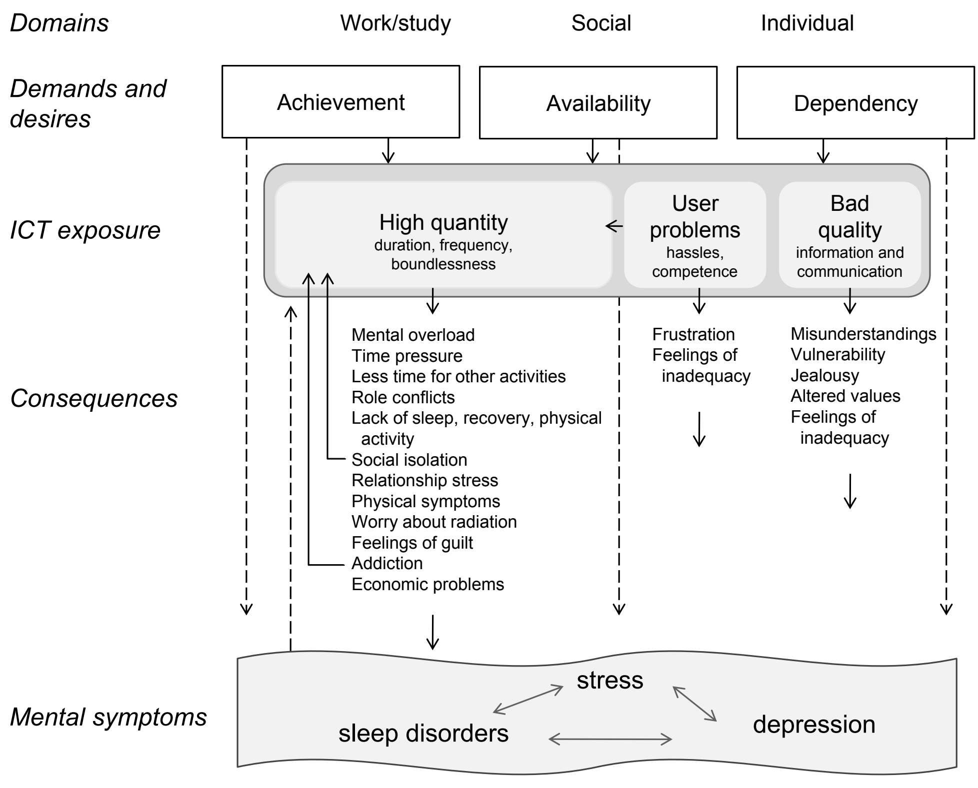

Figure 7. A model of possible paths for associations between ICT use and mental health symptoms. The proposed model is based on the concepts and ideas expressed by the young adults in Study II.

4.2.4 A model of possible paths

The proposed model (Figure 7) includes pathways to stress, depression, and sleep disorders, via the consequences of high quantitative ICT use, negative qualitative use, and user problems. The central factors appearing to explain high quantitative ICT use were demands for, and expectations of, achievement and availability, originating from the domains of work, study, social life, and individual aspirations. These demands could also be direct sources of stress or symptoms of mental ill health. Another central reason for high use was personal dependency. Dependency on ICT could also be a direct source of stress or a correlate to mental ill health. The consequences of high quantitative use included mental overload (interruptions, distractions, multitasking, speed of processing), time pressure, role conflicts, less time for other activities, neglecting bodily signals and personal needs (physical activity, nutrition, recovery, sleep), feelings of guilt due to unreturned messages, relationship stress, social isolation, physical symptoms, worry about electromagnetic radiation, addiction, and financial problems. Some factors could be part of a negative loop: for instance, high quantitative use could lead to social isolation or addiction, which in turn could generate even heavier use. Destructive communication and information could also have consequences including misunderstandings, vulnerability, effects on attitudes and values, and feelings of inadequacy. User problems including competence issues could be a source of frustration and feelings of inadequacy, and add to the time spent on ICT. In addition to these pathways leading from ICT use to symptoms, there were ideas expressed concerning paths leading in the opposite direction, for example mental ill health leading to altered (higher or lower) ICT use. Positive effects of ICT use on mental health were also considered to be a possibility, but are not included in the illustrated model (see Figure 7).

4.3 Study III: Mobile phone use and mental health outcomes

Results from cross-sectional and prospective analyses of associations between mobile phone exposure variables and mental health outcomes are presented below. The mobile phone variables *calls* and *SMSs* are included in the analyses as separate exposure variables; however, in Study III, only the combined variable (*mobile phone use)* was used. Furthermore, *reduced performance* has been added here as a mental health outcome in the analysis of mobile phone variables, which was not done in Study III. The robust variance option has been used in the prospective analysis in the thesis, but not in Study III. Hence, the CIs in Table 14 in the thesis are narrower than those in Table 4 in Paper III.

4.3.1 Cross-sectional associations

There were positive associations between *high* compared to *low mobile phone use* and current stress, sleep disturbances, and symptoms of depression (two items) for both the men and the women, after adjusting for relationship status, educational level, and occupation (Table 13).

Among the more qualitative mobile phone variables, *availability demands* was associated with current stress and symptoms of depression (two items) for the men and with all mental health outcomes used in Study III for the women. *Being awakened at night* was associated with current stress, sleep disturbances, and symptoms of depression for the men and women. For the men, *overuse* was associated with current stress, sleep disturbances, and symptoms of depression (two items), while for the women, *overuse* was associated with all mental health outcomes. The strongest associations (highest PRs) were found for *accessibility stress* in relation to the mental health outcomes. For the men, *accessibility stress* was associated with current stress, symptoms of depression (one and two items), and reduced performance; for the women, *accessibility stress* was associated with all mental health outcomes.

In all cross-sectional analyses in Study III (not including the additional variables in the thesis), the high category of the exposure variables generated a higher or equivalent PR compared to the medium category, indicating a dose–response relationship between the exposure variables and mental health outcomes, though not all associations were statistically significant. All but three PRs (77/80) were >1.0.

When separating *calls* and *SMSs* in the analysis, both exposures seemed to contribute to stress, sleep disturbances, and reduced performance, in a similar pattern, but only *SMSs* seemed to be a risk for symptoms of depression (two items). Furthermore, all mobile phone exposure variables except for *availability demands* were associated with reduced performance for the men and women (*calls* and *SMSs* separately did not reach statistical significance for the women) (Table 13).

4.3.2 Prospective associations

When excluding participants reporting symptoms at baseline from the analysis of the outcome concerned, *high* compared to *low mobile phone use* at baseline was associated with reported sleep disturbances and symptoms of depression (one item) for the men (PR 1.8, 95% CI 1.3–2.6, and PR 1.7, 95% CI 1.2–2.3, respectively) and symptoms of depression (two items) for the women (PR 1.5, 95% CI 1.1–2.1), at 1 year follow-up (Table 14. Note that these CIs are narrower than those in Table 4 in Paper III.)

There were no clear prospective associations between *availability demands* or *awakened at night* and the mental health outcomes in Study III, but with accurate CIs (using the robust variance option), *high availability demands* was a risk factor for current stress for both sexes. *High overuse* was now also statistically significantly associated with symptoms of depression (one item) for the men. For the women, both *high* and *medium overuse* were associated with sleep disturbances, and *medium overuse* was associated with current stress at follow-up. *High accessibility stress* was associated with current stress, sleep disturbances, and symptoms of depression (two items) for both sexes, and for the women, also with reduced performance.

In the majority of analyses (32/40) in Study III (i.e., not counting analyses including *calls*, *SMSs*, or *reduced performance*), the *high* category of the exposure variable generated a higher PR compared to the *medium* category.

Separately analyzing *calls* and *SMSs* gave results in a similar pattern as *mobile phone use* for the men (i.e., *high calls* and *SMSs* were risk factors for sleep disturbances and symptoms of depression (one item)). For the women, whereas *high SMS use* was associated with sleep disturbances and both symptoms of depression outcomes, *high mobile phone use* was only associated with symptoms of depression (two items) in Study III. *Calls* did not appear to be a prospective risk factor for the mental health outcomes for the women.

High and *medium accessibility stress* and *medium overuse* were risk factors for reduced performance among the women. None of the mobile phone exposure variables were prospectively associated with reduced performance in the men (Table 14).

Table 13. Cross-sectional associations between mobile phone exposure and mental health outcomes at baseline. Study group = 1455 men and 2701 women before analysis. The prevalence ratios (PRs) with 95% confidence intervals (CIs) were adjusted for relationship status, educational level, and occupation. PRs with a 95% CI not including 1.00 before rounding are presented in bold. For a more detailed presentation, including n and prevalence % for each category in analysis, see Table 3 in Paper III (not applicable for Calls and SMSs, or for the outcome Reduced performance).

		Current stress		Sleep disturbances		Symptoms of depression 1 item		Symptoms of depression 2 items		Reduced performance	
		PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
CALLS											
Men	High	**2.0**	**1.4-2.8**	**1.8**	**1.3-2.4**	0.9	0.6-1.2	1.0	0.7-1.4	**1.7**	**1.0-2.9**
	Medium	**1.6**	**1.2-2.1**	**1.3**	**1.1-1.7**	**1.3**	**1.0-1.5**	1.2	1.0-1.5	1.4	1.0-2.1
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	1.3	1.0-1.6	**1.4**	**1.1-1.7**	1.1	0.9-1.4	1.1	0.9-1.3	1.4	1.0-1.9
	Medium	**1.2**	**1.0-1.4**	**1.3**	**1.1-1.4**	1.1	1.0-1.2	1.1	0.9-1.2	1.2	1.0-1.5
	Low	1.0		1.0		1.0		1.0		1.0	
SMS											
Men	High	**1.8**	**1.3-2.5**	**1.8**	**1.4-2.3**	1.2	0.9-1.6	**1.6**	**1.3-2.0**	**1.9**	**1.2-2.9**
	Medium	1.0	0.7-1.4	0.9	0.6-1.2	1.2	1.0-1.5	1.1	0.9-1.4	1.1	0.7-1.8
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.2**	**1.0-1.4**	**1.3**	**1.1-1.5**	**1.2**	**1.0-1.4**	**1.3**	**1.1-1.4**	1.2	1.0-1.6
	Medium	1.2	1.0-1.3	**1.2**	**1.1-1.4**	1.1	1.0-1.2	1.1	1.0-1.3	1.2	1.0-1.5
	Low	1.0		1.0		1.0		1.0		1.0	
MOBILE PHONE USE											
Men	High	**1.9**	**1.4-2.5**	**1.7**	**1.4-2.2**	1.2	0.9-1.5	**1.3**	**1.0-1.6**	**1.6**	**1.1-2.4**
	Medium	1.3	1.0-1.8	1.1	0.9-1.5	1.2	1.0-1.5	1.1	0.9-1.4	1.4	1.0-2.1
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.2**	**1.1-1.5**	**1.4**	**1.2-1.6**	**1.2**	**1.0-1.4**	**1.2**	**1.1-1.3**	**1.3**	**1.1-1.6**
	Medium	**1.2**	**1.1-1.4**	1.1	1.0-1.3	1.1	0.9-1.2	1.1	1.0-1.3	**1.3**	**1.0-1.5**
	Low	1.0		1.0		1.0		1.0		1.0	
AVAILABILITY DEMANDS											
Men	High	**1.5**	**1.0-2.2**	1.3	1.0-1.6	1.0	0.8-1.2	**1.3**	**1.0-1.6**	1.3	0.9-2.0
	Medium	**1.5**	**1.0-2.0**	1.1	0.8-1.4	0.9	0.7-1.1	1.1	0.9-1.4	0.8	0.5-1.2
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.3**	**1.1-1.6**	**1.4**	**1.2-1.6**	1.2	1.0-1.3	**1.3**	**1.1-1.4**	1.2	0.9-1.5
	Medium	1.1	1.0-1.3	**1.2**	**1.0-1.4**	**1.2**	**1.0-1.3**	**1.2**	**1.0-1.3**	1.1	0.9-1.3
	Low	1.0		1.0		1.0		1.0		1.0	
AWAKENED AT NIGHT											
Men	High	**1.8**	**1.3-2.5**	**1.9**	**1.4-2.4**	**1.3**	**1.0-1.7**	**1.6**	**1.3-2.0**	**1.9**	**1.2-2.9**
	Medium	1.2	0.9-1.6	**1.3**	**1.0-1.6**	1.1	0.9-1.3	1.1	0.9-1.4	1.3	0.9-1.8
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.5**	**1.2-1.8**	**1.4**	**1.2-1.7**	1.1	1.0-1.3	**1.4**	**1.3-1.7**	**1.4**	**1.1-1.8**
	Medium	**1.2**	**1.0-1.4**	1.1	1.0-1.3	1.0	0.9-1.1	**1.2**	**1.0-1.3**	1.1	0.9-1.3
	Low	1.0		1.0		1.0		1.0		1.0	
ACCESSIBILITY STRESS											
Men	High	**3.5**	**2.6-4.6**	1.3	1.0-1.8	**1.8**	**1.4-2.3**	**2.4**	**2.0-2.9**	**2.7**	**1.8-4.1**
	Medium	**1.6**	**1.2-2.1**	1.2	1.0-1.5	**1.3**	**1.1-1.6**	**1.4**	**1.2-1.7**	**1.5**	**1.1-2.2**
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**2.5**	**2.1-2.9**	**1.6**	**1.4-1.8**	**1.4**	**1.2-1.7**	**1.7**	**1.5-1.9**	**2.3**	**1.9-2.9**
	Medium	**1.6**	**1.4-1.9**	**1.2**	**1.0-1.3**	1.1	0.9-1.2	**1.4**	**1.2-1.5**	**1.4**	**1.2-1.7**
	Low	1.0		1.0		1.0		1.0		1.0	
OVERUSE											
Men	High	**2.1**	**1.3-3.5**	**1.7**	**1.1-2.5**	1.3	0.8-2.1	**1.7**	**1.2-2.4**	**2.7**	**1.4-5.0**
	Medium	1.2	0.8-1.7	1.1	0.8-1.4	1.1	0.9-1.4	**1.4**	**1.1-1.7**	**1.8**	**1.2-2.7**
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.6**	**1.3-2.0**	**1.3**	**1.1-1.6**	**1.3**	**1.0-1.6**	**1.4**	**1.2-1.7**	**1.5**	**1.2-2.0**
	Medium	**1.3**	**1.1-1.5**	**1.2**	**1.0-1.4**	**1.2**	**1.1-1.4**	**1.2**	**1.1-1.4**	**1.3**	**1.1-1.6**
	Low	1.0		1.0		1.0		1.0		1.0	

Table 14. Prospective associations between mobile phone exposure at baseline and mental health outcomes (new cases) at follow-up. Participants who reported symptoms at baseline were excluded from analysis of mental health outcome concerned[1]. The prevalence ratios (PRs) with 95% confidence intervals (CIs) were adjusted for relationship status, educational level and occupation. Prevalence ratios with a CI not including 1.00 before rounding are presented in bold. Results of analyses with fewer than five cases are not presented, indicated as "…". For a more detailed presentation including n and prevalence % for each category in analysis, see Table 4 in Paper III (not applicable for Calls and SMS, or for the outcome Reduced performance).

		Current Stress		Sleep Disturbances		Symptoms of depression 1 item		Symptoms of depression 2 items		Reduced performance	
		PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
CALLS											
Men	High	1.3	0.7-2.4	**1.9**	**1.2-3.0**	**1.5**	**1.1-2.2**	…	…	1.1	0.5-2.4
	Medium	1.4	0.9-2.2	1.3	0.9-1.9	1.0	0.7-1.5	1.2	0.7-2.1	0.8	0.4-1.5
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	1.4	0.9-2.0	1.0	0.6-1.5	0.9	0.5-1.6	1.2	0.7-2.2	1.3	0.7-2.1
	Medium	1.1	0.9-1.5	1.2	1.0-1.5	1.1	0.8-1.4	1.1	0.8-1.5	1.1	0.8-1.5
	Low	1.0		1.0		1.0		1.0		1.0	
SMS											
Men	High	0.5	0.2-1.1	**1.8**	**1.2-2.8**	**1.6**	**1.1-2.4**	…	…	0.8	0.4-1.9
	Medium	0.7	0.4-1.2	**1.5**	**1.0-2.1**	**1.5**	**1.1-2.1**	1.4	0.8-2.3	1.2	0.7-2.1
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	0.9	0.7-1.2	**1.3**	**1.0-1.7**	**1.6**	**1.2-2.1**	**1.5**	**1.0-2.3**	0.8	0.5-1.2
	Medium	1.1	0.9-1.4	1.1	0.9-1.4	1.0	0.8-1.3	**1.5**	**1.1-2.0**	1.3	1.0-1.7
	Low	1.0		1.0		1.0		1.0		1.0	
MOBILE PHONE USE											
Men	High	0.9	0.5-1.4	**1.8**	**1.3-2.6**	**1.7**	**1.2-2.3**	1.1	0.6-2.0	0.9	0.5-1.6
	Medium	1.2	0.8-1.8	**1.4**	**1.0-2.0**	1.4	1.0-2.0	1.5	0.9-2.4	0.9	0.5-1.6
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	1.1	0.9-1.4	1.2	0.9-1.5	1.2	0.9-1.6	**1.5**	**1.1-2.1**	1.1	0.8-1.5
	Medium	1.0	0.8-1.3	1.1	0.8-1.4	0.9	0.7-1.2	1.2	0.9-1.7	1.0	0.8-1.4
	Low	1.0		1.0		1.0		1.0		1.0	
AVAILABILITY DEMANDS											
Men	High	**1.6**	**1.0-2.5**	1.4	1.0-2.0	1.2	0.8-1.7	1.6	0.9-2.9	1.0	0.5-1.8
	Medium	0.9	0.6-1.4	1.0	0.7-1.4	1.0	0.7-1.4	1.1	0.7-1.9	0.8	0.5-1.4
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.3**	**1.0-1.7**	1.1	0.8-1.4	0.9	0.7-1.1	1.4	1.0-2.0	1.3	1.0-1.8
	Medium	1.1	0.9-1.4	1.0	0.8-1.3	0.8	0.7-1.1	1.2	0.9-1.7	1.0	0.8-1.4
	Low	1.0		1.0		1.0		1.0		1.0	
AWAKENED AT NIGHT											
Men	High	1.4	0.8-2.3	1.4	1.0-2.2	1.1	0.8-1.7	1.4	0.7-2.7	1.4	0.7-2.6
	Medium	1.1	0.7-1.6	1.0	0.8-1.4	1.0	0.8-1.4	1.0	0.7-1.6	0.8	0.5-1.4
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	1.2	0.9-1.5	1.2	0.9-1.6	1.2	0.9-1.7	1.0	0.7-1.6	1.1	0.8-1.6
	Medium	0.9	0.7-1.1	1.1	0.9-1.3	1.0	0.8-1.3	1.2	0.9-1.7	1.1	0.8-1.4
	Low	1.0		1.0		1.0		1.0		1.0	
ACCESSIBILITY STRESS											
Men	High	**2.2**	**1.3-3.6**	**1.7**	**1.1-2.6**	0.9	0.4-1.9	**2.3**	**1.1-4.6**	1.4	0.7-2.8
	Medium	1.3	0.9-2.0	1.2	0.9-1.6	1.3	0.9-1.7	**1.6**	**1.0-2.4**	1.3	0.8-2.2
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**2.2**	**1.7-2.9**	**1.5**	**1.2-2.0**	1.3	0.9-1.8	**2.3**	**1.7-3.3**	**2.2**	**1.6-3.1**
	Medium	**1.5**	**1.2-1.8**	1.2	1.0-1.5	1.1	0.9-1.4	1.2	0.9-1.6	**1.4**	**1.0-1.8**
	Low	1.0		1.0		1.0		1.0		1.0	
OVERUSE											
Men	High	…	…	1.4	0.6-3.1	**1.9**	**1.1-3.4**	…	…	…	…
	Medium	1.3	0.8-2.1	0.9	0.5-1.4	1.1	0.7-1.6	0.6	0.3-1.5	0.8	0.4-1.7
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	1.3	0.8-1.9	**1.8**	**1.3-2.4**	0.9	0.5-1.5	1.0	0.6-1.9	1.4	0.9-2.2
	Medium	**1.4**	**1.1-1.7**	**1.4**	**1.1-1.7**	1.2	1.0-1.6	1.3	1.0-1.8	**1.5**	**1.2-2.0**
	Low	1.0		1.0		1.0		1.0		1.0	

[1]Study group n was for Current stress: 1222 men and 1913 women, Sleep disturbances: 1107 men and 1762 women, Symptoms of depression (one item): 617 men and 791 women, Symptoms of depression (two items): 534 men and 692 women, and Reduced performance: 1143 men and 1801 women. Missing values were excluded from the analyses, which means that the n varied further in the analyses.

4.4 Study IV: Computer use and mental health outcomes

Results from cross-sectional and prospective analyses of associations between computer use exposure variables and mental health outcomes are presented below. The cross-sectional analyses are presented in the thesis, but not in Paper IV.

4.4.1 Cross-sectional associations

High computer use was associated with concurrent symptoms of depression (two items) for the men, and with all mental health outcomes (including reduced performance) in the women (Table 15). *High email/chat use* was associated with sleep disturbances and symptoms of depression (two items) for both sexes, and for women, also with stress and reduced performance. For the men, *medium computer game playing* was actually associated with less perceived stress, but at the same time, with increased reports of sleep disturbances and symptoms of depression (one item). For the women, computer gaming was associated with most concomitant mental health outcomes. Furthermore, *CU without breaks* and *CU causing lost sleep* were associated with nearly all mental health outcomes for both the men and the women.

In all but one analysis, the high category of the computer exposure variables generated a higher or equivalent PR compared to the medium category. For women, all but two PRs were greater than 1.0. For men, *medium computer use* and *computer gaming* generated several PRs <1.0 (Table 15).

4.4.2 Prospective associations

When excluding participants reporting symptoms at baseline, from the analysis of the outcome concerned, both *high* and *medium computer use*, compared to *low computer use* at baseline, were associated with sleep disturbances at 1 year follow-up for the men, but not for the women (Table 16). For the men, *high computer use* was also associated with reduced performance. *High email/chat use* was negatively associated with current stress for the men, but was positively associated with reported sleep disturbances. For the women, both *high* and *medium email/chat use* were (positively) associated with current stress and sleep disturbances. Also for the women, *high email/chat use* was associated with symptoms of depression (one item). There were no other statistically significant associations with symptoms of depression (one item) in the prospective analyses. .

The only clear association concerning *computer gaming* and mental health outcomes was for women, where *medium gaming* was associated with symptoms of depression (two items). Both *high* and *medium CU without breaks* were associated with current stress, sleep disturbances, and symptoms of depression (two items) for the women. For the men, only *medium CU without breaks* had a clear association with sleep disturbances (*high CU without breaks* gave several PRs >1.0 that did not reach statistical significance). *High* (and, for the women, also *medium*) *CU causing lost sleep* was associated with current stress and sleep disturbances for both sexes. Furthermore, *high* and *medium CU causing lost sleep* were associated with reduced performance among the men, while *medium* (but not *high*) *CU causing lost sleep* was associated with symptoms of depression (two items) and reduced performance for the women (Table 16).

Table 15. Cross-sectional associations between computer exposure and mental health outcomes at baseline. Study group = 1458 men and 2705 women before analysis. Missing values were excluded from the analyses, which means that the *n* varied in the analyses. The prevalence ratios (PRs) with 95% confidence intervals (CIs) were adjusted for relationship status, educational level, and occupation. PRs with a 95% CI not including 1.00 before rounding are presented in bold.

		Current stress		Sleep disturbances		Symptoms of depression: 1 item		Symptoms of depression 2 items		Reduced performance	
		PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
COMPUTER USE (CU)											
Men	High	1.1	0.8-1.5	1.2	0.9-1.5	1.0	0.8-1.2	**1.3**	**1.0-1.7**	1.3	0.8-2.1
	Medium	0.9	0.6-1.2	0.9	0.7-1.2	0.8	0.7-1.0	1.2	1.0-1.6	1.0	0.7-1.7
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.2**	**1.1-1.4**	**1.2**	**1.1-1.4**	**1.2**	**1.0-1.4**	**1.4**	**1.2-1.5**	**1.3**	**1.1-1.6**
	Medium	1.1	0.9-1.2	1.1	1.0-1.3	1.0	0.9-1.2	1.1	1.0-1.2	1.1	0.9-1.4
	Low	1.0		1.0		1.0		1.0		1.0	
EMAIL/CHAT USE											
Men	High	1.2	0.8-1.8	**1.3**	**1.0-1.8**	1.2	1.0-1.6	**1.3**	**1.0-1.7**	1.1	0.7-1.9
	Medium	1.1	0.8-1.5	1.1	0.9-1.4	1.1	0.9-1.3	**1.2**	**1.0-1.5**	1.2	0.8-1.8
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.3**	**1.1-1.6**	**1.4**	**1.1-1.6**	1.2	1.0-1.4	**1.4**	**1.3-1.6**	**1.5**	**1.1-1.9**
	Medium	1.1	1.0-1.3	1.1	0.9-1.2	1,1	0.9-1.2	1.1	1.0-1.3	1.2	1.0-1.5
	Low	1.0		1.0		1.0		1.0		1.0	
COMPUTER GAMING											
Men	High	0.8	0.5-1.2	**1.4**	**1.0-1.8**	**1.3**	**1.0-1.7**	1.2	0.9-1.5	1.0	0.6-1.7
	Medium	**0.6**	**0.4-0.9**	0.9	0.6-1.2	1.1	0.9-1.4	1.0	0.7-1.2	0.7	0.4-1.2
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.9**	**1.4-2.5**	**1.4**	**1.0-1.8**	1.3	0.9-1.8	**1.6**	**1.3-1.9**	**1.9**	**1.2-3.0**
	Medium	1.1	0.8-1.4	**1.3**	**1.1-1.7**	1.1	0.9-1.5	**1.3**	**1.0-1.5**	1.0	0.7-1.5
	Low	1.0		1.0		1.0		1.0		1.0	
CU WITHOUT BREAKS											
Men	High	1.4	1.0-1.9	**1.4**	**1.1-1.7**	**1.3**	**1.0-1.6**	**1.4**	**1.1-1.8**	**1.7**	**1.1-2.5**
	Medium	1.0	0.8-1.4	1.1	0.8-1.4	1.1	0.9-1.4	1.2	1.0-1.5	1.1	0.8-1.7
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.6**	**1.3-1.9**	1.1	0.9-1.3	**1.2**	**1.0-1.4**	**1.4**	**1.2-1.6**	**2.0**	**1.6-2.5**
	Medium	**1.4**	**1.2-1.6**	**1.1**	**1.0-1.3**	**1.2**	**1.1-1.4**	**1.3**	**1.2-1.4**	**1.4**	**1.2-1.7**
	Low	1.0		1.0		1.0		1.0		1.0	
CU CAUSING LOST SLEEP											
Men	High	**1.7**	**1.2-2.3**	**1.7**	**1.4-2.2**	**1.5**	**1.2-1.8**	**1.8**	**1.4-2.2**	**2.0**	**1.4-3.0**
	Medium	**1.4**	**1.0-1.9**	1.1	0.9-1.4	1.1	0.9-1.3	**1.3**	**1.1-1.7**	1.4	0.9-2.0
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.9**	**1.6-2.2**	**1.7**	**1.5-2.0**	**1.3**	**1.0-1.6**	**1.8**	**1.6-2.0**	**2.8**	**2.3-3.4**
	Medium	1.6	1.3-1.8	**1.2**	**1.0-1.4**	**1.3**	**1.1-1.5**	**1.3**	**1.2-1.5**	**1.8**	**1.5-2.2**
	Low	1.0		1.0		1.0		1.0		1.0	

Table 16. Prospective associations between computer exposure at baseline and mental health outcomes (new cases) at follow-up. Participants who reported symptoms at baseline were excluded from analysis of the mental health outcome concerned[1]. The prevalence ratios (PRs) with 95% confidence intervals (CIs) were adjusted for relationship status, educational level, and occupation. PRs with a CI not including 1.00 (before rounding) are given in bold. Results of analyses with fewer than five cases are not presented, indicated as "…". For a more detailed presentation including n and prevalence % for each category in analysis, see Table 4 in Paper IV.

		Current stress		Sleep disturbances		Symptoms of depression 1 item		Symptoms of depression 2 items		Reduced performance	
		PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
COMPUTER USE											
Men	High	1.0	0.6-1.5	**1.8**	**1.1-2.8**	1.4	1.0-2.0	1.1	0.6-2.0	**2.0**	**1.0-4.0**
	Medium	1.0	0.7-1.6	**1.8**	**1.2-2.8**	1.1	0.7-1.5	1.1	0.6-1.9	1.2	0.6-2.5
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	1.1	0.9-1.4	1.2	1.0-1.5	0.9	0.7-1.2	1.2	0.8-1.8	1.1	0.8-1.5
	Medium	1.0	0.8-1.3	0.8	0.7-1.1	1.0	0.8-1.2	1.2	0.9-1.7	1.1	0.8-1.5
	Low	1.0		1.0		1.0		1.0		1.0	
EMAIL/CHAT USE											
Men	High	**0.4**	**0.2-1.0**	**1.9**	**1.3-2.8**	1.3	0.8-2.0	…	…	0.9	0.4-2.0
	Medium	0.8	0.5-1.3	1.1	0.8-1.6	1.1	0.8-1.6	0.9	0.5-1.5	1.3	0.7-2.2
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.7**	**1.2-2.2**	**1.7**	**1.2-2.2**	**1.9**	**1.5-2.5**	1.4	0.7-2.5	1.3	0.8-1.9
	Medium	**1.4**	**1.1-1.8**	**1.3**	**1.0-1.6**	0.9	0.7-1.2	1.2	0.9-1.7	1.2	0.9-1.6
	Low	1.0		1.0		1.0		1.0		1.0	
COMPUTER GAMING											
Men	High	0.9	0.5-1.5	1.2	0.7-1.8	1.3	0.9-1.9	1.1	0.6-2.0	0.7	0.3-1.7
	Medium	0.9	0.6-1.5	1.0	0.7-1.6	0.9	0.6-1.4	0.6	0.3-1.2	0.8	0.4-1.6
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	1.3	0.7-2.5	1.0	0.5-2.1	…	…	...	…	…	…
	Medium	1.0	0.6-1.6	1.4	0.9-2.1	0.9	0.5-1.7	**1.9**	**1.2-3.0**	0.8	0.4-1.6
	Low	1.0		1.0		1.0		1.0		1.0	
CU WITHOUT BREAKS											
Men	High	0.9	0.6-1.5	1.4	0.9-2.1	1.4	1.0-1.9	0.8	0.5-1.4	1.9	1.0-3.6
	Medium	1.2	0.8-1.8	**1.5**	**1.1-2.2**	1.0	0.7-1.4	0.8	0.5-1.3	1.6	0.9-3.0
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.6**	**1.2-2.2**	**1.7**	**1.3-2.2**	1.2	0.8-1.7	**1.8**	**1.2-2.6**	1.1	0.8-1.7
	Medium	**1.2**	**1.0-1.5**	**1.3**	**1.1-1.6**	1.0	0.8-1.3	**1.6**	**1.2-2.1**	**1.3**	**1.0-1.7**
	Low	1.0		1.0		1.0		1.0		1.0	
CU CAUSING LOST SLEEP											
Men	High	**1.8**	**1.2-2.7**	**2.0**	**1.4-2.9**	1.4	0.9-2.0	1.0	0.5-2.0	**2.1**	**1.1-4.0**
	Medium	1.2	0.8-1.9	1.4	1.0-1.9	1.2	0.9-1.6	1.3	0.8-2.1	**2.5**	**1.4-4.2**
	Low	1.0		1.0		1.0		1.0		1.0	
Women	High	**1.7**	**1.3-2.3**	**1.5**	**1.1-2.1**	1.1	0.6-1.7	1.5	0.9-2.5	1.4	0.9-2.2
	Medium	**1.5**	**1.2-1.9**	**1.4**	**1.1-1.8**	1.1	0.8-1.5	**1.9**	**1.4-2.6**	**1.6**	**1.1-2.1**
	Low	1.0		1.0		1.0		1.0		1.0	

[1]The study group *n* was: for *Current stress:* 1224 men and 1915 women; for *Sleep disturbances:* 1109 men and 1764 women; for *Symptoms of depression (one item):* 617 men and 791 women, and *Symptoms of depression (two items):* 535 men and 693 women; and for *Reduced performance:* 1145 men and 1802 women. Missing values were excluded from the analyses, which means that the *n* varied further in the analyses.

4.4.3 Combined computer and mobile phone exposure

Because *computer use* and *email/chat use* were risk factors for sleep disturbances among the men in Study IV (just as mobile phone use had been in Study III), these two computer exposure variables were tested in combination with the mobile phone use exposure variable, with sleep disturbances as the outcome. Furthermore, since *CU without breaks* was a risk factor for symptoms of depression among the women in Study IV (just as *mobile phone use* had been in Study III), these were tested in a combined analysis, with symptoms of depression (two items) as the outcome.

There seemed to be an interaction between *computer use* and *mobile phone use* in relation to sleep disturbances in a near additive fashion for the men, while for the women, only the "*high–high*" category was a risk exposure (Table 17). Men with *high email/chat use* in combination with *medium* or *high mobile phone use* had an almost tripled risk for sleep disturbances at follow-up, using "*low–low*" users as reference (Table 17). In the same analysis, for women, only effects of the *email/chat use* variable could be seen. Finally, there was a tendency towards interaction between *CU without breaks* and *mobile phone use*, with symptoms of depression as outcome, for the women (Table 18), while there were too few cases among the men to generate relevant results. Caution in interpretation of combination effects is necessary since in all these analyses, the CIs overlapped.

Table 17. Interaction between computer variables and mobile phone use at baseline and sleep disturbances (new cases) at 1 year follow-up[1].

	MEN Mobile phone use			WOMEN Mobile phone use		
	Low	Medium	High	Low	Medium	High
Computer use						
High	**2.2 (1.0–4.5)**	**2.9 (1.3–6.3)**	**3.4 (1.5–7.6)**	1.2 (0.8–1.7)	1.1 (0.7–1.8)	**1.8 (1.3–2.5)**
Medium	2.1 (1.0–4.3)	**3.2 (1.5–7.2)**	**3.9 (1.8–8.4)**	1.0 (0.7–1.3)	0.8 (0.5–1.3)	0.8 (0.5–1.3)
Low	1.0 (ref)	1.7 (0.7–4.4)	**2.4 (1.0–5.9)**	1.0 (ref)	1.3 (0.9–1.9)	1.1 (0.8–1.7)
Email/Chat						
High	1.8 (1.0–3.3)	**2.9 (1.7–5.2)**	**2.9 (1.5–5.6)**	**1.7 (1.1–2.7)**	1.7 (0.9–3.1)	**1.7 (1.1–2.7)**
Medium	1.4 (0.8–2.3)	1.8 (1.0–3.5)	…	1.1 (0.8–1.6)	1.4 (0.9–2.1)	1.5 (1.0–2.1)
Low	1.0 (ref)	1.3 (0.8–2.1)	**2.2 (1.4–3.3)**	1.0 (ref)	1.0 (0.8–1.4)	1.1 (0.8–1.5)

[1]Tables 17 and 18: Subjects who reported symptoms at baseline were excluded from analysis of mental health outcome concerned. The prevalence ratios (PRs) with 95% confidence intervals (CIs) were adjusted for relationship status, educational level, and occupation. Prevalence ratios with a CI not including 1.00 (before rounding) are given in bold. Results of analyses with fewer than five cases are not presented, as indicated by "…".

Table 18. Interaction between computer use (CU) without breaks and mobile phone use at baseline and symptoms of depression: two items (new cases) at 1 year follow-up[1].

	MEN Mobile phone use			WOMEN Mobile phone use		
	Low	Medium	High	Low	Medium	High
CU without breaks						
High	0.9 (0.5–1.9)	…	…	**1.9 (1.1–3.4)**	**2.4 (1.1–5.1)**	**2.3 (1.1–4.6)**
Medium	1.0 (0.5–1.8)	1.2 (0.5–2.6)	…	**1.7 (1.1–2.5)**	**1.8 (1.0–3.1)**	**2.3 (1.4–3.9)**
Low	1.0 (ref)	1.8 (0.9–3.8)	1.7 (0.8–3.7)	1.0 (ref)	1.3 (0.8–2.1)	**1.6 (1.0–2.6)**

[1]See note, Table 17

4.4.4 Associations with social support

Frequency of mobile phone use at baseline had little, if any, association with perceived access to social support for the men (r=0.08; p<0.01) and no association for the women (r=-0.01; p=0.48). There were no associations between social support and computer use variables at baseline for the men, except for a low ("little, if any") negative association with *CU causing lost sleep* (-0.10; p<0.001). For the women, there were low ("little, if any") negative associations with all computer variables (between -0.06 and -0.12; p<0.05).

4.5 Additional results

Additional results include correlations between exposure variables and correlations between mental health outcomes in the epidemiological studies. In addition, mobility in exposure and mental health outcomes from baseline to follow-up in studies III and IV is shown.

4.5.1 Correlations between exposure variables

Study I

Spearman correlation analysis showed high correlations between the computer use and the total ICT variable (r=0.96 and 0.90, for men and women, respectively), but low correlations between the mobile phone (hrs/wk) and the total ICT variable (r=0.21 and 0.33), indicating that computer use made up most of the variable (see Table 19). There were moderate correlations between computer use, Internet surfing, and chatting online. Furthermore, there were moderate associations between duration of mobile phone use and frequency of mobile phone calls and SMSs. There were little, if any, associations between the remaining exposure variables in Study I.

Table 19. Spearman correlation coefficients between exposure variables in study I, for the men (n=394-466; shaded cells) and women (n=405-512; white cells). All correlations are statistically significant (p<0.001) unless indicated as non-significant (ns).

	Computer use	Mobile phone use	ICT	Internet surf	Emailing	Chatting online	Phone calls	SMS
Computer use	-	0.16	0.96	0.53	0.22	0.48	0.08	0.11
Mobile phone	0.23	-	0.21	0.13	0.21	0.06 ns	0.58	0.43
ICT	0.90	0.33	-	0.53	0.25	0.46	0.11	0.15
Internet surf	0.52	0.21	0.53	-	0.18	0.35	0.09 ns	0.11
Emailing	0.26	0.10	0.26	0.23	-	0.13	0.14	0.14
Chatting online	0.46	0.16	0.43	0.36	0.25	-	0.03 ns	0.14
Phone calls	0.21	0.53	0.25	0.18	0.07 s	0.13	-	0.53
SMS	0.23	0.47	0.29	0.18	0.09 ns	0.24	0.51	-

Studies III and IV

The frequency of mobile phone use variable had low ("little, if any") positive correlations with all of the more qualitative mobile phone variables, as calculated using Spearman's correlation analysis, for both sexes (Table 20). Furthermore, there were low positive ("little, if any") correlations between most of the qualitative mobile phone variables, and no association between availability demands and accessibility stress. Among the computer variables, there were moderate positive associations between *computer use* (hours per day) and *computer use without breaks*, for both sexes (Table 20). The correlation coefficients were low positive for the remaining computer variables. Furthermore, there were little, if any, associations between the computer and the mobile phone variables. The strongest positive correlations could be seen between *SMSs* and *email/chat use* (Table 20).

Table 20. Correlations between exposure variables in WAYA. Spearman correlation coefficients between exposure variables in study I, for the men (n=1458; shaded cells) and women (n=2705; white cells). All correlations are statistically significant (p<0.05) unless indicated as non-significant (ns).

	Calls	SMSs	Mobile phone use	Awakened at night	Availability demands	Accessibility stress	Overuse	Computer use	Email/chat use	Computer gaming	CU without breaks	CU causing lost sleep
Calls	-	0.29	0.76	0.28	0.25	0.11	0.26	-0.13	-0.02 ns	-0.11	-0.08	-0.06
SMSs	0.40	-	0.77	0.22	0.14	0.04	0.17	-0.02 ns	0.17	-0.02 ns	-0.04 ns	0.03 ns
Mobile phone use	0.71	0.88	-	0.31	0.24	0.09	0.24	-0.09	0.08	-0.09	-0.06	-0.02 ns
Awakened at night	0.30	0.28	0.32	-	0.28	0.07	0.14	-0.06	0.10	-0.05 ns	-0.01 ns	0.06
Availability demands	0.23	0.18	0.23	0.29	-	0.00 ns	0.10	0.02 ns	0.08	-0.01 ns	0.05	0.06
Accessibility stress	0.09	0.06	0.10	0.09	0.03 ns	-	0.20	-0.04 ns	0.02 ns	-0.07	0.01 ns	0.09
Overuse	0.26	0.25	0.30	0.21	0.11	0.22	-	-0.12	-0.02 ns	-0.06	-0.09	0.04 ns
Computer use	-0.00 ns	0.07	0.05	0.06	0.06	0.00 ns	-0.02 ns	-	0.39	0.37	0.59	0.39
Email/chat use	0.08	0.21	0.18	0.18	0.14	0.01 ns	0.09	0.40	-	0.17	0.31	0.29
Computer gaming	-0.00 ns	0.03	0.02 ns	0.03 ns	0.03 ns	-0.03 ns	-0.04	0.18	0.04	-	0.36	0.27
CU without breaks	0.00 ns	0.07	0.04	0.08	0.07	0.07	0.02 ns	0.56	0.32	0.17	-	0.40
CU causing lost sleep	0.01 Ns	0.09	0.07	0.13	0.10	0.10	0.08	0.31	0.31	0.19	0.34	-

4.5.2 Correlations between mental health outcomes

There were relatively low positive associations between the mental health variables in the studies (ranging from 0.12 to 0.47 in the H24, and from 0.18 to 0.37 in the WAYA cohort), as shown in Tables 21 and 22.

In the WAYA cohort, the proportion of participants reporting reduced performance, due to stress/depressed mood or fatigue, evidently increased with number of mental symptoms reported, as can be seen in Table 23. Of those who reported neither stress, nor sleep disturbances, nor symptoms of depression, only a few percent reported reduced performance. Among those who reported all three mental health symptoms 40% of the men, and 52% of the women, had been categorized as reporting reduced performance.

Table 21. Spearman correlation coefficients between mental health outcomes in Study I, for the men (n=394-466; shaded cells) and women (n=405-512; white cells). All correlations are statistically significant (p<0.001).

	Current stress	Stress >7 days	Difficulties falling asleep	Repeated awak-enings	Symptoms of Depression	Reduced productivity
Current stress	–	0.30	0.31	0.30	0.35	0.28
Stress >7 days	0.29	–	0.27	0.13	0.35	0.25
Difficulties falling asleep	0.34	0.23	–	0.34	0.28	0.15
Repeated awakenings	0.20	0.18	0.45	–	0.12	0.16
Symptoms of depression	0.47	0.30	0.28	0.16	–	0.41
Reduced productivity	0.33	0.22	0.19	0.11	0.43	–

Table 22. Spearman correlation coefficients between mental health outcomes in the studies III and IV, for the men (n=1458; shaded cells) and women (n=2705; white cells). All correlations are statistically significant (p<0.001).

	Current stress	Sleep disturb-ances	Symptoms of depression	Reduced performance
Current stress	–	0.35	0.34	0.31
Sleep disturbances	0.36	–	0.26	0.18
Symptoms of depression	0.37	0.32	–	0.29
Reduced performance	0.35	0.27	0.33	–

Table 23. Percentage of reported reduced performance (due to stress, depressed mood, or fatigue), stratified by number of reported mental health symptoms (current stress, sleep disturbances, and symptoms of depression: one or two items), for the men (n=1458) and women (n=2705) in the WAYA cohort.

	Reduced performance by number of symptoms			
	0	1	2	3
Men	3%	8%	22%	40%
Women	4%	13%	29%	52%

4.5.3 Mobility in exposure

Mobility between the exposure categories from baseline to 1 year follow-up in studies III and IV, was examined by investigating if reported exposure had increased, decreased, or remained unchanged from baseline to 1 year follow-up. The categories formed for the studies were used. Possible mobility within the categories is not accounted for.

Stability in exposure categories between baseline and follow-up was 58–78% for the men and 58–92% for the women (Table 24). In total, both sexes had an overweight of increase (as compared to a decrease) in SMS use and, hence, in mobile phone use. Being awakened at night by the mobile phone seemed to have decreased slightly among the women, while *avail-*

ability demands had decreased in the men. For both sexes, the reported increase for *accessibility stress* was larger than the decrease. Both sexes reported increased computer use, and women also reported an increase in using the computer without breaks. Men seemed to have a slight increase in *CU causing lost sleep*. Differences between decreases and increases have not been statistically tested.

Table 24. Mobility in exposure from baseline to follow-up in studies III and IV (WAYA cohort).

	MEN n=1458			WOMEN n=2705		
Exposure	Unchanged %	Increased %	Decreased %	Unchanged %	Increased %	Decreased %
Mobile phone variables						
Mobile phone use	63	21	16	62	21	17
Calls	72	15	13	75	12	13
SMSs	70	18	12	64	20	16
Awakened at night	58	21	21	58	19	23
Availability demands	61	17	22	59	20	22
Accessibility stress	64	22	14	62	23	15
Overuse	78	13	10	69	16	15
Computer variables						
Computer use	63	23	15	56	26	17
Chat/email use	69	15	15	70	14	16
Computer gaming	76	11	13	92	4	4
CU without breaks	61	20	19	59	23	18
CU causing lost sleep	67	18	15	73	14	13

4.5.4 Mobility in mental health outcomes

Mobility in mental health outcomes from baseline to 1 year follow-up in studies III and IV was examined by investigating if reported mental health symptoms had increased (from non-case to case), decreased (from case to non-case), or remained unchanged (as case or as non-case). The categories formed for the studies were used. However, for simplicity, both symptoms of depression outcomes (*one item* and *two items*) were considered to be "case". Possible mobility within the categories is not accounted for.

Stability in the mental health outcomes (i.e., remaining a non-case or a case from baseline to follow-up) was 68-88% for the men, and 69-94% of the women (Table 25). In both sexes, a slightly higher proportion had increased rather than decreased in depressive symptom reports.

Table 25. Mobility in mental health outcomes from baseline to follow-up in the in the WAYA cohort; percentage (%) of participants that remained unchanged as non-case (0–0), unchanged as case (1–1), changed from non-case to case (0–1), and changed from case to non-case (1–0).

	MEN n=1458				WOMEN n=2705			
Mental health outcomes	0 – 0 %	1 – 1 %	0 – 1 %	1 – 0 %	0 – 0 %	1 – 1 %	0 – 1 %	1 – 0 %
Current stress	75	9	9	8	57	15	14	14
Sleep disturbances	65	13	12	10	53	21	13	13
Symptoms of depression[1]	31	37	17	15	20	49	17	15
Reduced performance	84	4	6	6	69	10	11	10

[1]Symptoms of depression: case = reporting one or two items.

5. Discussion

The ICT revolution has, in a very short time, brought about a new and extensive type of exposure, affecting almost everybody and most domains of life, yet we know little about possible effects of the exposure. There are many aspects to be considered and many possible questions that can be posed in this context. This thesis reflects only a fraction of possible focal points, taking a focus on behavioral aspects of ICT exposure and possible negative effects on mental health. Positive effects are also important to study, but were outside the scope of this thesis. The overall aim was to examine possible associations between ICT use and mental health symptoms among young adults.

In this section, first, the main results are summarized and discussed in terms of consistency. Then the results are discussed in the light of current knowledge, taking a starting point in a simplified version of the model proposed in Study II. Next, methodological considerations are discussed, including strengths and limitations of the thesis. Finally, implications for research and public health are suggested.

5.1 Main results

The main results indicate that intensive ICT use can have an impact on mental health in young adults. First, the explorative Study I showed prospective associations between high ICT use and mental health symptoms in a selected cohort of young adults. A model for possible paths explaining the associations was proposed in Study II, based on high ICT users' perceptions and reports, and theoretically validated against research in the field, showing that factors, quantitative as well as qualitative, in different domains, should be considered in epidemiological studies. The results included that high ICT exposure had a variety of consequences that could act as pathways to mental health symptoms. The suggested major causes of high ICT exposure (namely, demands for achievement, availability demands, and personal dependency) could also be direct sources of stress and mental symptoms. Parts of the model were tested in a population-based sample of young adults in studies III and IV. Both frequent mobile phone use and daily long duration of general computer use were prospective risk factors for sleep disturbances in the men. Frequent mobile phone use was also a risk factor for depressive symptoms in the men. In the women, frequent mobile phone use was a prospective risk factor for symptoms of depression, and often using the computer without breaks was a prospective risk factor for stress, sleep disturbances, and symptoms of depression. These prospective associations were in the range of PRs 1.6–1.8. A combined intensive mobile phone and computer use could be seen as enhancing the associations with mental health outcomes.

Of the more qualitative mobile phone variables, availability demands was a prospective risk factor for reporting stress in both sexes. Subjective overuse was prospectively associated with stress and sleep disturbances in the women, and with symptoms of depression in the men. Perceiving mobile phone accessibility as stressful seemed to be a risk factor for several mental health symptoms, but at the same time was not related to actual frequency of use or reported availability demands.

Regarding specific computer uses, intensive email/chat use in leisure time was associated with an increased risk for reporting sleep disturbances at follow-up in both sexes. In the women, high email/chat use was also a risk factor for stress and depressive symptoms, while it was a protective factor for stress in the men. Daily computer gaming for 1–2 hours meant an increased risk for symptoms of depression in the women. Often using the computer late at night (and consequently losing sleep) was a prospective risk factor for stress and sleep disturbances, including reduced performance, in both sexes.

Consistency of results

Frequent mobile phone use as a risk factor for sleep disturbances and symptoms of depression among the men was consistent across studies I and III, as was intensive email/chat use in relation to stress and symptoms of depression among the women in studies I and IV, in spite of the fact that these were different study populations, studied 5 years apart.

The results within Study III (the mobile phone study) were consistent in that most analyses resulted in PRs >1.0, and there was even a general tendency towards a dose–response relationship in the analyses. Also in Study IV (the computer use study), the majority of the analyses generated PRs >1.0, but the results were somewhat more diverse. For example, there were some clear negative associations among the men: computer game playing was associated with less reported current stress, and high email/chat use was associated with less reported stress at follow-up. On the other hand, in the same analyses, these exposures were positively associated with sleep disturbances. (A negative, although non-significant, association between email/chat use and stress can also be seen among the men in Paper I (Table 3), which suggests that there was some consistency in the inconsistency.) Other inconsistencies include the finding that high duration of total computer use seemed to be a prospective, but not concurrent risk factor for the men; by contrast, for women, it was a concurrent, but not (a clear) prospective risk factor. Some of the inconsistencies may reflect gender differences rather than chance findings. However, the results that both the medium and the high category of general computer use (i.e., using a computer 2–4 hours, and >4 hours, per day, respectively) were equal risks for sleep disturbances in the men, can raise some questions about these associations.

When analyzing *SMSs* and *calls* (the two components of *mobile phone use* in Study III) separately, the pattern was mostly the same, but there was a tendency that frequent *SMS*ing, more often than frequent *calls*, was associated with symptoms of depression. (There was also some inconsistency in the prospective associations with stress in the men.) Possibly, SMS use involves a somewhat different exposure, with different connotations compared to the use of regular phone calls. For example, correlation analysis in Table 20 shows positive (although low) associations between *SMSs* and *email/chat use*, not seen between *calls* and *email/chat use*. The reason for merging the two variables into one was that we had no theory about this in Study III.

There were generally more statistically significant associations in the cross-sectional analyses than in the prospective analyses in studies III and IV. The size of associations did not differ to any great extent (the statistically significant PRs ranged 1.1–3.5 in the cross-sectional analyses and 1.2–2.5 in the prospective analyses). The tested mental health outcomes occurred as effects in at least some of the analyses, in both sexes. In the prospective analyses, there was possibly an emphasis on sleep disturbances as effect among the men, while a more general pattern of mental health effects occurred among the women. There were no clear prospective associations between mobile phone exposures and reduced performance, or between computer exposures and symptoms of depression, among the men.

Positive effects

Positive effects of ICT use on mental health were not specifically examined in the studies in this thesis. Regardless of this, potential positive aspects were disclosed in the interviews in

Study II, such as ICT being stimulating, useful, and entertaining, and giving rise to flexibility and accessibility, as well as facilitating communication. A few “positive” results, i.e., negative associations, were found in Study IV. Men with medium computer gaming reported less concurrent stress compared to low gaming men. Moreover, for men, emailing or chatting for >2 hours per day prospectively reduced the risk for stress at follow-up in Study IV (this was indicated also in Study I), suggesting that this behavior is preventive. Then again, this conclusion is complicated as the risk for sleep disturbances increased in the same analysis.

5.2 Possible explanations for associations

Intensive computer use (in terms of duration for the men in the cohort, and continuous use without breaks for the women) was a prospective risk factor for mental health outcomes in Study IV. High quantity of computer use has been associated with mental health symptoms also in other studies [27-29]. However, we still do not know if it is the actual computer exposure that is the risk factor or if the factors covarying with intensive computer use are the real risk factors. For example, a work (or study) situation with high quantity of computer use may imply simultaneous exposure to high psychosocial or mental demands [21] that are established risk factors for mental health [122, 123]. Quantity of ICT use, as in terms of total hours of computer use (as in Study IV) can, consequently, probably at most be seen as an indicator. We do not know the intensity of the computer use, nor the context, the content, or how the individual perceives the use. Quantitative factors, such as duration and frequency, seem easier to measure than more qualitative factors. However, both quantitative and qualitative factors are likely to be relevant when trying to explain how ICT use can be a risk factor for mental health outcomes. As suggested in the Study II model, demands for achievement, availability demands, and personal dependency can lead to high quantitative ICT use, but can also be direct sources of stress and mental health problems, independently of ICT use.

Furthermore, these demands and expectations originate from different domains. In the epidemiological studies in this thesis, exposure was not differentiated in work, school, and leisure, neither were personality traits measured. Therefore it is not possible to link the context of the ICT use to effects (with the exception of email/chat use and computer gaming in Study IV, which reflected leisure use).

Taking a starting point in a simplified version of the Study II model (Figure 8), the results and possible explanations for associations are discussed, first regarding the demands and desires that cause high ICT use, including a selection of possible consequences of high ICT exposure. Thereafter, factors concerning quality of the information and communication in ICT and, finally, aspects of technology use will be briefly outlined.

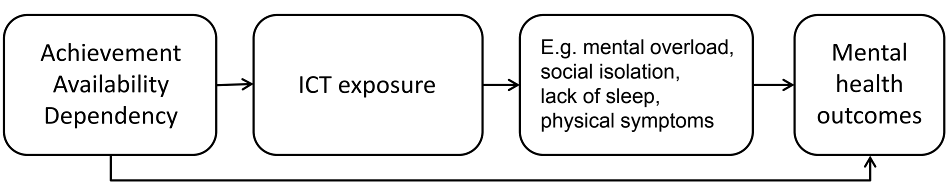

Figure 8. Simplified version of the model of possible paths for associations between ICT use and mental health outcomes in Study II.

5.2.1 Demands for achievement

In the interview study (Study II), demands related to work or study were acknowledged to result in periodic work or study overload, with long hours at the computer. This included performing complex, and mentally demanding, tasks and trying to keep to deadlines. The concept of demands is represented in well-known psychosocial stress models, for example the models of demand–control [20] and effort–reward imbalance (ERI) [122]. Chronic psychosocial stress, as defined in these models, has an established association with depression [122, 123]. This also applies to young adults; in one study, previously healthy young adults who were exposed to high psychological demands at work had a twofold risk of developing major depressive disorder and generalized anxiety disorder [124]. Furthermore, long work hours in general have a broad impact, leading to less time for sleep and recovery, longer exposure to workplace hazards and demands, and less time to attend to private life and family [125]. The boundless work situation offered by ICT puts high demands on the individual's own capacity to set limits for work. This could be especially difficult for people with high intrinsic demands in terms of achievement or performance. The concept of demands originating from the individual's own aspirations in the Study II model is comparable to individual characteristics such as overcommitment in the ERI stress model [122] and performance-based self-esteem (PBSE) [126], the latter of which has been suggested as a risk factor for burnout. In a study among the young adults in the WAYA cohort, by Löve et al [127], high levels of PBSE were found to increase the risk of attending work or studies even in illness and are therefore a risk factor for "pushing oneself too hard". Of relevance perhaps to Study I, is that PBSE seems to be higher among medical students than other populations [128].

In conclusion, intensive computer use was associated with mental health symptoms in Study IV. However, as previously mentioned, we do not know the reasons for, or context of, use. It is possible that demands for achievement, including work- or study-related psychosocial stress, can explain some of the associations.

5.2.2 Demands for availability

Another possible cause of high quantitative ICT use is demands for availability. Availability demands were central in the proposed model, whether emanating from work or studies, made by the social circle, or coming from the individual him or herself. The majority of the young adults in Study III reported that they were expected to be reachable via the mobile phone all day or around the clock. Constant availability via ICT implies difficulties separating the domains of work and personal life and can lead to role overload, role conflicts, and work/non-work interference. Role overload has been associated with negative mental health effects, at least in women [129]. Another possible consequence of constant availability is cognitive overload, in that distractions and dual-tasking are demanding on working memory [48, 49]. Mobile phone use has further been shown to distract attention [51-54] and enhance allergic responses [50], implying that the exposure related to availability can be stressful. Yet most respondents in Study III did not consider accessibility via mobile phones to be stressful. And in actual fact, a common dictum in the interview study (Study II) was that *not* being accessible was the major stressor. However, reporting high availability demands was associated with concurrent mental health symptoms, and was prospectively associated with stress symptoms (in the new analysis in the thesis). The risk for reporting mental health symptoms at follow-up was greatest among those respondents who indicated that they perceived accessibility offered by mobile phones as stressful. Paradoxically, this "accessibility stress" variable seemed to be unrelated to actual frequency of use and availability demands, and may therefore possibly reflect a personality trait. In addition, the variable can be argued to be close to the outcome as it includes “stress” in the phrasing and yet was analyzed as an exposure. However, the item was developed based on the interviews in Study II and was suggested as a possible mechanism related to ICT use. Moreover, stress is a multifaceted concept, with connotations both to the exposure stress (=stressor) and the effect stress (=strain).

In Study IV, intensive email/chat use in leisure time was associated with several mental health outcomes. An aspect of availability demands in the interviews in Study II was the tendency for unhandled messages to build up, whether on the computer or on the phone. This was acknowledged to add to load and guilt feelings. Demands for immediacy was another issue. Interviewees told how they had to reply promptly and failure to do so could result in questioning. Email use at work has elsewhere been found to be stressful and to contribute to overload [46, 55]. It is possible that some of the associations between quantitative exposure and mental health outcomes found in this thesis can be explained by demands associated with availability.

5.2.3 Personal dependency

Some respondents in Study II described a compulsion towards the mobile phone or computer, expressed as feeling an urgent need to check for messages. Others described addiction to e.g., computer games as a potential mental health risk related to ICT use. Personal dependency was a suggested cause of high ICT use in the model, and addiction was posited as a possible consequence of high ICT use. Addictions can consist of excessive behaviors of all types, and some factors have been argued to be present in all types of addictions (e.g., salience, tolerance, withdrawal, conflict, and relapse) [130]. Dependency, compulsion, or addiction, whether it concerns chatting, game playing, gambling, or other aspects of ICT use, is a possible cause of (or form of) mental ill health.

In Study III, perceived overuse of, or dependency on, the mobile phone was associated with most mental health outcomes in the cross-sectional analysis, and was a prospective risk factor for symptoms of depression for the men and sleep disturbances for the women. Associations between “problematic mobile phone use” and mental health symptoms have also been found in other studies [69, 90, 92]. The most common symptom of problem mobile phone use among adolescents in a study by Yen et al [92] was “withdrawal symptoms without cellular phone use.” Impulsivity, especially urgency, has been related to mobile phone dependency, and feeling compelled to provide for needs as soon as possible has been suggested to increase the likelihood of using the mobile phone in a destructive way, for example when prohibited [131]. However, subjective overuse had low positive correlations with frequency of mobile phone use in Study III, indicating that the variable reflected personal perception of behavior rather than an actual extreme use.

Addiction to the Internet has also been suggested as a possible mental health risk factor [68, 69, 81]. In Norway, the prevalence of “Internet addiction” was estimated to be 1% (with 5% being at risk). Internet addiction was not assessed in the studies in this thesis. Neither was online gambling (included in addiction in the model), which is another possible ICT-related health hazard. There is also the risk for addiction through gambling on mobile phones [91], which could be detrimental since the mobile phone enables gambling without time or space restrictions.

Computer gaming is potentially addictive [132] and can lead to high quantity of computer use. In this thesis, gaming was more common among the men than among the women in Study IV, as in other studies [3, 10-12]. Spending 1–2 hours per day on the computer playing games (*medium gaming*) was actually associated with decreased concurrent stress reports among the men. On the other hand, gaming >2 hours per day (*high gaming*) was positively associated with concurrent sleep disturbances and symptoms of depression in both sexes (and, in women, also with stress). The results suggest that for men, a limited amount of gaming reduces stress. (However, since the results were cross-sectional they may also suggest that unstressed (male) persons engage in a limited amount of gaming.) The same effects were not seen in the prospective analysis. Nevertheless, computer gaming can probably be a way of coping with stress. In a study of online game players, playing computer games at the workplace was related to recovery experience [133], and in a cross-sectional study of male college students, electronic gaming was suggested as a healthy source of socialization, relaxation, and coping [134].

For the women in Study IV, computer gaming was a prospective risk factor for reporting symptoms of depression. In a population of Internet game players (90,9% males), habitual gaming at night was related to an increase in depression scores in adolescents and emerging adults (though not in the group defined as young adults, aged 23–30 years) [79]. The association with depression was independent of total time spent playing, and was not mediated by sleep problems. The study was cross-sectional, which limits interpretation of causality. However, computer game playing at night may have negative effects on sleep, which is discussed below.

5.2.4 Consequences of high ICT exposure

In addition to the consequences of high ICT exposure, already discussed above, some participants in Study II who spent a lot of time on the computer (e.g., playing computer games) admitted to neglecting other activities, such as sleep, social life, or physical activity. Also, mobile phone use was considered to have consequences for sleep and social interaction, and to have a physical impact. These possible consequences of high ICT exposure will now be discussed as potential paths to mental health problems.

Impact on sleep and recovery

Disturbed sleep because of late night mobile phone calls or messages were reported in Study II and were considered a possible pathway in the model. When tested in Study III, only few respondents reported being woken up regularly by the mobile phone. However, being awakened at least a few times during the previous month was sufficient to be a concurrent risk factor for all mental health outcomes (though with no clear prospective effect). Furthermore, short sleep, dislocated sleep, or difficulties falling asleep because of getting stuck at the computer late at night were reported in Study II. This was the rationale for constructing the variable *CU causing lost sleep* in Study IV, which in the analysis confirmed that a negative impact on sleep can be a potential pathway to mental health symptoms. Several other studies have shown intensive ICT use to have a negative impact on sleep habits and to be associated with insufficient sleep [10, 64, 65]. Insufficient sleep or sleep restrictions have in laboratory studies (performed on animals as well as humans) shown physiological effects on stress systems and are consequently a risk factor for stress-related disorders, including depression [135, 136]. With regard to difficulties falling asleep, computer gaming before going to bed increased sleep latency and heart rate, and decreased subjective sleepiness and REM sleep, compared to controlled conditions in a laboratory study [137]. Furthermore, it has been suggested that computer use can negatively affect sleep by means of the exposure to the light transmitted from the screen and its effects on melatonin levels [138, 139].

Sleep disturbances (i.e., insomnia, fragmented sleep, or premature awakening) was a central mental health outcome in the prospective analyses in studies III and IV. Sufficient sleep and recovery is an established predictor of physical and psychological wellbeing, also among adolescents [140] and young adults [141]. Sleep disorders are a predictor of major depression onset, with an odds ratio of nearly 4, according to a prospective study of young adults [142]. Apart from being a risk factor for mental health problems (and a mental health problem in itself), sleep disturbances are also one of the diagnostic criteria in major depression (according to the DSM-IV). The importance of sleep and recovery, and the body of evidence that intensive ICT use potentially has a negative impact on sleep makes this an important mechanism to study.

Impact on social interaction

Computer use for communication purposes, such as emailing or chatting, seemed to be a central, and time-consuming, activity for many of the young adults in Study II. Information and communication technology provides the means to develop, expand, and maintain large social networks via email, SMS, and social media. It has been suggested that one of the advantages of ICT is facilitation of social support [61, 73, 143]. Since social support is a well-known factor that both promotes health and buffers negative effects of psychosocial strain [144, 145], this should be a positive aspect of ICT use. Interestingly, there seemed to be little, or no, association between frequency of mobile phone use or hours spent emailing or chatting on the computer, and perceived social support in studies III and IV.

In studies I and IV, high email/chat use was a prospective risk factor for symptoms of depression in the women. These results are supported by findings in a longitudinal study [146], where instant messaging and chatting was positively associated with depression 6 months later. However, the opposite, i.e., that emailing or chatting is associated with decreased depression, has also been reported in several studies [61, 72-74]. The context and the content of emailing and chatting needs to be further examined for better understanding the heterogeneous results. For example, in one longitudinal study, Internet use had no general effect on depression, but among the adolescents with poor friendship quality, Internet surfing (for non-communication purposes) predicted higher levels of depression, while instant messaging predicted lower levels of depression [147]. The results suggested that for adolescents with low friendship quality, instant messaging as a mode of communication brought about social support.

Several explanations for the relationship between communicating via the Internet and mental health problems in studies I and IV can be hypothesized. Perhaps young adults at risk of developing mental health symptoms have a greater need to communicate with others? Perhaps the quality of communication and interaction online is not truly supportive and interferes with real-life social relations? Social isolation was proposed to be a consequence of high quantitative ICT use and a pathway to, e.g., depression in the model in Study II. In addition, a negative loop was suggested between social isolation and ICT use, i.e., that social isolation leads to an even higher ICT use. A negative loop has also been shown by Morahan-Martin et al [75], who found that lonely individuals were more likely than their non-lonely counterparts to use the Internet for social interaction and emotional support, and to report that their Internet use interfered with real-life social activities. Caplan [148] concluded that social anxiety rather than loneliness explains the preference for online social interaction, because of benefits in comparison to face-to-face communication. Such benefits include having control of self-presentation, phrasing, and the speed of interaction, and therefore feeling safer and more confident than during interactions “in real life.” However, in a prospective study among adolescents, loneliness was negatively related to instant messaging 6 months later [146], indicating that those with a high level of loneliness were not more drawn to this type of communication.

Loneliness was not assessed in this thesis; the only near equivalents were correlation analysis of social support and ICT use (and controlling for relationship status in studies III and IV).

Physical impact

Information and communication technology use includes exposure to both physical factors and psychological factors, with effects on musculoskeletal symptoms, as described in a model by Gustafsson [13], and intensive computer use together with psychosocial factors increases the risk for musculoskeletal symptoms [17, 18, 21]. Physical symptoms or pain was suggested as a possible pathway to mental health problems in the Study II model. There is a reciprocal relationship between pain and depression [149], and pain is also closely related to sleep disturbances [150]. Since pain may cause depression and sleep disturbances, this is a plausible alternative pathway, which was, however, not assessed in the epidemiological studies in this thesis.

Also, intensive ICT use may result in a sedentary lifestyle. The sedentary nature of computer use and neglect of physical activity were common complaints in the interview study and were added as possible pathway to mental health symptoms in the suggested model. A high level of sedentary leisure activities, including TV viewing and computer use, negatively affects mental health and increases risk for depression [151, 152], while physical activity has positive effects on mental health and is acknowledged as a possible complementary treatment for depression and stress-related disorders [151, 153]. However, the possible role of physical activity was not assessed in the studies in the epidemiological studies in this thesis.

Another aspect of physical impact is anxiety about possible exposure to electromagnetic radiation as a consequence of high ICT use, which was reported as stressful in the interviews in Study II. Some participants even proposed radiation as a possible cause of mental ill health. Perceived electrosensitivity is associated with reporting symptoms of depression and worse general health compared to controls [36]. However, as mentioned in the Introduction, exposure to EMFs due to ICT use is not known to have any major health effects [37, 42]. Worrying about exposure to electromagnetic radiation is probably of greater significance for mental health than the actual exposure to EMFs, and worrying was consequently added as a possible pathway in the model in Study II (but was not tested in the epidemiological studies).

Financial problems

Financial problems as a consequence of ICT use, leading to reduced mental wellbeing, were mentioned in the interviews in Study II and were added to the model. Financial problems in this context can be an effect of online gambling, but can also be due to expensive phone bills. The increasing development towards payment via mobile phone, as well as applying for, and accepting, loans or credit via SMS, may increase impulse purchases and result in financial problems. In addition, keeping up with the ICT developments can lead to frequent costly purchases of new technology and expensive applications.

5.2.5 Quality of information and communication

The possibly destructive quality (or contents) of information and communication was suggested as a risk factor for mental health in the proposed model, but was only investigated to a limited extent in the thesis. It seemed easier to handle quantitative aspects than qualitative aspects within the study design of the epidemiological studies. Moreover, it is not clear how to define quality of ICT use. For example, computer game playing, which was examined in Study IV (and discussed in terms of quantity of use), can be seen in terms of quality or content of use. However, there are many different types of computer games, from Solitaire to online violent war games played in interaction with others. In an evaluation of the short-term physiological and psychological effects of playing violent video games, compared to non-violent games, effects on arterial pressure and state of anxiety (but not on measures of hostility) were found [154], which indicates that the quality of the game has a bearing on the effects. In Study IV, we add no information on this aspect.

Destructive aspects of communication, suggested in the interviews, included chat communications leading to misunderstandings and an increased risk to send and receive messages with negative content, creating frustration and interpersonal tension. Other qualitative aspects may be attitudes towards ICT and perceptions of use. Attitudes towards availability, i.e., "accessibility stress," were analyzed in Study III, a "qualitative factor" that was unrelated to quantitative exposure, but yet was an important risk factor for mental health outcomes. As proposed previously, it may reflect a personality trait.

Furthermore, feelings of vulnerability and inadequacy with regard to the Internet and the infinite possibilities offered were reported in the interviews in Study II. This can be seen as a parallel to the general cultural process of the increased individualism leading to load on the individual in the face of multiple or infinite opportunities, that have been proposed as contributing to the general increase in mental health problems among the young the past decades [63, 104].

Also, ICT as a vehicle for bullying or harassment was mentioned in the interviews. Bullying can be done via email, web pages, and by mobile phone, and includes misuse of picture taking [9, 155, 156]. Cyber bullying can be done anonymously and often affects victims in the privacy of their own homes, and yet can have a "worldwide" spread, making it difficult to defend oneself. This can lead to feelings of vulnerability. In 2010, in a Swedish survey, 9% of children aged 9–16 years had experienced cyber bullying. The (upsetting) experience of finding that someone has posted pictures of you on the Internet has become increasingly common in the past few years [9]. Another example of destructive content is that the Internet provides information and advice on suicide methods, enables interaction with other people contemplating suicide, e.g., in order to form suicide pacts, and can provide the means to committing suicide via online shopping [157-159]. However, as Bell points out in a review of the Internet and mental health [158], the Internet is just a medium, and cannot in itself be considered good or bad for mental health. Apart from possibly destructive content, the Internet also contains mental health information, as well as online support groups, online therapy, and more. The Internet potentially has an increasingly important role to play in health care, especially in management of psychological disorders, according to a review of Internet-based interventions for depression and anxiety [160]. Also, mobile phone based interventions has potential in the field of mental health, according to an overview by Harrison et al [161], suggesting that the mobile phone for e.g., self-management and monitoring of psychological problems, may be particularly appealing to young people.

5.2.6 Technology problems

User problems, including technical frustrations and competence problems, were mentioned as a cause of irritation and frustration in the interview study, adding to workload and causing more time to be spent at the computer than planned. User problems have been associated with stress [57, 58] and were included as a possible pathway in the proposed model. Yet the participants in Study II were all experienced ICT users. The majority had a computer science background and several worked in the IT field. Some said they were expected to have high ICT competence and described difficulties keeping up with developments. This can be experienced with regard to self-efficacy, which is considered to be a mediating factor between social behavior and mental health, also in relation to ICT use [60, 61]. The increasing dependence on ICT in all domains of life makes it likely that frustrations arise when technology fails. Experiencing difficulties to keep up with developments, with feelings of inadequacy, may be a common factor for many of us. On the other hand, it is also possible that competence issues, technology anxieties, and technostress (e.g., [25, 26, 57]) will be a problem of the past, i.e., a problem in the transition to becoming an ICT society, as technology seems to be increasingly user-friendly and the new generations handle technological artifacts and electronic media from an early age.

5.2.7 Gender aspects

In this thesis, both sexes displayed associations between exposure and mental health outcomes. The number of associations was greater among the women compared to the men. In the prospective analyses, there seemed to be an emphasis on sleep disturbances as the outcome for the men, while for the women a more general pattern occurred. Some results of the analyses were inconsistent between the sexes. The largest discrepancy can be seen in that intensive email/chat use was a clear protective factor for stress in the men but a risk factor for the women, in prospective analysis in Study IV.

The prevalence of the mental symptoms at baseline and new cases at follow-up was generally higher for women, which is consistent across health surveys [95, 99, 162]. There were differences in the exposure reports between the sexes in this thesis. The men reported a more intensive computer use in studies I and IV compared to women. In addition to differences in quantity of use, it is possible that men and women use the computer for different purposes. For example, computer gaming was more common among the men, as already mentioned. It has been suggested that whereas men are concerned with information gathering and entertainment motives, women use the Internet for communication [163]. However, in Study IV, and in recent statistics [2, 3], it seems that men and women have about the same levels of email/chat use. Furthermore, statistics show that gender differences are negligible among the younger age groups concerning several aspects of ICT use, including frequency and duration of Internet use and the use of social media [2, 3]. However, in 2011, the relatively new phenomenon of the mobile Internet was still more common among men >25 years old [7], and in the older age groups (55+), where ICT use generally is lower, men have a higher, e.g., Internet use compared to women [2, 3].

Several studies [10, 69, 164] have indicated gender differences in mobile phone use, with women and girls having a more intense use. In Study I, although the frequency of mobile phone calls seemed to be about the same for both sexes, women reported longer duration of mobile phone use and a slightly more frequent use of SMSs. In Study III, differences in mobile phone use were minor although perceived overuse was more commonly reported among the women than among the men.

It is difficult to interpret if the differences in the results between the sexes, in this thesis, reflect genuine gender differences in health effects of ICT use, or general gender differences in health reports, gender differences in e.g. content or context of ICT usage, or methodological aspects such as power or selection bias (e.g., considering the lower participation rate among the men compared to the women in studies III and IV).

5.3 Methodological considerations

The major strengths of the methodologies of the studies in this thesis include the combination of qualitative and quantitative methodologies, the prospective design of the epidemiological studies, the relatively large study groups, the use of a population-based sample in two of the studies, and the fact that a multitude of ICT use aspects and mental health outcomes has been considered. Major limitations include self-report of exposure and mental health outcomes, the 12 month interval between measurements, low response rate, selection bias, and uncontrolled confounding.

5.3.1 Study designs

Combining qualitative and quantitative methodologies can lead to a better understanding when studying a rapidly changing exposure and its impact on health, as in this thesis [165]. The qualitative interview study with its inductive methodology gave insights and provided suggestions for "what to look for" and thus helped us define research questions concerning what to test deductively in the epidemiological studies. However, the proposed model included a multitude of possible pathways, thus encompassing several different, perhaps parallel, or even mutually exclusive, mechanisms or pathways, and therefore is difficult to test in totality.

Another advantage is the longitudinal design of the epidemiological studies, with exposure assessed among symptom-free participants prior to outcome assessment. This facilitates conclusions to be drawn about the direction of associations and perhaps even gives clues as to causal relations. However, the time span between the two measurements, 1 year, could be considered a fairly long latency period for associating ICT exposure with mental health symptoms. We have no information about the exposure in the latency period, and the same applies to the mental health symptoms which are common in the population and which may come and go during the latency period. The study design therefore permits either cross-sectional analysis (making causal inference difficult) or prospective analysis with a 1 year latency period that could be considered too long. We know little about what time span may be relevant, and whether concurrent, short-term, or long-term exposure is of interest in relation to the outcomes. For example, it is possible that long-term exposure is needed to develop (or at least contribute to), say, depression, or that short-term exposure and a short latency period is relevant for perceived stress. Moreover, it is possible that the prospective associations are actually also concurrent associations, since there is an association between baseline and follow-up exposure. We did not control for concurrent exposure at follow-up in the prospective analyses. Consequently, it is difficult to draw clear inferences about the effect of the exposure on the outcomes within the study design.

It is further possible that there is a reciprocal relationship between the exposure and mental health symptoms. As discussed by De Lange et al [166], reversed effects between work aspects and mental health symptoms should be considered in longitudinal research. Translated to this thesis, this concerns reversed effects between ICT use and mental health symptoms, e.g., the effects of depressed mood, or problems with sleep, on levels or type of ICT use. However, reversed causality was not explored in the prospective studies in the thesis. This should be considered in future research.

Another issue is contrast in exposure categories. The variables based on time spent at the computer in Study IV did not permit us to evaluate extreme use. The cutoff for the highest category of general computer use was >4 hours per day, and the category therefore included almost 40% of the men and 30% of the women. Likewise, the high category for mobile phone use in Study III included more than 20% of the participants. It is possible that more extreme exposure is more hazardous to health, but is not captured in this thesis. Furthermore, having more categories with higher cutoffs may have enabled a more detailed dose–response analysis. In Study I, the categories were based on upper and lower quartile limits, and were not preset as in studies III and IV. It should be noted that when creating the categories in Study I, we based the cutoffs on the whole group. When performing analysis stratified for sex, this meant that the high and low categories were populated differently since exposure differed between the sexes, leading to a higher proportion of men compared to women in the high category and the opposite in the low category. At the same time, we did not wish to create cutoffs that were different for men and women, since we had no reason to believe that different thresholds should pose different risks for men and women.

Another limitation of Study I is that, apart from the stratified analysis for sex, we did not control for confounders. It can be assumed that medical and computer science students differ in ICT exposure. It can further be argued that the two groups may have differed in several additional relevant aspects, including health and sociodemographics. The results in studies III and IV were adjusted for potential confounding. The downside of this is introducing more missing values to the analysis and thus potentially losing power. Also, we adjusted only for confounder factors at baseline, and situations may have changed during the latency period, which has not been accounted for. Moreover, we adjusted for potential confounding in all analyses even though all confounders were not relevant in all analyses. Age was not considered a confounder because of the limited age span in the study population. However, there may be significant differences concerning health as well as exposure between a 20-year-old and a 24-year-old, which could confound the results. Then again, it is possible that when we adjusted for educational level, we to some degree adjusted for age, since it should be almost impossible for a 20-year-old to have completed higher education. In addition, geographical confounding may be present because half of the source population was from one region of Sweden and the other half was from the rest of the country, which was not controlled for.

Finally, in terms of study designs, it should be noted that when executing studies with multiple comparisons and using 95% CIs, there is always the risk that random results appear. We have not considered adjusting for multiple analyses, e.g., with Bonferroni correction [167]. While the first study was explorative, perhaps an adjustment for multiple comparisons would have been justified. Then again, this could have led to us missing relevant associations. Studies III and IV were hypothesis-driven. In other words, the tested exposures and outcomes were not chosen at random and a correction did not seem necessary.

5.3.2 Validity of exposure assessments

Among the limitations in the thesis is the use of self-reports for exposure assessment as well as for outcome assessment. This raises some reliability and validity questions. It is possible, but not obvious, that recall bias is an issue in the epidemiological studies. The questionnaires included many types of exposures and health outcomes, so specifically or selectively connecting mental health symptoms to ICT exposure should not be a concern. Recall difficulties were most certainly present. Estimating a whole week's ICT exposure and correctly specifying number of hours of computer or mobile phone use in retrospect (as in Study I) may be difficult and the estimations are probably rough. In studies III and IV, categorical response sets were offered in an attempt to facilitate recall and minimize misclassification. However, in a validation study using categories for computer use at work, agreement between self-reported and registered exposure clearly was low, with more than 80% of respondents misclassifying their computer use [168]. Overestimation seems to be common in relation to logged data [168-170]. In evaluations of self-reported mobile phone use in relation to, e.g., network operator records, it is common that the duration of calls is overestimated [171-173], while frequency is underestimated [171, 172]. The same seems to apply to adolescents, whose self-reports in comparison to logged data were only modestly accurate [174]. However, there are some inconsistencies in validation studies; in Shum et al [171], the correlations between reported mobile phone use and billing records were considered to be relatively high, but in contrast to expected findings, the participants reported slightly lower duration of calls and a higher frequency compared to billing records, and reports concerning monthly exposure were more accurate than estimated weekly or daily use. The case of overestimations (or underestimations) in exposure reports should be of minor importance if it concerns all respondents. However, in Tokola et al [172], light users underestimated and heavy users overestimated the duration of calls. If this is a general tendency there is a risk of false contrast generated when categories are based on respondents' reports. The categories in studies III and IV were preset and generally broad, so this should not be critical. And even so, risk estimates should not be affected unless exposure reports are biased by the effect outcomes.

In an attempt to increase validity of the exposure assessment in Study I, we chose to include only those respondents who had indicated that the previous week's exposure represented typical use. This unfortunately meant a loss in terms of numbers, but hopefully it better reflected long-term exposure. For this purpose, the exposure in studies III and IV was proposed to render average daily use over the previous month.

There were several other validity problems with exposure assessment in Study I. For example, it is possible that responses in some cases reflected how much time the phone was switched on rather than how active the use was, exemplified by the fact that some respondents reported mobile phone use to be 168 hours/week. We did not exclude reports that seemed unreasonable, since it was an explorative study and we could not know when the reported exposure was reasonable or not. However, the "outlying" numeric exposure values were not submitted to analysis, since we used categories.

Several of the more qualitative exposure items in studies III and IV were constructed based on the results of Study II and had not been formally validated. However, the WAYA questionnaire was reliability-tested (test–retest reliability of most ICT exposure variables was moderate to high) and validating feedback was received in a pilot study before administering the questionnaire in the cohort [110].

In Study III, potential misclassification existed in the merged mobile phone use variable, in that while the *high* and *low* categories were distinct from each other, the *medium* category overlapped to some extent with both the *high* and the *low* categories, which means that, in some instances, individuals in the *medium* category may in fact have had a higher exposure (in terms of number of calls and SMS messages) than some individuals in the *high* category, or lower exposure compared to some in the *low* category.

In conclusion, it is possible that misclassification of exposure may have obscured the results in this thesis. Perhaps in a future study, it would be advisable to use objective exposure assessment via technical registration, rather than self-reports. Then again, when studying psychosocial aspects of ICT use, exposure should probably be measured differently than when studying physical aspects. It can also be argued, as in social–cognitive theory [61], that it is the perception of behavior, rather than the actual behavior itself, that matters. In other words, what counts the most when taking a psychosocial perspective on ICT exposure in this research is whether the participants perceive themselves as high or low users.

5.3.3 Validity of mental health outcomes

It is important to point out that the study concerns subjective symptom reports and not actual mental disorders or diagnoses. We used validated outcomes (*current stress* [111], and *symptoms of depression* [113]) and items that were either adapted from a validated item (*continuous stress*), singled out from full instruments (the two sleep disturbance items in Study I), or constructed for the study based on items in existing instruments and using the same response format (*sleep disturbances* in studies III and IV). The *reduced productivity/performance* items were adapted from a previously validated item [115], but were not validated for the present studies. Not using fully validated outcomes is a weakness of this thesis.

A semi-validation of the *reduced performance* item was done in the thesis. In strata defined by the number of endorsed mental health symptoms in the WAYA cohort (studies III and IV), *reduced performance* (due to stress, depressed mood, or fatigue) evidently increased in line with number of symptoms, implying that the variable captured severity of mental health problems to some extent.

The stress item (*current stress*) is considered to have satisfactory content, criterion, and construct validity as a measure of mental wellbeing in group level analysis [111]. However, the stress item includes problems with sleep in its definition of stress, which means that there is potential overlap with the sleep disturbance items. There were overall relatively low correlations between the mental health variables in the studies (e.g., from 0.18 to 0.37 in the WAYA cohort), indicating that although there probably is overlap and co-morbidity of symptom reports, the symptoms could be used as separate outcomes.

In the WAYA cohort study group, approximately 50% of the men and almost 65% of the women confirmed at least one of the two depressive items. The PRIME-MD manual proposes that if one of the two depressive items is confirmed in screening, this is sufficient to go forward with a clinical assessment of mood disorder. This procedure has been shown to have high sensitivity for major depression diagnosis (86% [113] and 96% [114]), but lower specificity (75% [113] and 57% [114]) in primary care populations. In the youngest age group (<35 years old) in Whooley et al [114], the sensitivity was 100% and the specificity 59%. Following the suggested PRIME-MD procedure [113, 114], a predictive power of 33%, as suggested in Whooley et al [114], would imply that about 20% of the study population in studies III and IV were clinically depressed. However, the predictive value decreases if the prevalence of depression is lower in our young adult populations than in the mentioned studies. For comparison, the 1 month prevalence of depression among Finnish young adults (20–24 years of age) was 9.6% [175]. Suspecting that the instrument would be too sensitive for our population, we chose to adapt the analysis accordingly, expecting that the two-item outcome would have higher specificity than if following the suggested procedure.

Another validity aspect is the method of measurement. The questionnaire in Study I was web-based. In studies III and IV, it was possible to complete the baseline questionnaire in paper or on the Internet, while the follow-up questionnaire was administered only via the web (except after the third reminder). We do not know if the use of different forms of questionnaires affects responses. Some subjects may have been unwilling to reveal personal information via the Internet. However, web data have been found to be comparable to pencil-and-paper data concerning personality questionnaires and other self-report instruments [176-178], though in one study, one of the instruments (the Symptom Checklist-90) generated lower reports in the web-based version, compared to the paper version [178]. Web-based methodology is increasingly common in many domains including research and health care and young adults are probably accustomed to using it.

5.3.4 Validity of the qualitative study

Methodological considerations of qualitative studies can be discussed in terms of trustworthiness, i.e., the study's credibility, dependability, and transferability [120]. In Study II, interviews seemed an optimal method of capturing perceptions about associations. Dependability was ensured by using a manual for the semi-structured interviews; also, one interviewer performed all the interviews. Credibility was sought for by the careful data analysis, including the low level of interpretation used in the analysis and presentation. Furthermore, preliminary results were discussed and validated in a reference group of specialists in child psychiatry, student psychiatry, stress medicine, and sleep medicine, and the model was developed in conjunction with the co-authors of Study II.

The interview participants as a group perceived connections between ICT use and mental symptoms, however, some were more prone to identify themselves within the context of these connections, while others maintained that the connections did not apply to themselves. This means that they sometimes spoke in more general terms, rather than through personal experience; therefore, some of the factors that emerged could be mere speculation. On the other hand, we were primarily interested in concepts and ideas.

The interviews were performed with a highly selected study group so as to enhance the potential to identify factors or conditions that could connect ICT use with mental symptoms and it is possible that the current mental states of the subjects affected their perceptions. The study group was also highly selected in that it consisted of students from high achieving academic fields. Neither socioeconomic factors nor academic background were taken into account. The selectiveness of the participants may prevent transferability of the results. The issue of gender differences was not pursued in Study II, though they certainly could exist. In addition, the focus of the study was to explore possible explanations for negative effects of ICT on mental health. It is probable that taking a more neutral stance or a positive stance concerning ICT and mental health would result in a different model. The suggested model does not include positive pathways between ICT and mental health though these may certainly exist. However, investigating these was not within the scope of the study.

5.3.5 Generalizability

The first two studies were performed in a selected population of university students and the results cannot easily be transferred to the general young adult population. One major advantage of studies III and IV was that they were performed in a population-based sample. However, the response rate was low. This is fairly common in questionnaire studies administered in the general population, a problem that has increased in the past decades [179]. Non-response or attrition from longitudinal studies is generally found to be associated with male gender, younger age, and lower education, but is also often due to worse mental health, e.g., depressive symptoms [180-182]. The young adult population is probably particularly difficult to recruit because more often than with other age groups, their life situation undergoes drastic changes, including moving more often and therefore being more difficult to reach. In the WAYA cohort, women and native-born Swedes were overrepresented [110] and the final study groups in studies III and IV contained almost twice as many women as men. Confounding due to sex was eliminated by performing separate analyses for men and women throughout the epidemiological studies in the thesis. However, the participation rate for the men was only 15% in studies III and IV and it is questionable to what extent the participants are representative of the general population of young adult men and, consequently, to what extent the results can be considered valid for this population.

A healthy selection bias can be expected in the studies. The prevalence of mental health symptoms was about the same in the study group and the dropout group from baseline to follow-up in the WAYA cohort (studies III and IV), except for a slightly lower prevalence of sleep disturbances among the men, which at least indicates that attrition seemed to increase the healthy selection bias to only a small extent. However, when excluding those with symptoms at baseline before analysis, the remaining participants (=the true study group/s in the prospective analyses) might differ from the source population in several respects including health and resilience, which is not accounted for in the results.

It can be argued that problems connected with low participation rates are of less importance in prospective studies than in, e.g., prevalence studies [167]. However, if non-participation is associated with the exposure or outcome under study, this could nevertheless be an issue, affecting risk estimates and, consequently, the conclusions drawn from the study [179, 183]. In studies III and IV, the dropout group differed in exposure with regard to having slightly lower computer use and higher mobile phone use compared to the study group. It can be hypothesized that these differences were even more pronounced among the non-respondents in the source population. In addition, the study group in studies III and IV was biased towards students and higher education, which needs to be considered when generalizing the results. In conclusion, caution should be used when generalizing the results to a general population of (Swedish) young adults.

5.4 Implications for research and future work

The seemingly ever increasing exposure to ICT warrants research on physical, as well as, psychosocial aspects of the exposure, and potential physical and mental health effects. The impact on health may be both positive and negative, which should be recognized in future studies. In addition to positive health outcomes, outcomes could include creativity, social interaction or networking, and career aspects. The studies in this thesis focused on negative outcomes, i.e., examined ICT use as an epidemiological mental health risk. The amount of prospective studies in the field is relatively limited, but has increased since Study I. Contribution of this thesis to the current knowledge includes that intensive ICT use had an impact on reported mental health symptoms in the population-based prospective cohort studies among young adults. Moreover, the findings indicate that sleep is an important mediating factor to focus on in future studies.

Most factors and conditions in the proposed model in Study II can be argued to influence mental health, but only parts of the model could be tested within the framework of this thesis. It is probable that different pathways are relevant for different groups of individuals and different social situations, and that high ICT use can reflect different usage patterns and lifestyles. For example, one person could be active and socially outgoing, carry a high workload with high demands, use computers and mobile phones heavily in both work and social life, and lead a hectic lifestyle with insufficient recovery. Another person might spend much of the day and night at the computer, playing interactive games online, leading a social life on the Internet but having few friends "IRL" (in real life), experiencing dislocated sleep, and leading a sedentary lifestyle. In both cases, ICT use may be associated with effects on mental health but possibly through different pathways. An implication for future research is consequently to study patterns of exposure (e.g., frequency, duration, intensity, type of use), lifestyle factors (e.g., social interaction, sleep, physical activity), psychosocial factors (e.g., demands, control, social support), individual characteristics (e.g., performance-based self-esteem, self-efficacy, dependency), and mental health outcomes, for example by using cluster analysis (e.g., [184]). In addition to quantitative aspects of ICT use, qualitative aspects (such as contents of use and perception of use), should be acknowledged. Although ICT use infers boundlessness between different domains and roles, it is probably pertinent in studies to differentiate between exposure related to work, studies, and leisure. Different types of psychosocial stressors can be connected to the different domains of ICT use. (However, difficulties separating the domains may be part of the problem.) Furthermore, possible reversed effects between ICT use and mental health should be considered and examined. In conclusion, more research of the possible mechanisms connecting ICT use and mental health symptoms is needed to explain the epidemiological findings. Tailoring seems necessary when designing interventions and intervention studies. Interestingly, ICT has shown some promising features as a vehicle for mental health interventions, and could perhaps be utilized for this in future studies.

Finally, the rapid development of ICT and the rapid popularization and spreading of different applications makes it difficult to keep up in research on the subject. Just between the baseline of Study I in 2002 and the Study III and IV baselines in 2007, ICT exposure increased drastically. For example, the young adult age group doubled their Internet use [3] and SMS use increased several-fold [6], which makes comparison between the studies somewhat complicated. The cutoffs in Study I can in several instances put those previously categorized as high users in the low category in studies III and IV. To state risk thresholds in an ever increasing exposure is probably difficult and perhaps faulty. Development after studies III and IV to date (February 2012) includes the large increase in social media use and mobile Internet access. Computers and mobile phones are merging into one. An ever changing development of the technology and its applications is a challenge for research and caution is advised when comparing and interpreting study results over time. The combination of qualitative and quantitative methodologies seems appropriate when aiming to capture the impact of a changing exposure. When designing methods for exposure assessment it is crucial that they are applicable also in longitudinal studies.

5.5 Public health implications

The new technologies and their applications have had a major breakthrough in the daily life for almost all, but particularly for the young. The use of ICT puts high demands on the individual's own capacity to set limits for activity and accessibility. It allows a blurring of boundaries, e.g., permits work to invade private life. Societal and individual attitudes and norms play an important role in this respect. The transition to the ICT age has been rapid while cultural norms develop slowly. There seems to be a diversity in attitudes and norms in different subgroups regarding e.g., accessibility and ICT behaviors. Shared cultural norms will likely progress in due course, leading to more common ethics regarding ICT behaviors, in terms of availability demands, communication rules, information-seeking and updating demands, and overall intensity of use. From an occupational health perspective it is important to support norms that ensure a healthy work life balance.

Possible negative effects on mental health and on performance suggest subjective suffering for the individual. It can also have bearings on work ability and productivity, and can therefore have societal implications. Consequently, it seems desirable to support healthy use of the modern technologies in order to prevent possible destructive uses or effects. Public health prevention strategies aimed at the young could include information, in schools and universities, about healthy ICT use, comprising information about the importance of taking breaks and ensuring recovery when using, e.g., computers intensively, as well as advice to set limits for accessibility (i.e., turn off the phone) at certain times such as at night, when needing to focus or rest, or when others need to focus or rest. Shifts in attitude could include limiting your demands and expectations on others' availability.

6. Conclusions

The main findings in this thesis suggest that intensive ICT use can have an impact on mental health among young adults.

- The concepts and ideas of the young adults with high ICT use and mental health symptoms generated a model showing several possible paths for associations between ICT exposure and mental health. Factors in different domains may have an impact and should be considered in epidemiological studies.

- Intensive computer use ("intensive" in terms of duration of use or continuous use without breaks) was a prospective risk factor for reporting sleep disturbances in the men and stress, sleep disturbances, and symptoms of depression in the women. Often using the computer late at night and thus losing sleep was a prospective risk factor for several mental health outcomes in both sexes.

- Frequent mobile phone use was a prospective risk factor for reporting sleep disturbances and symptoms of depression in the men, and symptoms of depression in the women. Perceiving the accessibility offered by mobile phones as stressful was associated with most mental health outcomes in both sexes.

- Combined intensive computer and mobile phone use enhanced associations with mental health symptoms.

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