Cal State Fullerton
COLLEGE OF BUSINESS AND ECONOMICS
DEPARTMENT OF ECONOMICS | https://business.fullerton.edu/academics/ECONOMICS | 657-278-2228

Department of Economics
Working Paper Series

2022/002R

The Economic Burden of Adolescent Internet Addiction: A Korean Health Cost Case Study

Robert W. Mead and Edward Nall

July 2022

800 N. State College Blvd., SGMH 3313, Fullerton, CA 92831
CSUF

The Economic Burden of Adolescent Internet Addiction: A Korean Health Cost Case Study

Robert W. Mead
Department of Economics
California State University—Fullerton

Edward Nall
California State University—Fullerton

Address correspondence to Dr. Robert W. Mead, Department of Economics, California State University—Fullerton, Fullerton, CA 92834 USA. Telephone: (657) 278-4479. E-mail: rmead@fullerton.edu.

Robert W. Mead is an Associate Professor of Economics at California State University, Fullerton. Previous work has included looking at economic valuation of the health costs of urban air pollution in China.

Edward Nall is a graduate from the College of Business and Economics at California State University, Fullerton with an undergraduate concentration in accounting.

The Economic Burden of Adolescent Internet Addiction: A Korean Health Cost Case Study

While internet saturation is the source of a number of benefits, such as productivity increases and general economic growth, it has given rise to concerns over the emergence of a new clinical disorder: internet addiction. Noting the extent of high internet use amongst adolescents in the Republic of Korea, this paper provides some quantification regarding the extent of subsequent health costs upon adolescents in Korea. Using Korea-based health-effects and valuation studies, the authors project, and value in dollar figures, the number of internet addiction related cases of adolescent atopic dermatitis, allergic rhinitis, asthma, obesity, depression, and suicides over a projected 15-year period. The results indicate that these health costs may be substantial: over $29 billion for the study period.

Keywords: Internet Addiction, Korea, Health, Cost of Illness, Adolescent

1. Introduction

The Republic of Korea (hereafter Korea) is the world's top internet nation. The United Nations' International Telecommunications Union ranks Korea first in the information and communication technology development index. Over 98% of households have internet access and Korean internet use increased from 83.7% in 2015 to over 90% in 2017 (ITU, 2015 & 2018). This internet growth has generated economic gains such as productivity increases (Jung et al., 2013) and general economic growth (Hwang & Shin, 2017). It also gives rise to Korea being the epicenter of a vast internet gaming phenomenon.

Making the internet public in 1991 opened new pathways to enormous amounts of information and instant global communication. Since then, the internet has gradually become an ever-present facet of modern life to the extent that a mobile phone is now enough to give anyone of any age anywhere access. While easy internet availability is a source of benefits, it also has a dark underbelly. The degree of saturation and usage gives rise to concern over the emergence of a new proposed clinical disorder: internet addiction[1] (Young, 1998; Young & de Abreu 2010).

Korean adolescents are particularly vulnerable to this disorder because the unparalleled access to and extensive usage of the internet interacts with vulnerabilities in their physiological and social development (Kwon, 2011). For example, adolescents are at a developmental stage where they are especially prone to impulsiveness (Tereshchenko & Kasparov, 2019). They are also vulnerable to the consequences of internet addiction, e.g., sleep deprivation, because they are still in the formative stages of their physical and mental health (Choi et al., 2018).

[1] Our reading of the literature uncovered a host of terms to identify and characterize a spectrum of internet maladies. Young (1998) initially introduces the idea of internet addiction as a clinical diagnosis, but we have found the terms internet gaming disorder, internet dependency, internet use disorder, problematic internet use, online game addiction, as well as others to identify internet-based disorders. More recently, we have seen references to smartphone addiction as yet another category. We use internet addiction to both establish a threshold level and to examine a particular population profile in our analysis.

Estimates of Korean internet addiction vary, but civil concern pushed the Korean National Assembly to pass the Youth Protection Revision Act in 2011. This law, frequently called the "Cinderella Law" in the media, prohibited youth under the age of 16 from certain internet activities between the hours of midnight and 6:00 am. The intent of this shutdown is to mitigate certain sources of internet addiction and the subsequent adverse health consequences of sleep deprivation. The shutdown had minimal impact in terms of either decreasing internet use or increasing sleep duration in adolescents (Choi et al., 2018; C Lee et al., 2017) and was eventually rescinded in 2021 (Kattula et al., 2021). The concerns driving the shutdown, however, prompt an interesting question: what are the potential gains should Korea successfully prevent or mitigate internet addiction amongst adolescents?

While internet addiction is claimed to be a serious public health problem in Korea (e.g. Kwon. 2011), there is woefully little work quantifying the underlying health costs. DJ Cho et al. (2018) develop a broad cost-benefit analysis across the entire population looking at the non-health effect costs for gaming addiction in Korea and find a one-year cost of $3.5 billion. Elsewhere, there is some identification of limited (about $9.8 million annually) government efforts to address internet addictions: 12 regional "Internet Addiction Prevention Centers" within the Ministry of Science, ICT, and Future Planning; five "Game Overcommitment Healing Centers" within the Ministry of Culture, Sports, and Tourism; and internet addiction treatment services from the Addiction Management Centers operated by the Ministry of Health and Welfare (Király et al., 2017). The central government's budget for addiction increased from $3.66 million in 2010 to $4.483 million in 2014 and the budget for mental health promotion for young people tripled over the same time period, increasing from $921,000 to $2.852 million (Roh et al., 2016). Locally, the municipal government of Seoul has also established and allocated $2.5 million dollars in 2012 for "I Will Centers" to allow young people to seek help for internet addiction (Seoul Solution, 2014).

To provide some understanding of the health costs stemming from internet addiction amongst Korean adolescents, this paper estimates and values several negative health effects induced by internet addiction over a projected 15-year period. The next section begins by identifying our methodological approach. We then establish baseline data points in terms of the Korean adolescent population and level of internet addiction within the adolescent population. We then use the Korean health and social literature to establish prevalence levels, relative risk factors, and case valuations for atopic dermatitis, allergic rhinitis, asthma, obesity, as well as suicidal ideation, suicide attempts, and suicides. We then provide some results and discussion before concluding the paper.

2. Methodology

In direct terms, the cost burden of adolescent internet addiction in a particular year is the product of the cost of the illness and the number of attributable cases summed across the identified health outcomes. To determine the cases attributable to internet addiction, we use the adolescent internet addicted population, the overall prevalence of a particular health effect, and the appropriate relative risk factor as reported in the Korean health literature. Hence, total costs for particular year are obtained using equation 1.

$$Cost_{year} = \sum_i COI_i * P_i \, (RR_i - 1) * AIAP_{year} \quad (1)$$

where COI is the cost of the i^{th} health outcome, P is the prevalence of the outcome in the overall population, RR is the relative risk or the probability of the outcome in the identified population, and AIAP is the adolescent internet addicted population.

Because the Korean health studies which we use to examine the associations between internet addiction and adverse health outcomes are based upon cross sectional surveys rather than controlled cohort studies, the findings are reported as odds ratios (OR), or ratio of the odds of outcome in the internet addicted group to the odds in the non-internet addicted group, instead of relative risks. While the odds ratios and relative risk values are often similar, using an odds ratio will tend to overstate the association and the magnitude of the discrepancy will increase as the baseline prevalence of the ailment of focus increases. To correct for this overestimation, we use Zhang & Yu (1998) in Equation 2 to convert the reported odds ratios into relative risk values used in Equation 1.

$$RR_i = \frac{OR_i}{(1 - P_i) + (P_i * OR_i)} \quad (2)$$

2.1 Baselines

Because it is the year in which the online game shutdown policy was initiated, this study uses 2011 as the initial year for its 15-year projection. Because we need population age group cohorts broken out with more granularity than other sources, we use age levels from Statistics Korea which projects future population numbers under three different future fertility scenarios: low, medium, and high (Statistics Korea). In our analysis, we use their medium fertility scenario and define the adolescent population as 20% of the 10-14 age cohort and the entire 15-19 age cohort for each year of the projection. Reflecting Korea's present declining fertility rates and aging population, it is key to note, before our analysis, that this age group is shrinking in size.

Examining the effects of the gaming shutdown, Choi et al. (2018) use government study numbers identifying 11.7% of the adolescent population as the internet addicted base, and they note this level is higher than their reported numbers for either the U.S. (3.7%) or China (2.4%).[2] While the Korean level may seem high, it may be conservative in the context of Korea. Both Heo et al. (2014) and Sohn et al. (2018) reference other government studies indicating approximately 12.5% of Korean adolescents are addicted to the internet. Moreover, Sohn et al. note that smartphone addiction is classified separately and approaches 30%. Other media reports place the number of addicted Korean teenagers at 15%, a 0.9% increase from the year before (W Lee, 2018). Rather than try to project trends or reconcile diagnostic methods, we use a constant 11.7% rate as reported by Choi et al.

2.2 Identifying Health Effects and Valuing Costs

Unlike pollution or smoking where direct exposure to toxins produces biochemical reactions that lead to adverse health effects, internet addiction health effects are more indirect and nuanced. Internet addiction is associated with certain behavioral patterns which have been linked to adverse health outcomes. For example, Mak et al. (2014) observe that internet addiction is characterized by high levels of frequent internet use and extended durations of use. Similarly, MS Lee et al. (2007) see longer use periods more often in higher risk internet users. Lam (2014) finds that problematic internet use is connected to sleep problems while Y Kim et al. (2010) and JY Lee et al. (2013) both find links between diets and screen time or internet addiction. JH Kim et al. (2010) also report links between problematic internet use and sedentary behavior.

[2] As a new disorder referenced in a variety of ways, there are also a number of different proposed diagnostic criteria. The method used by the Korean government is the Korean Internet Self-assessment Tool, commonly called the KS scale (Heo et al., 2014). Additional details on this assessment tool are in DI Kim et al. (2008).

Diets, sedentary behavior, and sleep habits are the mechanisms that in turn link heavy internet use to adverse health outcomes. For example, Seo et al. (2017) link late night electronic use to sleeplessness and depression. Similarly, Lim et al. (2017) find sedentary habits, lack of sleep, and lack of physical activity are associated with atopic dermatitis, allergic rhinitis, and asthma. Elsewhere, Shin (2018) finds an association between screen time, physical activity, and obesity.

In our review of the Korean health literature, we find reported associations linking internet addiction, screen time, or sedentary behavior to atopic dermatitis, allergic rhinitis, asthma, obesity, depression, and suicide. In this study, we specifically use the Korean-based health literature to estimate the health outcomes. To explain, certain cultural or local conditions may affect the norms, especially with respect to prevalence levels of certain health effects. For example, the WHO (2000) has indicated that Asian obesity has a different body-mass index threshold than the west, and Fan et al. (2017) note that Asian urbanization is generating new trends in terms of obesity and some liver disease. Also, Korea has the highest rate of teenage suicide within the Organization for Economic Cooperation and Development (Sohn et al., 2018). Because the underlying prevalence rates may vary by country, the health response may also vary. Hence, we use a fairly extensive Korean based health literature to estimate the health outcomes.

On the cost side, two methods are commonly used to value health outcomes: willingness to pay (WTP) which captures certain intangible individual preferences and cost of illness (COI) which measures identifiable costs. On a theoretical level, WTP values are preferred because they provide a more complete accounting, but they are harder to obtain because they require surveying or observing individual behaviors or preferences to derive the values. COI values, on the other hand, are often easier to produce, but they tend to be lower because they omit the intangible costs captured in WTP calculations. Because of availability, we generally use cost of illness values in this study for the morbidity outcomes, but note that intangible costs are often quite large. For suicides, however, our *Value of Statistical Life* figure does include intangible costs.

2.2.1 Atopic Dermatitis

Atopic dermatitis, commonly known as eczema, is characterized as dry, itchy skin which may also include a rash. In severe cases symptoms may include skin bumps which can ooze or skin which is cracked or scaly, and extreme cases can be debilitating. The persistent itchiness and subsequent scratching may lead to raw skin and other complications. Kwon et al. (2013) quantify cases of atopic dermatitis among middle school and high school students in the Korea Youth Risk Behavior Web-based Study during the period 2007-2011. Taking their five-year average, we use 19.66% as the baseline prevalence.

Turning to the risk factor, Lim et al. (2017) find associations with both sedentary behavior and sleep patterns after controlling for other factors such as age, gender, smoking, obesity, and economic level. For this study, we use their reported adjusted odds ratio 1.07 for sleep of more than six hours but less than seven along with the above prevalence rate to obtain a derived relative risk factor of 1.055.

To provide monetary valuation for atopic dermatitis, we draw BK Kim et al. (2016) who look at a six-year study on allergic diseases in Korea. The study uses the Korean National Health Insurance database to track expenditures for multiple allergic diseases. Using the number of patients and medical expenditures, we find the average annual costs per patient for the period

2009-2014. Using the Asian Development Bank's (ADB) Korea values for the all-city health consumer price index (ADB, 2018), we use an average 2011 indexed direct cost of $31.

We believe this value is clearly a lower bound. C Kim et al. (2015) track a small sample over a three-month period in 2010 both through a family journal and the national Electronic Data Exchange (EDI). Extrapolating journal expenses for the under 19 subgroup, the annual cost of outpatient and pharmacy expenses was $1492. (The EDI number is $833 but appears to omit pharmacy expenses.) Indirect costs across the entire study in terms of missed work are just over $1300. Outside of Korea, Carroll et al. (2005) look across multiple countries and note costs from $71 per patient to over $2000 which likely reflect both the range of health systems and the range of severity of cases.

Though low, we stay with the $31 figure because it is conservative, based upon a large sample size, and consistent with our use of Korea-specific values. Implicit in this low valuation figure is an assumption that most cases are not severe.

Baseline prevalence, used odds ratios, derived relative risk factors, and valuations for atopic dermatitis as well as the subsequent health outcomes are provided in Table 1.

2.2.2 Allergic Rhinitis

While commonly associated with allergies, allergic rhinitis is nasal irritation which can lead to sneezing, itchy nose, stuffed nose, eye irritations, and cough. Severe cases may involve the use of prescription medication. To determine prevalence rates, we average across three studies. SY Kim et al. (2010) use insurance claim records from the Korea National Health Insurance Corporation to derive a 15-19 age group prevalence level of 9.3%. D Kim et al.

(2018) use International Study of Asthma and Allergy identified cases and confirm with a pin-prick test to find a current prevalence of 10.7% in the age 14-16 age group. Finally, Hwang et al. (2013) use a series of National Health Insurance Corporation claims to find a high school student prevalence of 12.17% for the period 2004-10. Averaging, we use a value of 10.72%.

To derive the risk of internet addiction cases, we use the 10.72 prevalence rate and again use Lim et al. (2017). For allergic rhinitis the odds ratio of 1.08 for more than six but less than seven hours of sleep results in a relative risk factor of 1.071.

For cost valuation, we begin with BK Kim et al.'s (2016) study on allergic diseases in Korea. Using the number of patients and medical expenditures, we find an average patient cost. Updating with the ADB price index, we arrive at a 2011 value of $28.23. Next, we turn to SY Kim et al. (2010) who use the National Health Insurance data system and account for costs in 2010. Their cost coverage is broader because they include non-covered services and some pharmacy costs. This broader methodology updated with the ADB price indices gives a 2011 value of $53.83. Averaging the two, we use $40.50 as a direct cost estimate.

SY Kim et al. (2010) also provide values for nonmedical and indirect costs. Nonmedical costs include transportation and guardian costs and are $3.25 per patient. Indirect costs account for lost productivity by parent or caregiver from missing work. These costs total $11.52 per individual. Updated to 2011 terms using the ADB's nonfood price index gives total nonmedical cost of $14.77. Added to the medical costs, we use a value of $55.27.

2.2.3 Asthma

Asthma is a chronic condition which can cause an individual's airways to constrict or fill with mucus, making breathing difficult. While it can often be controlled, a change in conditions can trigger asthma attacks which can be life threatening when severe. For prevalence rates, we average two studies. Sol et al. (2019) report annual prevalence levels for the 15-19 age cohort across the period 2010-14 using Korea National Health Insurance Corporation Claims. We use their five-year average of 2.6%. BS Kim et al. (2007) survey 1499 high school students across three regions in 2006. Using both responses to questionnaires and a bronchial challenge test, they report a high school prevalence of 3.2%. The averaged prevalence level is 2.9%.

To derive the number of internet addiction cases, we reference Lim et al.'s (2017) reported odds ratio of 1.13 for sitting more than three hours which gives us a relative risk factor of 1.126.

For direct asthma costs, we begin with BK Kim et al. (2016). Using their six year tracking results and indexing to 2011, we obtain an asthma cost value of $75.18. We next use Sol et al. (2019) who focus upon pediatric asthma over the period 2010-2014, collecting outpatient, hospitalization, emergency room visit, and medication costs (but omitting uninsured expenses). They report a per patient direct cost of $121 in the 15-19 age group. A study by CY Kim et al. (2011) looking at the entire population in 2003 reports direct formal and direct informal costs per patient of $162.20 and $302.80 respectively, which sum to $531.68 when indexed to the year 2011. YH Lee et al. (2011) estimate of direct and indirect costs for 2008. For the entire country, they estimate the per capita asthma costs are $366, of which 62.2% are direct medical costs. For children in the 10-19 age, they report a per capita cost of $175. Applying the 62.2% direct and indirect cost split, we obtain a 2008 direct medical cost of $108.85 or $115.15 when indexed to 2011. Averaging across all four studies, direct medical costs are $210.75.

For indirect costs, we turn to studies by YH Lee et al. (2011) and CY Kim et al. (2011). Beginning with YH Lee et al., using their per capita cost of $175 for the 10-19 cohort, the indirect cost component is $66.15. Using the Asian Development Bank nonfood price index, this updates to $71.45 in 2011. CY Kim et al. also calculate indirect costs. While they don't report a per capita value as they did for direct expenses, they do indicate that indirect expenses account for 53% of the total of indirect and direct expenses. Accordingly, we find their per capita indirect cost is $523 which is $643 in 2011 terms. Averaging the two studies, we use $357. Adding direct and indirect costs together, we arrive at a figure of $567.75.

CY Kim et al. also provide a measure as to the size of intangible costs associated with asthma in Korea. In their study, they survey individual asthmatics by asking their willingness to pay to bring their quality of life to a normal level. Survey responses were $159.90 per month which they halve because of expected over-reporting. The subsequent intangible valuation is roughly equal to their direct and indirect costs and nearly double our averaged cost of illness figure. While we use only the direct and indirect costs in our morbidity calculations, their findings indicate that our estimates are very much a lower bound.

2.2.4 Obesity

Obesity is defined as abnormal or excessive fat accumulation that presents a risk to current and future health, and the Korean medical literature indicates that it is a growing issue with Ha & Kim (2016), B Kim et al. (2012), and DM Kim et al. (2005) all indicating increasing levels in Korean youth. To address the different levels of obesity, we identify two levels for our efforts. Following the WHO (2000) breakdowns, we use a Body Mass Index (BMI) greater than 25 as an indication of moderate risk of health co-morbidities and refer to it as Obesity I. In reporting childhood obesity levels in Korea, Ha & Kim (2016) use the 25 BMI and/or greater than the 95th percentile as an indicator. A BMI greater than 30, which the WHO identifies as indicating severe risk of co-morbidities, serves as a threshold of severe or morbid obesity which we will refer to as Obesity II.[3]

To determine prevalence levels, we average (10.6%) the annual nationwide levels for the years 2001 through 2013 reported by Ha & Kim (2016) for children age 6-18 for Obesity I. For Obesity II or morbid obesity, we use the average (3.02%) from 2009 through 2013 of the annual rates in adults as reported by JW Lee et al. (2018).

To determine odds ratios for Obesity I, we draw on studies by B Kim et al. (2012) and Kang et al. (2006). Kang et al. draw from over 4000 5th graders in Gunpo City and report an obesity odds ratio of 1.70 for children spending over 5 hours a day on the computer or TV which results in a derived relative risk factor of 1.583. B Kim et al. study 1644 students in the Seoul area and in multilevel logistic analysis controlling for factors such as father's education, school exercise facilities, hours of physical education per week, and school lunch fat content report an obesity odds ratio of 1.22 for a relative risk of 1.192. Averaging the two studies, we report an average odds ratio of 1.46 and use a relative risk factor of 1.387.

For Obesity II, we use Byun et al.'s (2012) study which uses the 2005 Korean National Health and Nutrition Examination Surveys to look at youth between the ages of 12 and 18. Here, the indicator of obesity is waist circumference greater than the 90th percentile by age and gender. Adjusting for age, sex, household income, and moderate-to-vigorous physical activity, they report an odds ratio for video and PC usage of 1.20 which leads to a relative risk factor of 1.193.

[3] The WHO (2000) identifies categories for Obesity I and II at these benchmarks. However, WHO Expert Consultation (2004) identifies BMI trigger points for public health action at 23 for overweight and 27.5 for obese. We stick with the two obesity classifications, but note that using 2011 Korean child prevalence rates for overweight and obesity instead would increase our Obesity I numbers by about 72% and Obesity II numbers by about 94%.

Our decision to use waist circumference as the indicator of morbid obesity even though it is a rarer measure than BMI is driven by two factors. First, as a matter of practicality, the Byun study is based upon waist circumference. Second, some studies suggest it is a better indicator than BMI for severe health consequences of obesity (e.g. Korean studies include YH Kim et al. (2019) and GJ Cho et al. (2018)).

Obesity costs are broken down by our two categories: Obesity I and Obesity II. Starting with Obesity I, we begin with Song et al. (2018) who look at the impact of obesity on medical expenditures over the period 2002 and 2013 and report average medical expenditures by weight category. In 2012-13, the difference between normal weight medical expenditures and their Obesity I category expenditures was 320,000 Korean Won or $294.40. Deflating to 2011 levels results in a value of $290.68. Another study by Kang et al. (2011) reports a direct Obesity I category cost just over $600 million in 2005. Using their reported prevalence rate and the adult population, we derive a per patient cost of $59.71. Indexing to 2011 gives a value of $66.79. Averaging the two studies, we use a per individual case cost of $178 as the direct medical cost.

Turning to morbid obesity, Song et al. report an expenditure difference between normal weight and Obesity II category patients of 793,000 Korean Won or $729.56. Indexed to 2011 gives a value $720.35. Kang et al. estimate Obesity II category direct expenditures of over $210 million. Using reported prevalence rates and the adult population, we derive a cost of $167.43 per patient and index to $187.29 in 2011. We then add JW Lee et al. (2018) who look at the costs of morbid obesity during the period 2009-2013. Like Kang et al., they report total direct and indirect costs. Using their total reported direct costs, prevalence rates, and adult population figures for three years, we derive estimated per patient costs which are indexed to 2011 values and average to $335.06. Averaging the studies, we use $414 as our Obesity II direct cost value.

For indirect costs, we again use the Kang et al. and JW Lee et al. studies. For Obesity I and Obesity II, Kang et al. report indirect costs of over $376 million and over $119 million, respectively. Again using the prevalence figures and population figures, we generate per case indirect costs of $37.46 and $95.07 for Obesity I and Obesity II cases. For Obesity I, indirect costs, we update the figures to 2011 values and use $44 for our calculations. For Obesity II, we also use the figures reported by JW Lee et al. Like Kang et al., they report totals for three years. We use their reported prevalence and population to derive per case values. Averaging the three years in 2011 terms gives a value of $83.79. Averaging across both studies in 2011 levels, we use $98 as the value of indirect costs for Obesity II.

Adding the direct and indirect costs together, we use a value of $222 for our Obesity I cost and $512 for our Obesity II cost.

2.2.5 Suicidal ideation, suicide attempts, and suicides

Suicide is a problem in Korea: Korea has the highest suicide rate of all OECD nations, and amongst adolescents, Korea's suicide rate of 9.4 per 100,000 is almost 50% higher than the OECD average of 6.5 per 100,000 (Park & Jang 2018). In this study, we identify three different categories of health outcomes. Suicidal ideation broadly includes contemplation and preoccupation with death and suicide. Suicide attempts are incidents where an individual has unsuccessfully attempted suicide. Finally, suicides are those instances where the attempt was completed.

For prevalence rates of suicidal ideation and suicide attempts, we use the findings of SY Lee et al. (2016). They use the results of the over 200,000 youth surveyed in the Korea Youth Risk Behavior Survey over the period 2008-10 to report a suicidal ideation level of 19% and a suicide attempt level of 4.7%. We also note that these numbers seem to be fairly steady: Kang et al. (2015) report levels of 19.1% and 4.9% respectively for just the 2010 cohort of the same Korea Youth Risk Behavior Survey.

To form a connection to internet addiction, we use SY Lee et al. (2016) who study a three-year sample from the Korea Youth Risk Behavior Survey. Using questions about suicidal ideation and suicide attempts and internet use while controlling for gender, school year, perceived economic status, school performance, frequent depression, stress awareness, and family structure, they report odds ratios of 1.94 for suicidal ideation and 1.91 for suicidal attempts in individuals with risky levels of internet use, leading to relative risk factors of 1.646 and 1.832 respectively.

Suicide numbers are derived indirectly using SM Kim & Lee (2019). They report one four-year study across 16 hospitals which finds that 2.7% of attempted suicide patients die in a subsequent attempt and then mention another study which finds that among individuals who have attempted suicide, 4.5% die within a month. Their own study of patients who had been discharged from a hospital after a suicide attempt is characterized by a 9.9% mortality level in study participants. Consistent with our conservative approach, we use the 2.7% value.

Though Korea is suffering from a suicide epidemic, there appears to be a paucity of literature looking the economic burden of suicidal behaviors, so we turn to a limited Korean mental health cost literature for suicide ideation. Chang et al. (2012) use a combination of the National Health Insurance databank for 2005 and two national epidemiological surveys to estimate depression costs. We use their reported per-patient direct cost of $273 as a proxy for the costs of suicidal ideation. Updated to a 2011 indexed value, we use $305 in our calculations. For suicide attempts, we use a study by HS Lee (2013) who looks at the impact of emergency room treatment for depression patients in 2009 and reports a mean medical expense of 1.481 million Korean Won. Converting into US dollars and updating to 2011 with the ADB health price index gives a value of $1215. Both of these values suggest a single treatment and are likely to understate the actual costs.

While our morbidity valuation efforts have used a cost of illness approach, international research on the value of statistical life allows for a fuller accounting for the costs of suicide. Early attempts to place an economic value on statistical deaths or averted mortality in cost-benefit analysis generally took the cost of illness type approach by trying to account for lost earnings and productivity. Such an approach, however, omits a variety of indirect costs and completely ignores intangible costs like grief or lost spending of time with family Economists therefore moved toward the more comprehensive *willingness-to-pay* (WTP) and *willingness-to-accept* (WTA) measures which more completely capture the overall value of life by assessing the value groups of individuals place on reducing the probability of giving up life earlier than otherwise expected. The resulting value is identified as the *value of a statistical life* (VSL).

Though there are a number of VSL studies globally, the international distribution is rather skewed with many centered in the US. To overcome the lack of Korean studies, we take advantage of a study by Viscusi & Masterman (2017) looking at a number of international VSL and labor market studies to generate VSLs for 189 countries. For Korea, they report a value of $4.723 million. Indexing this value to a 2011 level, we use $4.402 million as our value.

3. Results and discussion

Applying the various relative risk factors and prevalence rates to our identified adolescent internet addicted population, we estimate of the number of internet addiction related cases for a number of health outcomes. Clearly, there is a notable number of adverse health outcomes: our projections (Table 2) indicate over 100,000 adverse health outcomes in 2011 and over 1.3 million over the entire projection. The leading outcomes are suicidal ideation at just over 710 thousand cases and obesity I with over 275 thousand instances. Suicide attempts are the next largest group at a bit under a quarter million cases. In looking at the case totals, on average one in four internet addicted adolescents experiences an adverse health consequence in a given year.

While there is a substantial decline in the annual totals over the period studied, this decline is solely a result of Korean demographics and not from any modeled intervention. Moreover, applying some suggested trends and incorporating increases in addiction rates would begin to offset the demographically induced declines observed here. Similarly, it is quite plausible that the Covid-19 pandemic would create a notable blip in these trends: D Kim & Lee (2021) look specifically at addictive internet gaming and find a slight possible decrease in overall addictive gaming between 2018 and 2020, but they observe a substantial increase in the amount of time spent gaming amongst those identified as highly addicted gamers.

Placing economic values on these outcomes we estimate that the health effects are valued in real 2011 dollars at over $1.6 billion per year and well exceed $2 billion per year when the adolescent population is at higher levels. Over the entire period studied, total health costs are over $29 billion.   While the annual values are lower than the 2010 value of $3.5 billion reported by DJ Cho et al. (2018), we are looking at just certain identified health costs for a much narrower age population segment than examined in that study. Moreover, our values dwarf the $9.8 million in expenditures that we listed for Korean government efforts to address internet addiction.

Looking across the outcomes, suicides constitute the largest cost component at nearly $29 billion over the entire study period, reflecting the relatively large valuation of a statistical life. Combining suicidal ideation, suicide attempts, and suicides together accounts for well over 90% of our total values. The next largest cost component is obesity I and II, which while less than the suicide related values, still accounts for over $6 million in 2011 and for over $78 million over the study period.

If we put these cost numbers on a per capita basis, they initially do not look particularly impressive going in real terms from $48 in 2011 to just $30 in 2025. However, this decline is driven by the demographic decline in the adolescent population and implicitly assumes that none of these health costs will be recurring. However, if we look at the costs per adolescent, the value spikes dramatically to almost $600, roughly 18% of the OECD's reported per capita Korean health expenditure of $3182 (OECD, 2019). Looking at the costs on a per internet addicted basis, these costs jump to over $5000 which is more than 50% greater than the per capita health expenditure in Korea. Clearly, adolescent internet addiction incurs costs greater than its share of the overall Korean population.

Moreover, there are several reasons to believe that our projected health costs are a lower bound. First, as mentioned at the beginning of the cost section, a cost of illness approach like the one taken with most of our health outcomes (even with the indirect costs included for some illnesses) tends to generate values lower than what is seen in other approaches because of its inability to fully account for intangible costs. For example, we again note that CY Kim et al. (2011) produced a willingness to pay value that put the intangible costs of asthma at double what we use in our valuation estimates. Similarly, the atopic dermatitis costs would increase over 20-fold using the small-sample cost reported by C Kim et al. (2015). Second, because of the limited number of cost studies, our cost valuations are not age specific or adjusted. However, there is literature that suggests that suggests that parents place a higher value on the health of their children than themselves (e.g. Blomquist et al., 2011; Guerriero et al., 2018; Hammitt & Haninger, 2010). Both Blomquist et al. and Hammitt & Haninger in narrowly focused efforts suggest that parental valuations for children may be double the valuation for themselves. Third, our cost accounting implicitly assumes these health outcomes are acute in nature: internet addiction causes a particular symptom, there is a treatment, and the ailment goes away. Our focus upon the adolescent population also means that we don't account for post-adolescence internet addiction and health costs. In actuality, these conditions are generally more persistent, and total costs are likely to accumulate over multiple years. Moreover, some costs, like obesity for example, are likely to grow as the person ages into adulthood and beyond.

Our efforts here have been focused specifically upon health costs because our previous experience looking at pollution suggests health costs, especially premature deaths, dominate other types of costs (e.g. OECD, 2016 and Lanzi et al., 2018); however, we also acknowledge there are likely other costs to internet addiction in Korean adolescents. SY Kim et al. (2017) report that a negative correlation between school performance and the use of the internet for general (non-study specific) purposes. Internet addiction has also been associated with a number of adverse work outcomes such as using employee online access for personal use (Young, 1998), internet abuse which may have detrimental effects upon a particular firm (Chen et al., 2008), and lower levels of information security awareness in the workplace (Hadlington & Parsons, 2017). In both cases, however, most of these cost elements associated with internet addiction are not likely to be observed in the adolescent age bracket: less than 10% of the 15-19 age group are employed (Jones & Beom, 2022) and 86% of them are enrolled in tertiary educational activitities (OECD, 2022), deferring most associated internet addiction costs to post-adolescence.

Outside of the cost issues, it is also important to note other uncertainties in developing these estimates. On the health connection between internet addiction and the health outcomes, we have been careful to use Korean based health studies, but outside of the Korean health literature Rosen et al. (2014) report of studies finding links between screen time and back pain, headaches, sadness, aggression, and social isolation. Also, while Korean studies are most likely to capture cultural and environmental elements unique to Korea, they still include elements of uncertainty. Using the upper to lower bounds in the reported confidence intervals would increase or decrease the number of cases substantially. Finally, these health outcomes are a subset of possible health outcomes. Our analysis here is constrained by the existing health and valuation research. For example, SH Kim et al. (2011) note a connection between internet addiction and abnormalities in the dopaminergic brain system: an outcome which we presently lack the means to effectively quantify and value.

4. Conclusion

Noting the ineffectiveness of Korea's partial internet shutdown attempt, this study estimates the health costs of internet addiction in Korean adolescents. While the affected population is a relatively small portion of Korean society, the costs appear to be substantial, exceeding the reported expenditures on other mental health projects dealing with addiction issues. In addition, the per person costs within the affected group are much higher than the per capita national expenditures upon health. Moreover, we note additional factors which could increase our projected costs: accounting for intangible costs across all outcomes, recurring or chronic ongoing costs, poor school performance, and lost productivity within the adolescent workforce.   Obviously, policies and programs to address the issue of internet addiction in a meaningful way will incur some offsetting costs. Still, the values estimated here provide a starting point as to the actual benefits of reduced internet addiction.

References

ADB (2018) Republic of Korea Key Indicators 2018. Asian Development Bank https://data.adb.org/dataset/korea-republic-key-indicators.

Blomquist, G. C., Dickie, M., & O'Conor, R. M. (2011). Willingness to pay for improving fatality risks and asthma symptoms: values for children and adults of all ages. *Resource and Energy Economics*, *33*(2), 410-425.

Byun, W., Dowda, M., & Pate, R. R. (2012). Associations between screen-based sedentary behavior and cardiovascular disease risk factors in Korean youth. *Journal of Korean Medical Science*, *27*(4), 388-394.

Carroll, C. L., Balkrishnan, R., Feldman, S. R., Fleischer Jr, A. B., & Manuel, J. C. (2005). The burden of atopic dermatitis: impact on the patient, family, and society. *Pediatric Dermatology*, *22*(3), 192-199.

Chang, S. M., Hong, J. P., & Cho, M. J. (2012). Economic burden of depression in South Korea. *Social Psychiatry and Psychiatric Epidemiology*, *47*(5), 683-689.

Chen, J. V., Chen, C. C., & Yang, H. H. (2008). An empirical evaluation of key factors contributing to internet abuse in the workplace. *Industrial Management & Data Systems*, *108*(1), 87-106.

Cho, D. J., Kim, H. T., Lee, J., & Park, S. H. (2018). Economic cost–benefit analysis of the addictive digital game industry. *Applied Economics Letters*, *25*(9), 638-642.

Cho, G.J., Yoo, H.J., Hwang, S.Y., Choi, J., Lee, K.M., Choi, K.M., Baik, S.H., Han, S.W., & Kim, T. (2018). Differential relationship between waist circumference and mortality according to age, sex, and body mass index in Korean with age of 30–90 years; a nationwide health insurance database study. *BMC Medicine*, *16*(1), 131.

Choi, J., Cho, H., Lee, S., Kim, J., & Park, E. C. (2018). Effect of the online game shutdown policy on internet use, internet addiction, and sleeping hours in Korean adolescents. *Journal of Adolescent Health*, *62*(5), 548-555.

Fan, J-G, Kim, S-U, & Wong, V W-S. (2017). New trends on obesity and NAFLD in Asia. *Journal of Hepatology*, 67:862-873.

Guerriero, C., Cairns, J., Bianchi, F., & Cori, L. (2018). Are children rational decision makers when they are asked to value their own health? A contingent valuation study conducted with children and their parents. *Health Economics*, *27*(2), e55-e68.

Ha, K. H., & Kim, D. J. (2016). Epidemiology of childhood obesity in Korea. *Endocrinology and Metabolism*, *31*(4), 510-518.

Hadlington, L., & Parsons, K. (2017). Can cyberloafing and Internet addiction affect organizational information security? *Cyberpsychology, Behavior, and Social Networking, 20*(9), 567-571.

Hammitt, J. K., & Haninger, K. (2010). Valuing fatal risks to children and adults: Effects of disease, latency, and risk aversion. *Journal of Risk and Uncertainty*, *40*(1), 57-83.

Heo J, Oh J, Subramanian SV, Kim Y, & Kawachi I (2014) Addictive internet use among Korean adolescents: A national survey. *PLoS ONE* 9(2): e87819

Hwang, S.H., Jung, S.Y., Lim, D.H., Son, B.K., Kim, J.H., Yang, J.M., Oh, I.B., Kim, Y., Lee, J.H., Lee, K.H., & Kim, S.Y. (2013). Epidemiology of allergic rhinitis in Korean children. *Allergy, Asthma & Respiratory Disease*, *1*(4), 321-332.

Hwang, W. S., & Shin, J. (2017). ICT-specific technological change and economic growth in Korea. *Telecommunications Policy*, *41*(4), 282-294.

ITU (2015) *Measuring the Information Society Report 2015*, Report of International Telecommunication Union.

ITU (2018) *Measuring the Information Society Report 2018, Volume 2 ICT Country Profiles.* Report of International Telecommunication Union.

Jones, R. S., & Beom, J. (2022). Policies to increase youth employment in Korea. *OECD Economics Department Working Papers* No. 1740

Kang, E. H., Hyun, M. K., Choi, S. M., Kim, J. M., Kim, G. M., & Woo, J. M. (2015). Twelve-month prevalence and predictors of self-reported suicidal ideation and suicide attempt among Korean adolescents in a web-based nationwide survey. *Australian & New Zealand Journal of Psychiatry*, *49*(1), 47-53.

Kang, H. T., Ju, Y. S., Park, K. H., Kwon, Y. J., Im, H. J., Paek, D. M., & Lee, H. J. (2006). Study on the relationship between childhood obesity and various determinants, including socioeconomic factors, in an urban area. *Journal of Preventive Medicine and Public Health*, *39*(5), 371-378.

Kang, J. H., Jeong, B. G., Cho, Y. G., Song, H. R., & Kim, K. A. (2011). Socioeconomic costs of overweight and obesity in Korean adults. *Journal of Korean Medical Science*, *26*(12), 1533-1540.

Kattula, D., Philip, S., Shekhar, A., & Basu, A. (2021). A game of policies and contexts: restricting gaming by minors. *The Lancet Psychiatry*, 8(12), 1035-1036.

Kim, B., Lee, C. Y., Kim, H. S., Ko, I. S., Park, C. G., & Kim, G. S. (2012). Ecological risk factors of childhood obesity in Korean elementary school students. *Western Journal of Nursing Research*, *34*(7), 952–972.

Kim, B.K., Kim, J.Y., Kang, M.K., Yang, M.S., Park, H.W., Min, K.U., Cho, S.H., & Kang, H.R. (2016). Allergies are still on the rise? A 6-year nationwide population-based study in Korea. *Allergology International*, *65*(2), 186-191.

Kim, B.S., Kim, H.B., Lee, S.Y., Kim, J.H., Jin, H.S., Kim, B.J., Yu, J.H., Yoo, S.M., & Hong, S.J. (2007). Prevalence of allergic diseases in high school students in Korea. *Journal of asthma, allergy and clinical immunology*, *27*(3), 168-175.

Kim, C., Park, K.Y., Ahn, S., Kim, D.H., Li, K., Kim, M.B., Jo, S.J., Yim, H.W., & Seo, S.J. (2015). Economic impact of atopic dermatitis in Korean patients. *Annals of Dermatology*, *27*(3), 298-305.

Kim, C. Y., Park, H. W., Ko, S. K., Chang, S. I., Moon, H. B., Kim, Y. Y., & Cho, S. H. (2011). The financial burden of asthma: a nationwide comprehensive survey conducted in the republic of Korea. *Allergy, Asthma & Immunology Research*, *3*(1), 34-38.

Kim, D., & Lee, J. (2021). Addictive internet gaming usage among Korean adolescents before and after the outbreak of the COVID-19 pandemic: A comparison of the latent profiles in 2018 and 2020. *International Journal of Environmental Research and Public Health*, 18(14), 7275.

Kim, D., Lim, D., Samra, M., Kim, E., & Kim, J. (2018). How accurate are the ISAAC questions for diagnosis of allergic rhinitis in Korean children? *International Journal of Environmental Research and Public Health*, *15*(7), 1527.

Kim, D. I., Chung, Y. J., Lee, E. A., Kim, D. M., & Cho, Y. M. (2008). Development of internet addiction proneness scale-short form (KS scale). The *Korean Journal of Counseling*, *9*(4), 1703-1722.

Kim, D. M., Ahn, C. W., & Nam, S. Y. (2005). Prevalence of obesity in Korea. *Obesity Reviews*, *6*(2), 117-121.

Kim, J. H., Lau, C. H., Cheuk, K. K., Kan, P., Hui, H. L., & Griffiths, S. M. (2010). Brief report: Predictors of heavy internet use and associations with health-promoting and health risk behaviors among Hong Kong university students. *Journal of Adolescence*, 33(1), 215-220.

Kim, S. H., Baik, S. H., Park, C. S., Kim, S. J., Choi, S. W., & Kim, S. E. (2011). Reduced striatal dopamine D2 receptors in people with Internet addiction. *Neuroreport*, *22*(8), 407-411.

Kim, S. M., & Lee, H. S. (2019). Characteristics of inpatients who survive suicide attempts. *Osong Public Health and Research Perspectives*, 10(1), 32.

Kim, S. Y., Kim, M. S., Park, B., Kim, J. H., & Choi, H. G. (2017). The associations between internet use time and school performance among Korean adolescents differ according to the purpose of internet use. *PloS one*, 12(4), e0174878.

Kim, S. Y., Yoon, S. J., Jo, M. W., Kim, E. J., Kim, H. J., & Oh, I. H. (2010). Economic burden of allergic rhinitis in Korea. *American Journal of Rhinology & Allergy*, *24*(5), e110-e113.

Kim, Y., Park, J. Y., Kim, S. B., Jung, I. K., Lim, Y. S., & Kim, J. H. (2010). The effects of Internet addiction on the lifestyle and dietary behavior of Korean adolescents. *Nutrition Research and Practice*, 4(1), 51-57.

Kim, Y.H., Kim, S.M., Han, K.D., Jung, J.H., Lee, S.S., Oh, S.W., Park, H.S., Rhee, E.J., Lee, W.Y., & Yoo, S.J. (2019). Waist circumference and all-cause mortality independent of body mass index in Korean population from the National Health Insurance Health Checkup 2009–2015. *Journal of Clinical Medicine*, *8*(1), 72.

Király, O., Griffiths, M. D., King, D. L., Lee, H., Lee, S., Banyái, F., Zsila, Á., Takacs, Z. K., & Demetrovics, Z. (2017). Policy responses to problematic video game use: A systematic review of current measures and future possibilities. *Journal of Behavioral Addictions*, 7(3), pp. 503-517

Kwon, J-H (2011). Towards the prevention of adolescent internet addiction in Young, K. S., & De Abreu, C. N. (Eds.) *Internet addiction: A handbook and guide to evaluation and treatment*. John Wiley & Sons.

Kwon, J. A., Park, E. C., Lee, M., Yoo, K. B., & Park, S. (2013). Does stress increase the risk of atopic dermatitis in adolescents? results of the Korea Youth Risk Behavior Web-based Survey (KYRBWS-VI). *PloS one*, *8*(8), e67890.

Lam, L. T. (2014). Internet gaming addiction, problematic use of the internet, and sleep problems: a systematic review. *Current Psychiatry Reports*, 16(4), 444.

Lanzi, E., Dellink, R., & Chateau, J. (2018). The sectoral and regional economic consequences of outdoor air pollution to 2060. *Energy Economics*, *71*, 89-113.

Lee, C., Kim, H., & Hong, A. (2017). Ex-post evaluation of illegalizing juvenile online game after midnight: A case of shutdown policy in South Korea. *Telematics and Informatics*, *34*(8), 1597-1606.

Lee, H. S. (2013). The impact of emergency room utilization by depression patients on medical treatment expense in Korea. *Osong Public Health and Research Perspectives*, *4*(5), 240-245.

Lee, J. W., Choi, Y. E., Kim, D. W., Lee, S., & Cho, K. H. (2018). Trends in socioeconomic costs of morbid obesity among Korean adults, 2009–2013: Data from National Health Insurance Service. *Obesity Research & Clinical Practice*, *12*(4), 389-393.

Lee, J. Y., Jun, N., & Baik, I. (2013). Associations between dietary patterns and screen time among Korean adolescents. *Nutrition Research and Practice*, 7(4), 330-335.

Lee, M. S., Ko, Y. H., Song, H. S., Kwon, K. H., Lee, H. S., Nam, M., & Jung, I. K. (2007). Characteristics of internet use in relation to game genre in Korean adolescents. *CyberPsychology & Behavior*, 10(2), 278-285.

Lee, S. Y., Park, E. C., Han, K. T., Kim, S. J., Chun, S. Y., & Park, S. (2016). The association of level of internet use with suicidal ideation and suicide attempts in South Korean adolescents: a focus on family structure and household economic status. *The Canadian Journal of Psychiatry*, *61*(4), 243-251.

Lee, W. (2018). Phone, Internet addiction among S. Korean teens on rise. United Press International. https://www.upi.com/Top_News/World-News/2018/06/22/Phone-Internet-addiction-among-S-Korean-teens-on-the-rise/4871529646879/.

Lee, Y. H., Yoon, S. J., Kim, E. J., Kim, Y. A., Seo, H. Y., & Oh, I. H. (2011, November). Economic burden of asthma in Korea. In *Allergy and Asthma Proceedings* (Vol. 32, No. 6, p. 35).

Lim, M. S., Lee, C. H., Sim, S., Hong, S. K., & Choi, H. G. (2017). Physical activity, sedentary habits, sleep, and obesity are associated with asthma, allergic rhinitis, and atopic dermatitis in Korean adolescents. *Yonsei Medical Journal*, 58(5), 1040-1046.

Mak, K.K., Lai, C.M., Watanabe, H., Kim, D.I., Bahar, N., Ramos, M., Young, K.S., Ho, R.C., Aum, N.R., & Cheng, C. (2014). Epidemiology of internet behaviors and addiction among adolescents in six Asian countries. *Cyberpsychology, Behavior, and Social Networking*, 17(11), 720-728.

OECD (2016). *The economic consequences of outdoor air pollution*. Organization for Economic Cooperation and Development. OECD Publishing.

OECD (2019). OECD Health Statistics 2019 - Frequently Requested Data. Organization for Economic Cooperation and Development. http://www.oecd.org/health/OECD-Health-Statistics-2019-Frequently-Requested-Data.xls.

OECD (2022). *Education at a Glance 2022: OECD Indicators*. Organization for Economic Cooperation and Development. OECD Publishing.

Park, S., & Jang, H. (2018). Correlations between suicide rates and the prevalence of suicide risk factors among Korean adolescents. *Psychiatry Research*, *261*, 143-147.

Roh, S., Lee, S., Soh, M., Ryu, V., Kim, H., Jang, J. W., Lim, H. Y., Jeon, M., Park, J., Choi, S., & Ha, K. (2016). Mental health services and R&D in South Korea. *International Journal of Mental Health Systems*. 10:45

Rosen, L.D., Lim, A.F., Felt, J., Carrier, L.M., Cheever, N.A., Lara-Ruiz, J.M., Mendoza, J.S., & Rokkum, J (2014). Media and technology use predicts ill-being among children, preteens and teenagers independent of the negative health impacts of exercise and eating habits. *Computers in Human Behavior*, 35, 364-375.

Seo, J. H., Kim, J. H., Yang, K. I., & Hong, S. B. (2017). Late use of electronic media and its association with sleep, depression, and suicidality among Korean adolescents. *Sleep Medicine*, 29, 76-80.

Seoul Solution. (2014). *Youth Internet Addiction Prevention Programs*. Seoul, KOR. https://seoulsolution.kr/en/content/youth-internet-addiction-prevention-programs

Shin, J. (2018). Joint Association of screen time and physical activity with obesity: Findings from the Korea media panel study. *Osong Public Health and Research Perspectives, 9*(4), 207.

Sohn, M., Oh, H., Lee, S. K., & Potenza, M. N. (2018). Suicidal ideation and related factors among Korean High School Students: A focus on cyber addiction and school bullying. *The Journal of School Nursing*, 34(4), 310-318.

Sol, I.S., Kim, Y.H., Kim, S.Y., Choi, S.H., Kim, J.D., Kim, B.O., Moon, J.E., Kim, K.W., & Sohn, M.H. (2019). Prescription patterns and burden of pediatric asthma in Korea. *Allergy, Asthma & Immunology Research, 11*(2), 280-290.

Song, H. J., Hwang, J., Pi, S., Ahn, S., Heo, Y., Park, S., & Kwon, J. W. (2018). The impact of obesity and overweight on medical expenditures and disease incidence in Korea from 2002 to 2013. *PloS one, 13*(5), e0197057.

Statistics Korea. Projected Population by Age (Province). Downloaded July 2022 from https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1BPA001&language=en&conn_path=I3

Tereshchenko, S., & Kasparov, E. (2019). Neurobiological risk factors for the development of internet addiction in adolescents. *Behavioral Sciences*, 9(6), 62.

Viscusi, W. K., & Masterman, C. J. (2017). Income elasticities and global values of a statistical life. *Journal of Benefit-Cost Analysis, 8*(2), 226-250.

WHO (2000). The Asia-Pacific perspective: redefining obesity and its treatment. World Health Organization.

WHO Expert Consultation (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*, 363(9403), 157-163.

Young, K. S. (1998). Internet addiction: The emergence of a new clinical disorder. *Cyberpsychology & Behavior*, 1(3), 237-244.

Young, K. S., & De Abreu, C. N. (Eds.). (2010). *Internet addiction: A handbook and guide to evaluation and treatment*. John Wiley & Sons.

Zhang, J., & Yu, K. F. (1998). What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA*, *280*(19), 1690–1691.

Table 1. Health outcome relative risks, prevalence, and valuations

Symptom	Reported Odds Ratio	Derived Relative Risk*	Prevalence (Percentage)	Valuation** (2011 dollars)
Atopic Dermatitis	1.07	1.055	19.66	31
Allergic Rhinitis	1.08	1.071	10.72	55.27
Asthma	1.13	1.126	2.9	567.75
Obesity				
Obesity I	1.46	1.387	10.6	222
Obesity II	1.20	1.193	3.02	512
Suicide				
Suicidal ideation	1.94	1.646	19	305
Suicide attempts	1.91	1.832	4.7	1,215
Suicides	--	--	2.7***	4,723,000

*Relative Risk are derived from reported odds ratios using equation 2.

**Allergic rhinitis, asthma, and obesity costs include both a direct and indirect cost of illness component. Suicide valuation is based upon Korean Value of Statistical Life, a broader measure than cost of illness approach.

***Prevalence rate of suicide is conditional upon a previous suicide attempt and does not include first time attempts.

Table 2. Projected cases of Internet Addiction induced health outcomes in Korean adolescents

Year	Atopic Dermatitis	Allergic rhinitis	Asthma	Obesity I*	Obesity II*	Suicidal ideation	Suicide attempt	Suicide
2011	5222	3635	1746	22949	2788	58772	18716	505
2012	5142	3579	1719	22596	2745	57867	18428	498
2013	5020	3494	1678	22058	2680	56492	17990	486
2014	4878	3396	1631	21438	2604	54902	17484	472
2015	4747	3304	1587	20860	2534	53423	17013	459
2016	4591	3195	1535	20174	2451	51666	16453	444
2017	4384	3051	1466	19264	2340	49334	15711	424
2018	4177	2908	1397	18356	2230	47011	14971	404
2019	3999	2784	1337	17576	2135	45012	14334	387
2020	3788	2637	1267	16646	2022	42629	13575	367
2021	3580	2492	1197	15731	1911	40286	12829	346
2022	3497	2434	1169	15369	1867	39360	12534	338
2023	3495	2433	1169	15359	1866	39334	12526	338
2024	3460	2408	1157	15204	1847	38936	12399	335
2025	3460	2408	1157	15205	1847	38940	12401	335

*Obesity I cases are where BMI exceeds 25 kg/m.

**Obesity II cases are where BMI exceeds 30 kg/m.

Table 3. Dollar value of Internet Addiction induced health outcomes in Korean adolescents (2011 dollars)

Year	Atopic Dermatitis	Allergic rhinitis	Asthma	Obesity I	Obesity II	Suicidal ideation	Suicide attempt	Suicide	Total
2011	161885	200,903	991,405	5,094,627	1,427,386	17,925,342	22,739,843	2,386,672,887	2,443,170,894
2012	159393	197,811	976,146	5,016,216	1,405,417	17,649,454	22,389,856	2,349,939,753	2,405,568,200
2013	155605	193,109	952,943	4,896,980	1,372,010	17,229,925	21,857,648	2,294,081,554	2,348,387,703
2014	151226	187,675	926,125	4,759,167	1,333,398	16,745,031	21,242,517	2,229,520,154	2,282,297,982
2015	147153	182,620	901,183	4,630,994	1,297,488	16,294,059	20,670,420	2,169,475,456	2,220,831,882
2016	142313	176,615	871,546	4,478,695	1,254,817	15,758,196	19,990,632	2,098,127,923	2,147,795,384
2017	135889	168,642	832,205	4,276,531	1,198,176	15,046,887	19,088,275	2,003,420,537	2,050,846,049
2018	129490	160,700	793,012	4,075,124	1,141,747	14,338,240	18,189,296	1,909,067,616	1,954,259,569
2019	123983	153,867	759,291	3,901,842	1,093,197	13,728,550	17,415,851	1,827,890,273	1,871,160,565
2020	117422	145,724	719,107	3,695,344	1,035,342	13,001,992	16,494,149	1,731,152,565	1,772,132,845
2021	110967	137,713	679,575	3,492,197	978,425	12,287,224	15,587,404	1,635,984,691	1,674,712,121
2022	108417	134,548	663,959	3,411,951	955,943	12,004,881	15,229,228	1,598,392,050	1,636,229,573
2023	108344	134,458	663,515	3,409,669	955,303	11,996,852	15,219,042	1,597,323,060	1,635,135,277
2024	107249	133,099	656,809	3,375,205	945,647	11,875,591	15,065,213	1,581,177,752	1,618,607,772
2025	107260	133,112	656,874	3,375,541	945,741	11,876,772	15,066,711	1,581,334,981	1,618,768,723