

Chapter III

Smoking, Exposure to Passive Smoking, and Mental Health - A Focus on Gender Differences

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Abstract

Smoking and mental health problems are, individually, major public health issues in modern societies. Accumulating evidence shows a close relationship between smoking and mental health disorders/symptoms. Given that women are 2-3 times as likely as men to develop mental health disorders during their lifetimes, it is of a great importance to assess gender differences in mental health reactions to active and passive smoking.

This study examined the association of active and passive smoking with mental health among 156 female and 567 male white-collar workers in a commercial industry. We introduced multiple mental health indicators, i.e., General Health Questionnaire, Center for Epidemiologic Depression Scale, sleep habit questionnaire, and Rosenberg Self-Esteem Scale to evaluate mental health status of participants. Smoking status was identified as current, former, and never smokers, and exposure levels to passive smoking were assessed separately at work and at home as no, occasional, or regular exposure. Multiple logistic regression analysis adjusting for multiple confounders and correlational analysis were carried out for statistical data analyses. The results revealed that: 1) women had poorer mental health status than men irrespective of smoking status, 2) both female

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and male current smokers had a greater chance of developing poor mental health status than never smokers, but women indicated a stronger association, 3) in former smokers, men were more likely to have poor mental health than women, 4) poor sleep was more common in current smokers but smoking women suffered from various sleep disturbances more than smoking men, 5) current smoking was weakly associated with reporting low self-esteem in women only, and 6) exposure to passive smoking in never smokers was correlated with poor mental health in men while difficulty awakening in the morning was correlated with passive smoking exposure in both women and men. We conclude that smoking has a negative impact on various aspects of mental health in both women and men, but women suffer from mental health issues more often than men. Exposure to passive smoking may also be a possible factor that correlates with poor mental health status. Although the small sample size suggests a need for replication, current results highlight the importance of the relationships between smoking and exposure to passive smoking with mental health, especially in women.

Key words: *Smoking, Passive smoking, Mental health, Psychiatric morbidity, Depression, Sleep disturbance, Self-esteem, Gender difference, Women.*

Introduction

Although smoking is a well-established cause of physical health consequences such as heart disease, stroke, chronic lung disease, cancer, and all-cause mortality, it still remains to be a major public health problem throughout the world (Figure 1). Smoking causes approximately 5 million deaths worldwide including 438,000 in the US and 114,200 in Japan each year (CDC, 2005; Peto, Lopez, Boreham, Thun, and Heath, 2003). Smoking has also been indicated as a direct or indirect cause of various mental health problems such as depression, anxiety, panic disorder, schizophrenia, post-traumatic stress disorder, and affective disorders. Smoking could also set off a vicious cycle between poor physical and mental health, leading to premature death (WHO, 2003a).

Exposure to passive smoking is also a well-established cause of fatal chronic diseases such as lung cancer and heart disease (Kawachi, 1998; United States). Public Health Service. Office of the Surgeon General. and United States. Office on Smoking and Health., 2006; Vineis *et al.*, 2005). Even though exposure to passive smoking is prevalent in many developed/developing nations (Janson *et al.*, 2001; Lam *et al.*, 2000; Nakata, Tanigawa, Araki, Sakurai, and Iso, 2004; Pirkle *et al.*, 1996), the direct effect of passive smoking on mental health remains to be unknown.

Psychiatric disorders including depression, panic disorder, and anxiety affect women at rates significantly greater than men. For instance, the prevalence of depression in the US has been documented to be nearly twice as high in women than in men (Kessler, McGonagle, Swartz, Blazer, and Nelson, 1993). This ratio has been recorded across different countries and ethnic groups (Weissman *et al.*, 1996). Women also have a two-fold greater risk of developing post traumatic stress disorder, anxiety disorder, and panic disorder than men

during their lifetimes (Gater *et al.*, 1998; Kessler *et al.*, 1994; Olff, Langeland, Draijer, and Gersons, 2007).

A key to understanding why women are more likely to suffer from mental health problems than men may lie in an investigation of the association of active and passive smoking with mental health outcomes (Lasser *et al.*, 2000). In this chapter, we examine the relationship between smoking and mental health outcomes, focusing on gender differences.

Smoking and Mental Health

According to the World Health Organization (WHO), 450 million people worldwide are affected by mental, neurological or behavioral problems at any given time. These problems are expected to increase considerably in the future (WHO, 2003b). A report from the US Department of Health and Human Services (DHHS) estimated that the annual economic cost of mental illness in the US exceeded \$160 billion, with most due to the indirect costs of social services (DHHS, 2003). Among mental illnesses, depression alone has been estimated to cost 83.1 billion dollars in the year 2000 (P. E. Greenberg *et al.*, 2003). By year 2020, depression has been predicted to be the third most important disease in developed countries and the first in the developing countries (Murray and Lopez, 1997).

Smoking, including exposure to passive smoking, is another important public health problem causing economic burden to our society.

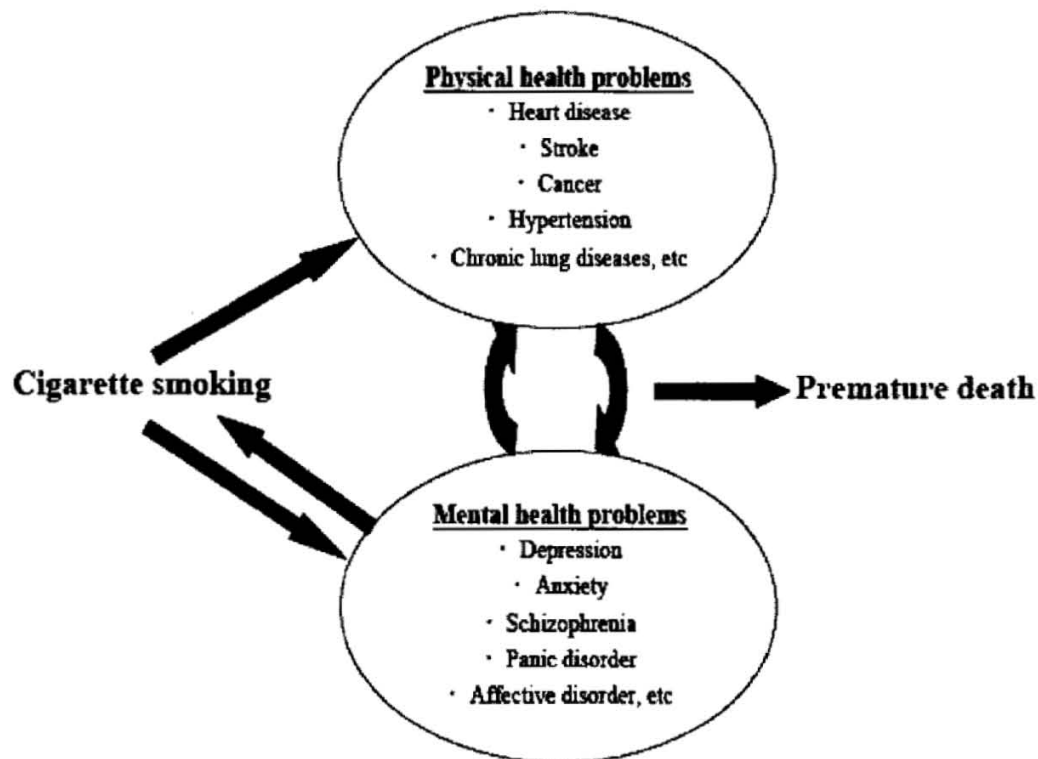


Figure 1. Health consequences of cigarette smoking.

In the US, adverse health effects of smoking was estimated as high as \$167 billion in annual health-related economic losses during 1997 to 2001 (CDC, 2005). Of these losses, \$92 billion are due to annual smoking-attributable productivity costs and over \$75 billion are due to smoking-attributable personal health-care expenditures.

A number of epidemiological studies have established a link between smoking and mental illnesses including depression, anxiety disorders, schizophrenia, post traumatic stress disorder, and affective disorder (Alvarado and Breslau, 2005; Breslau and Klein, 1999; Corvin *et al.*, 2001; Cuijpers, Smit, ten Have, and de Graaf, 2007; Degenhardt, Hall, and Lynskey, 2001; Glassman, 1996; Glassman *et al.*, 1990; Hapke *et al.*, 2005; Lasser *et al.*, 2000; Morissette, Tull, Gulliver, Kamholz, and Zimering, 2007; Morrell and Cohen, 2006; Paperwalla, Levin, Weiner, and Saravay, 2004; Poirier *et al.*, 2002; Williams and Ziedonis, 2004; Zvolensky, Feldner, Leen-Feldner, and McLeish, 2005). Although the nature of these relationships remains elusive, several hypotheses have been proposed to explain the association. The first hypothesis is that mental illness may cause smoking by increasing the likelihood that individuals will self-medicate negative emotions by smoking (Breslau, Kilbey, and Andreski, 1991; Escobedo, Reddy, and Giovino, 1998; Feldner, Babson, and Zvolensky, 2007; Fergusson, Goodwin, and Horwood, 2003; Gregor, Zvolensky, Bernstein, Marshall, and Yartz, 2007; Kassel and Unrod, 2000; Patton *et al.*, 1998; Sonntag, Wittchen, Hofler, Kessler, and Stein, 2000). Smokers with a history of mental illness are more likely to initiate smoking and progress to regular or heavy smoking (Anda *et al.*, 1990; Corvin *et al.*, 2001; Gonzalez-Pinto *et al.*, 1998; R. D. Goodwin, Lewinsohn, and Seeley, 2005; Patton *et al.*, 1998), become nicotine dependent (Breslau, Peterson, Schultz, Chilcoat, and Andreski, 1998; John, Meyer, Rumpf, and Hapke, 2004; Kelly and McCreadie, 1999), are less successful with smoking cessation (Covey, Glassman, and Stetner, 1997; Glassman *et al.*, 1990; Hapke *et al.*, 2005), and smokers are at greater risk of developing a new episode of mental illness when abstaining from smoking (Glassman, Covey, Stetner, and Rivelli, 2001; Tsoh and Hall, 2004). Second hypothesis is that smoking tends to precede the onset of mental illnesses (Breslau and Klein, 1999; Isensee, Wittchen, Stein, Hofler, and Lieb, 2003; J. G. Johnson *et al.*, 2000; Kelly and McCreadie, 1999; McCabe *et al.*, 2004; Weiser *et al.*, 2004; Zvolensky *et al.*, 2005). This concept was at first supported by the fact that adolescents who smoke are at increased risk of subsequently developing mental illnesses (Breslau and Klein, 1999; R. A. Brown, Lewinsohn, Seeley, and Wagner, 1996; Choi, Patten, Gillin, Kaplan, and Pierce, 1997; Goodman and Capitman, 2000; J. G. Johnson *et al.*, 2000; Steuber and Danner, 2006; Upadhyaya, Deas, Brady, and Kruesi, 2002; Wu and Anthony, 1999; Zvolensky *et al.*, 2005). Moreover, a reciprocal influence has been proposed to explain the smoking - mental illness association (Breslau *et al.*, 1998; Fergusson *et al.*, 2003; Windle and Windle, 2001). The third hypothesis is so-called 'non-causal' hypothesis. This hypothesis is based on the fact that shared genetic or environmental factors predispose individuals to both increased risk of smoking and mental illness, especially in depression (Dierker, Avenevoli, Stolar, and Merikangas, 2002; Duncan and Rees, 2005; R. Goodwin and Hamilton, 2002; Kendler *et al.*, 1993).

In this section, we summarized the effects of smoking on mental health, mainly using self-administered questionnaires to assess mental health outcomes. We will also discuss possible gender differences of smoking - mental health relationship.

Mental Health Measures

Psychiatric disorders in the community and non-psychiatric clinical setting are often identified by standardized screening instruments. Among such instruments, the General Health Questionnaire (GHQ) and Center for Epidemiologic Depression Scale (CES-D) are one of the most widely used and highly popular self-administered screening tests. The GHQ was originally developed by Goldberg (1979), and is available in 12, 20, 28, 30, and the full 60 item version (Goldberg *et al.*, 1997; Goldberg and Hillier, 1979; Pan and Goldberg, 1990). The CES-D was developed by Radloff (1977) with a full 20 items (Radloff, 1977), but shorter versions (e.g. 10 items) has also been developed (Andresen, Malmgren, Carter, and Patrick, 1994; Cheng, Chan, and Fung, 2006; Tuunainen, Langer, Klauber, and Kripke, 2001). The CES-D measures both frequency and severity of depressive symptoms. Higher scores in GHQ and CES-D mean poorer mental health status. Both of these scales have high test-retest reliability and construct validity in the original as well as translated versions (Boey, 1999; Furukawa, Hirai, Kitamura, and Takahashi, 1997; Knight, Williams, McGee, and Olan, 1997; Lobo, Perez-Echeverria, and Artal, 1986; Mahard, 1988; Malakouti, Fatollahi, Mirabzadeh, and Zandi, 2007; Nakagawa and Daibo, 1985; Naughton and Wiklund, 1993; Vallejo, Jordan, Diaz, Comeche, and Ortega, 2007).

Smoking and Mental Health – GHQ Score as an Outcome

There are at least seven studies that examined the relationship between cigarette smoking and mental health using GHQ as a mental health outcome. Mino *et al.* (2001) reported a relationship between cigarette smoking and mental health by cross-sectional and prospective study design among 322 women and 264 men, working in a precision machine production company (Mino *et al.*, 2001). They used GHQ-30 to assess mental health status and found that current smoking women ($n=19$) had significantly higher GHQ score than nonsmoking women ($n=303$), but no differences were observed between current smoking men ($n=148$) and nonsmoking men ($n=116$) by cross-sectional analysis. Subjects were followed-up at months 6, 12, 18, and 24. Consistently higher GHQ scores were found in current smoking women compared to nonsmoking women, but in men the scores were comparable between smokers and nonsmokers among all occasions. In the same study population, Mino *et al.* (2000) tested whether cessation of smoking improves mental health status in 18 men who voluntarily quit smoking and 173 men who continued smoking (Mino, Shigemi, Otsu, Tsuda, and Babazono, 2000). They tested the subjects twice and found that GHQ score of smoking cessation group was significantly reduced at 6th and 12th months compared to the baseline (0 month). Subjects who continued to smoke had no significant decreases in GHQ scores in both occasions. Another study in Japan surveyed 668 female and 2,132 male factory workers (Ezoe and Morimoto, 1994). They found no significant differences in total GHQ-28 scores including three subscales (somatic symptoms, anxiety-insomnia, and social dysfunction) between smokers and nonsmokers in both women and men. However, the results of multiple logistic regression analyses showed a statistical significance between smoking and somatic symptoms in women. Kageyama *et al.* (2005) examined the effects of smoking on mental

health among 522 Japanese female staff nurses and found a slight increase of GHQ-12 score in current smokers compared to nonsmokers (Kageyama, Kobayashi, Nishikido, Oga, and Kawashima, 2005). A recent study by Suda et al. (2007) also assessed smoking – mental health relationship but did not find any significant association using GHQ-28 (Suda, Nakayama, and Morimoto, 2007). One common problem in most of above studies is that subjects were classified into current smokers or nonsmokers (non-current smokers), which include former smokers as nonsmokers. If this is the case, the relationship could be underestimated because former smokers often include people experiencing serious physical/mental health consequences or people having good reasons to quit smoking. To estimate the relationship more clearly, classifying smoking status into at least current, former, and never smoking is necessary.

In terms of above classification, a community-based study was carried out in a population of 8,354 women and 7,052 men aged 45-64 in Glasgow, Scotland (Rasul, Stansfeld, Davey-Smith, Hart, and Gillis, 2001). This study used a GHQ-30 cutoff score of 3/4 to denote possible psychiatric morbidity. Smoking status was classified into current smoker (1 to 14 cigarettes/day, 15 to 24 cigarettes/day, 25 or more cigarettes/day, pipe/cigar user), former smoker, and never smoker. In female smokers, those who smoked 15 to 24 cigarettes/day had an OR of 1.30 (95% CI 1.08-1.57) and those who smoked 25 or more cigarettes/day had an OR of 2.29 (95% CI 1.65-3.18) for a potential increase of mental illness compared to never smokers by multivariate analyses; women who smoked 1 to 14 cigarettes/day had no significant increase of poor mental health (OR 1.16, 95% CI 0.95-1.43). Likewise, men who smoked 1 to 14 cigarettes/day had an OR of 1.63 (95% CI 1.16-2.30), 15 to 24 cigarettes/day had OR of 1.37 (95% CI 1.02-1.85), and 25 or more cigarettes/day had an OR of 1.73 (95% CI 1.26-2.39) compared to never smoking men. No significant increases were found among cigar/pipe users and former smokers in both sexes. The results suggested a dose-dependent increase between cigarette smoking and mental health issues, especially in women. More recently, Martinez-Ortega et al. (2006) reported that current smokers with a high nicotine dependence (Fagerstrom test for nicotine dependence (FTND) score ≥ 6) had 3.4 times higher self-reported psychiatric disorders and 3.5 times higher psychiatric morbidity (GHQ-28 > 6) than subjects without nicotine dependence (FTND score = 0); they found no significant increase of self-reported psychiatric disorders or psychiatric morbidity by GHQ-28 > 6 in current smokers compared to never smokers (OR, 1.25 and 1.26, respectively). It is possible that degree of nicotine dependence may be more sensitive to poor mental health status than mere smoking status.

It should be kept in mind when interpreting the results of above studies that GHQ threshold for denoting a potential psychiatric illness varies from study to study. Different cutoff score standards may yield different outcomes.

Smoking and Mental Health – CES-D Score as an Outcome

To the best of our knowledge, there are seven prospective (Albers and Biener, 2002; Duncan and Rees, 2005; Goodman and Capitman, 2000; Kinnunen *et al.*, 2006; Steuber and Danner, 2006; van Gool *et al.*, 2007; Windle and Windle, 2001) and 12 cross-sectional

studies, which used CES-D as mental health outcome in relation to smoking - depression link (Almeida and Pfaff, 2005; Anda *et al.*, 1990; Benjet, Wagner, Borges, and Medina-Mora, 2004; Covey and Tam, 1990; Frerichs, Aneshensel, Clark, and Yokopenic, 1981; Kageyama *et al.*, 2005; Kaholokula, Grandinetti, Crabbe, Chang, and Kenui, 1999; Perez-Stable, Marin, Marin, and Katz, 1990; Pomerleau, Zucker, and Stewart, 2003; Son, Markovitz, Winders, and Smith, 1997; Tsoh, Lam, Delucchi, and Hall, 2003; Zhu and Valbo, 2002). Among these studies, 16 studies found a positive relationship between smoking and depressive symptoms. Most often, prevalence of high depressive symptoms was highest in current smokers, followed by former smokers, and then never smokers. The association has been found to be robust among adolescents (Albers and Biener, 2002; Covey and Tam, 1990; Duncan and Rees, 2005; Goodman and Capitman, 2000; Steuber and Danner, 2006; Windle and Windle, 2001), adults (Benjet *et al.*, 2004; Frerichs *et al.*, 1981; Kaholokula *et al.*, 1999; Perez-Stable *et al.*, 1990; Pomerleau *et al.*, 2003; Son *et al.*, 1997; Tsoh and Hall, 2004; Zhu and Valbo, 2002), and elderly (Almeida and Pfaff, 2005).

In most positive findings, women yielded a stronger relationship between smoking and depressive symptoms than men. For instance, smoking women had higher ORs of depressive symptoms (OR 1.8, 95% CI 1.2-2.5) than smoking men (OR 1.4, 95% CI 0.9-2.2) in a population of Latinos living in San Francisco (Perez-Stable *et al.*, 1990). The study also found that 40% of current smoking women had a clinically relevant levels of depressive symptoms (CES-D score ≥ 16) compared to 22% of current smoking men. In the Third Mexican National Addictions Survey, the odds of depressive symptoms in current smoking women versus current smoking men differed greatly when compared with their nonsmoking counterparts (women OR 2.1, 95% CI 1.3-3.5, men OR 1.4, 95% CI 1.1-2.5) (Benjet *et al.*, 2004). In a community survey in Los Angeles County, current smoking women who are willing to quit smoking (CES-D score 12.55) had 1.3 times higher average CES-D score than never smoking women (CES-D score 9.64) while current smoking men who are willing to quit smoking (CES-D score 8.39) had only 1.1 times higher average CES-D score than the corresponding counterpart (CES-D score 7.57) (Frerichs *et al.*, 1981). Smokers who were not willing to quit smoking had CES-D scores of 10.69 and 8.02, respectively for women and men. Smokers willing to quit smoking may have more psychological conflict than smokers not willing to quit, leading to higher depressive symptoms. A recent reanalysis of the National Longitudinal Study of Adolescent Health data suggested that female smokers had OR of 1.79 (95% CI 1.33-2.39) compared to female nonsmoking counterpart while male smokers had OR of 1.05 (95% CI 0.77-1.43) (Duncan and Rees, 2005). These studies suggest a possibility that the effects of smoking on depressive symptoms are stronger in females than in males.

Although the relationship between smoking and depression/depressive symptoms seems positive, the direction of this relation is not well understood. Among the adolescent population, there is evidence showing that smoking may precede high depressive symptoms/disorders (Brook, Schuster, and Zhang, 2004; R. A. Brown *et al.*, 1996; Choi *et al.*, 1997; Goodman and Capitman, 2000; E. O. Johnson and Breslau, 2006; J. G. Johnson *et al.*, 2000; Martini, Wagner, and Anthony, 2002; Steuber and Danner, 2006; Wu and Anthony, 1999), while others studies partly supported that depressive symptoms/disorders precede smoking (Brook *et al.*, 2004; Lam *et al.*, 2005; Patton *et al.*, 1998; Repetto, Caldwell, and

Zimmerman, 2005) or a reciprocal relationship between smoking and depressive symptoms/disorders (Breslau *et al.*, 1998; Windle and Windle, 2001). In the adult population, three prospective studies supported that smoking itself leads to depressive disorder (Kinnunen *et al.*, 2006; Klungsoyr, Nygard, Sorensen, and Sandanger, 2006; Korhonen *et al.*, 2007). An 11-year prospective study of Norwegians showed that the risk of an initial episode of depression was 3.7 times higher for heavy smokers and 1.9 times higher for moderate smokers compared with never smokers (Klungsoyr *et al.*, 2006). More recently, Korhonen *et al.* (2007) reported in a study of twins in Finland that persistent smoking was a strong predictor of depression even after controlling for family and genetic background (Korhonen *et al.*, 2007). Taken together, the evidence shows that smoking and depressive symptoms/disorders may reinforce each other, which could result in a vicious cycle. However, more evidence is needed to explore whether depressive symptoms lead to actual depressive disorders by smoking, especially focusing on gender differences.

Smoking, Exposure to Passive Smoking, and Sleep Behaviors

Sleep disturbances, especially insomnia and poor sleep quality, are one of the most commonly reported health complaints with a prevalence of 2-68% in modern industrialized societies (Doi, 2005; Lichstein, Durrence, Riedel, Taylor, and Bush, 2004; Ohayon, 2002). It is a common health problem that is often underrecognized and undertreated (Neubauer, 2004). Various factors are known to induce sleep disturbances, but cigarette smoking has been suspected to be one of the most important modifiable risk factors in adults (Htoo, Talwar, Feinsilver, and Greenberg, 2004; Ohida *et al.*, 2001; Phillips and Danner, 1995) and in adolescents (Ohida *et al.*, 2004).

Many previous studies reported gender differences in the prevalence of sleep disturbances, with women more likely than men to report insomnia, dissatisfied sleep, poor sleep quality, and to have diagnosed with insomnia (Doi, 2005; Lichstein *et al.*, 2004; Ohayon, 2002). Why women are more likely to suffer from such sleep disturbances remain unclear, but multiple (biological, psychological, behavioral, and social) factors were proposed to explain these differences. Of these factors, smoking may be a strong behavioral factor that has a significant impact on women's sleep. To date, little information has been available concerning gender differences on sleep in relation to smoking. In this section, we review the effects of cigarette smoking and exposure to passive smoking on sleep in general, and possible gender differences of smoking – sleep relationship.

Smoking and Sleep Behaviors

The connection between smoking and sleep disturbances has been investigated in epidemiological and clinical studies, and it has been reported that smokers experience various sleep problems more often than nonsmokers. These include difficulty initiating sleep (Janson *et al.*, 1995; Kageyama *et al.*, 2005; Kaneita *et al.*, 2005; Nakata *et al.*, *in press*; Ohida *et al.*,

2007; Ohida *et al.*, 2004; Phillips and Danner, 1995; Soldatos, Kales, Scharf, Bixler, and Kales, 1980; Wetter and Young, 1994; Zhang, Samet, Caffo, and Punjabi, 2006), difficulty maintaining sleep (Lexcen and Hicks, 1993; Ohida *et al.*, 2007; Phillips and Danner, 1995), early morning awakening (Kageyama *et al.*, 2005; Kaneita *et al.*, 2005; Lexcen and Hicks, 1993; Ohida *et al.*, 2007), and difficulty awaking in the morning (Akerstedt *et al.*, 2002; Lexcen and Hicks, 1993; Nakata *et al.*, *in press*), as well as short sleep duration (Bale and White, 1982; Kaneita *et al.*, 2005; Nakata *et al.*, *in press*; Ohida *et al.*, 2001; Ohida *et al.*, 2007; Ohida *et al.*, 2004; Palmer, Harrison, and Hiorns, 1980; Riedel, Durrence, Lichstein, Taylor, and Bush, 2004; Soldatos *et al.*, 1980; Zhang *et al.*, 2006), subjective insufficient sleep (Kaneita *et al.*, 2005; Ohida *et al.*, 2007), poor sleep quality (Bale and White, 1982; Kageyama *et al.*, 2005; Lexcen and Hicks, 1993; Patten, Choi, Gillin, and Pierce, 2000; Underner, Paquereau, and Meurice, 2006), excessive daytime sleepiness (Kaneita *et al.*, 2005; Ohida *et al.*, 2007; Ohida *et al.*, 2004; Phillips and Danner, 1995), snoring (Franklin *et al.*, 2004; Khoo, Tan, Ng, and Ho, 2004; Ohida *et al.*, 2007; Shin, Joo, Kim, and Kim, 2003), sleep disordered-breathing (Ekici *et al.*, 2007; Khoo *et al.*, 2004; Wetter, Young, Bidwell, Badr, and Palta, 1994), and poor sleep hygiene (Jefferson *et al.*, 2005).

In contrast, some studies found a weak or no relationship between smoking and insomnia symptoms (Chen, Kawachi, Subramanian, Acevedo-Garcia, and Lee, 2005; K. Kim, Uchiyama, Okawa, Liu, and Ogihara, 2000; Phillips and Danner, 1995), poor sleep quality (Doi, Minowa, and Tango, 2003; Palmer *et al.*, 1980), early morning awakening (Janson *et al.*, 1995; Wetter and Young, 1994), difficulty initiating sleep (Lexcen and Hicks, 1993; Riedel *et al.*, 2004), difficulty maintaining sleep (Kageyama *et al.*, 2005; Kaneita *et al.*, 2005; Riedel *et al.*, 2004; Wetter and Young, 1994) and disturbed sleep (Akerstedt *et al.*, 2002). One study even found a significant positive effect from smoking such as waking up less often during the night and reduced difficulty remaining asleep (Fabsitz, Sholinsky, and Goldberg, 1997).

Inconsistent findings among these studies could be partly attributable to the fact that the assessment of sleep relied mainly on self-reporting, which may introduce recall/response bias. Although several previous studies found a moderate association between self-reported sleep behavior and physiologic recordings of sleep (Carskadon, Acebo, Wolfson, Tzixchinsky, and Darley, 1997; Riedel and Lichstein, 1998), a couple of studies suggested a poor correlation between the two (Chervin and Guilleminault, 1996; Edinger and Fins, 1995; Lewis, 1969; McCall, Turpin, Reboussin, Edinger, and Haponik, 1995), raising a question on the validity of self-reported sleep.

In an attempt to overcome such shortcomings, a recent survey in the 'Sleep Heart Health Study' examined the relationship between cigarette smoking and sleep by introducing sleep polysomnography (Zhang *et al.*, 2006). Polysomnography monitors sleep cycles and stages by recording brain waves, muscle activity, eye movements, breathing rate, blood pressure, blood oxygen saturation, and heart rhythm. A cohort of 779 current, 2,705 former, and 2,916 never smokers underwent home polysomnography to assess sleep quality. The results revealed that current smokers had an average of 5.4 minutes longer initial sleep latency and 14.0 minutes less total sleep duration than never smokers. The study also found that current smokers had an average of 24% more stage 1 sleep and 14% less slow wave sleep than never smokers (Zhang *et al.*, 2006). No significant differences were found between former and

never smokers in this study. The results were, however, consistent with many epidemiological studies exploring the relationship between smoking and sleep using self-administered questionnaires, which may support such methodology.

Passive Smoking Exposure and Sleep Behaviors

Although a number of studies have shown that cigarette smoking is adversely related to sleep, little attention has been given to its association with passive smoking. To date, two studies in schoolchildren (Corbo, Fuciarelli, Foresi, and De Benedetto, 1989; Forastiere *et al.*, 1992) and three studies of the adult population have examined this association (Franklin *et al.*, 2004; Nakata *et al.*, *in press*; Ohida *et al.*, 2007). A survey in Italy found that 3,092 primary schoolchildren exposed to any source of passive smoking were more likely to snore than non-exposed counterpart (OR 1.4, 95% CI 1.1-1.7) (Forastiere *et al.*, 1992). When children were exposed to passive smoking from both the mother and father, OR was as high as 1.6 (95% CI 1.2-2.0), compared to exposure from mother only (OR 1.4, 95% CI 1.0-1.9) or from father only (OR 1.2, 95% CI 1.0-1.6). Another study in Italy reported a similar findings but revealed that there is a dose-dependent relationship between number of cigarettes smoked by parents and snoring prevalence in children (Corbo *et al.*, 1989). In the adult population, a study by Franklin *et al.* (2004) revealed for the first time that passive smoking is a major risk factor for habitual snoring for never smokers. Never smoking people exposed to passive smoking on a daily basis had a snoring rate 1.6 times higher than their non-exposed counterparts, which was close (1.8 times) to active smokers' consuming 10 cigarettes a day (Franklin *et al.*, 2004). A recent study in a larger cohort of pregnant women ($n \geq 16,396$) in Japan found that nonsmoking pregnant women who were exposed to passive smoking by their family and/or friends suffered more from various sleep problems such as subjectively insufficient sleep, difficulty initiating sleep, difficulty maintaining sleep, early morning awakening, short sleep duration, excessive daytime sleepiness, and snoring loudly/breathing uncomfortably than nonsmoking pregnant women not exposed to passive smoking, with ORs ranging from 1.1 to 2.8 (Ohida *et al.*, 2007). Nonsmokers exposed to passive smoking from both family and friends seem to suffer from sleep problems more often than women merely exposed to either family or friends. In our previous study, we surveyed 296 small and medium-sized enterprises (732 women and 1,896 men) to examine the relationship between passive smoking and five major sleep symptoms, i.e., difficulty initiating sleep, difficulty maintaining sleep, early morning awakening, difficulty awaking in the morning, and short sleep duration (Nakata *et al.*, *in press*). This population is unique in the point that the majority of never smokers were exposed to passive smoking at work or at home; 68.6% of female and 62.2% of male never smokers were exposed regularly or occasionally (Nakata *et al.*, 2006). After adjusting for multiple confounding variables, we found that never smoking men occasionally exposed to passive smoking at work, but not at home, had increased odds (OR 1.8, 95% CI 1.1-2.9) of short sleep duration (less than 6 hrs of sleep) than the unexposed counterpart. These studies suggest that not only active but also passive smoking may have an adverse effect on sleep.

Smoking, Exposure to Passive Smoking, and Sleep Behavior in Relation to Gender

To date, there are only three studies reporting the relationship between cigarette smoking and sleep behavior in relation to gender (Franklin *et al.*, 2004; Nakata *et al.*, *in press*; Wetter and Young, 1994). These are often found in studies analyzing women and men separately. Wetter and Young (1994) observed that sleep problems such as nonrestorative sleep and excessive daytime sleepiness occurred more often in smoking women but nightmares or disturbing dreams occurred more often in smoking men compared to nonsmoking counterparts (Wetter and Young, 1994). A study by Farnklin *et al.* (2004) found that women smoking more than 10 or more grams per day had higher odds of snoring (OR 3.0, 95% CI 2.5-3.7) than men smoking an equivalent amount (OR 2.3, 95% CI 2.0-2.7). This was also true in women smoking less than 10 grams per day (OR 2.1, 95% CI 1.7-2.6) compared to men smoking an equivalent amount (OR 1.5, 95% CI 1.3-1.8), although men initially had 2.4 times higher snoring rate than women (Franklin *et al.*, 2004). In our study, both current smoking women and men had significantly higher odds of difficulty awakening in the morning than never smokers, but women had higher odds (OR 2.0, 95% CI 1.3-3.1) than men (OR 1.5, 95% CI 1.1-2.0). In addition, difficulty initiating sleep (OR 1.7, 95% CI 1.1-2.7) were only observed in smoking women but not in smoking men (OR 1.1, 95% CI 0.8-1.5) (Nakata *et al.*, *in press*).

Moreover, two studies have reported that there may be a gender differences between exposure to passive smoking and sleep. In the first study, Farnklin *et al.* (2004) found that never smokers exposed to passive smoking at home 'every day' had a higher snoring rate than never smokers not exposed to passive smoking in women (OR 1.6, 95% CI 1.0-2.5) and in men (OR 1.7, 95% CI 1.2-2.4); however, women exposed to passive smoking 'one to four times a week' (OR 1.7, 95% CI 0.7-3.8) and 'one to three times per month' (OR 1.1, 95% CI 0.7-1.7) had increased OR of snoring compared to non-exposed counterpart while men had decreased OR (OR 0.7 for both opportunities), suggesting women's sleep may be more sensitive to a small amount of passive smoking exposure than men (Franklin *et al.*, 2004). In the second study, there were no significant increase of passive smoking exposure and sleep except that never smoking men occasionally exposed to passive smoking at work had short sleep duration. However, odds for difficulty awakening in the morning and early morning awakening were relatively high for women regularly exposed to passive smoking at work (OR 1.7 and 2.6, respectively, $p > .05$) or at home (OR 1.7 and 2.1, respectively, $p > .05$) while men did not show such an effect (Nakata *et al.*, *in press*). More attention is required to better understand gender differences concerning the association of active/passive smoking and sleep behaviors.

Smoking and Self-Esteem

According to Morris Rosenberg, self-esteem was defined as "the evaluation which the individual makes and customarily maintains with regard to himself or herself; it expresses an attitude of approval or disapproval toward oneself (Rosenberg, 1965)." Previous literatures

reported that adolescents with low self-esteem had increased chance to suffer from suicidal ideation (McGee, Williams, and Nada-Raja, 2001; Wild, Flisher, and Lombard, 2004), depression (G. W. Brown, Andrews, Harris, Adler, and Bridge, 1986; O'Farrell, Flanagan, Bedford, James, and Howell, 2005), dysphoria (Whisman and Kwon, 1993), anxiety (J. Greenberg *et al.*, 1992), and eating disorders (Cervera *et al.*, 2003; Gual *et al.*, 2002; Silverstone, 1992). Studies in adolescents point to a direct relationship between cigarette smoking and low-self esteem (Abernathy, Massad, and Romano-Dwyer, 1995; Bonaguro and Bonaguro, 1987; Botvin, Baker, Goldberg, Dusenbury, and Botvin, 1992; Byrne and Mazanov, 2001; Conrad, Flay, and Hill, 1992; Crump, Lillie-Blanton, and Anthony, 1997; Emery, McDermott, Holcomb, and Marty, 1993; Glendinning and Inglis, 1999; Guillon, Crocq, and Bailey, 2007; Kawabata, Cross, Nishioka, and Shimai, 1999; Kawabata, Shimai, and Nishioka, 1998; Y. H. Kim, 2004; Miller, Plant, Choquet, and Ledoux, 2002; Murphy and Price, 1988; Pederson, Koval, McGrady, and Tyas, 1998; Simon, Sussman, Dent, Burton, and Flay, 1995; Tyas and Pederson, 1998). Deterioration of self-esteem may induce smoking and cause various psychological problems among adolescents. Based on such assumption, an attempt to promote or increase self-esteem in children has been made to prevent children from smoking. A school based health education program aimed at improving self-esteem resulted in preventing smoking among school children, especially in girls (Abernathy *et al.*, 1995).

Evidence in the adult population suggest that low self-esteem is associated with depression (Franck and De Raedt, 2007) and bipolar disorder (S. L. Johnson, Meyer, Winett, and Small, 2000). Moreover, a recent population-based study in Finland revealed that adult men with low self-esteem was associated with two-fold increase in 10-year mortality (Stamatakis *et al.*, 2004). Smoking may also relate to self-esteem but there are limited information concerning this relationship. Croghan *et al.* (2006) reported that current smokers had significantly lower scores of Rosenberg's self-esteem scale in young women and men compared with never smokers, but were not significant by multiple logistic regression analyses (Croghan *et al.*, 2006). Kowalski *et al.* (1997) explored the possibility of predicting success in smoking cessation adherence by an individual's level of self-esteem and self-efficacy. Approximately one-third of smokers in a smoking cessation programs remained as quitters after 3 months, but these subjects possessed higher self-esteem and self-efficacy prior to start the smoking cessation program, suggesting beliefs about oneself and one's capabilities are influential in determining successful smoking cessation (Kowalski, 1997). More evidence is warranted to explore the relationship between self-esteem and cigarette smoking in adult population.

Aim of the Current Study

In this study, we attempted to know the association of active and passive smoking with four different mental health indicators, i.e., General Health Questionnaire (GHQ), Center for Epidemiologic Studies Depression Scale (CES-D), nocturnal sleep behaviors, and Rosenberg Self-Esteem Scale, to understand the smoking – mental health relationship comprehensively.

Subjects and Methods

Subjects and Procedure

The study design was cross-sectional and data were collected by self-administered questionnaire. A total of 162 female and 618 male white-collar daytime workers aged 22 to 74 (mean 43) years underwent an annual health check-up in April 2005, at a commercial company. Questionnaires were distributed to 780 employees/employers working in 28 different locations, mostly in west part of Japan. Finally, responses were obtained from 778 workers, representing a response rate of 99.7%. Among 778 workers, we excluded 55 because of missing responses. Data on a total of 723 workers were subjected to the final analyses (Table 1). The questionnaire elicited information on sociodemographics, lifestyle, height and body weight, and history of physical/psychological disease(s). Smoking history, mental health, sleep habits, and self-esteem were included under the topics of lifestyle and physical/psychological disease(s). This study was carried out with the informed consent of all workers, and the study protocol was reviewed and approved by the Ethical Committee of the Kyushu University School of Medicine.

Instruments and Measures

1. Smoking Status

Smoking status was assessed by the following 3 questions: 1) Are you a current, former, or never smoker? 2) If you are a current smoker, how many cigarettes a day do you smoke and how many years have you been smoking? 3) If you were a former smoker, when did you quit smoking and how long have you been smoking? Exposure to passive smoking in never and former smokers was assessed by the following question: Are you currently exposed to cigarette smoke from other people? Exposure at work and home were asked about separately, and responses were classified into 3 levels for each location: no exposure, occasional exposure, and regular exposure (Kawachi *et al.*, 1997; Nakata *et al.*, 2006; Nakata *et al.*, 2007).

We validated the smoking status questionnaire using a dataset from our previous study (not published). Briefly, we measured urinary cotinine concentrations to determine active and passive smoking status among 340 white-collar workers. Gas chromatography/mass spectrometry method was used to measure urinary cotinine concentrations. We used a creatinine-adjusted cotinine (cotinine-creatinine ratios, CCR) concentration cut-off of 100 μ g/g creatinine to distinguish current smokers from non-smokers as suggested in a previous study (Haufrond and Lison, 1998), and by this way we found that sensitivity and specificity were 96.8% and 94.7%, respectively (kappa coefficient = .886). Spearman's rank correlation coefficients were calculated to examine the relationships between CCR and daily cigarette consumption in current smokers as well as exposure levels to passive smoking at work, at home, and either at work or at home in never smokers. The results suggested that CCR correlated highly with daily cigarette consumption ($r_s=.500$, $p<.001$) and correlated modestly with passive smoking exposure at work ($r_s=.260$, $p=.019$), at home ($r_s=.230$,

$p=.057$), and either at work or at home ($r_s=.253$, $p=.010$), which was similar to those reported in previous studies (Kawachi and Colditz, 1996).

2. Mental Health Instruments

a) General Health Questionnaire-28 (GHQ-28)

The Japanese version of the GHQ-28 was administered to examine general mental health status of past few weeks. It has been validated by Nakagawa and Daibo (1985) for use with Japanese speakers (Nakagawa and Daibo, 1985). The GHQ comprises 28 items with four subscales derived by factor analysis, i.e., somatic symptoms, anxiety-insomnia, social dysfunction, and severe depression. There are seven items, which are formulated in a positive manner such as "Have you recently felt that you are playing a useful part in things?" and "Have you recently been feeling perfectly well and in good health?" For those positive items, possible responses are 1 = better than usual, 2 = same as usual, 3 = worse than usual, 4 = much worse than usual (Likert scoring). In case of 18 negatively oriented items such as "Have you recently felt that you are ill?" and "Have you recently lost much sleep over worry?" possible responses are 1 = not at all, 2 = no more than usual, 3 = worse than usual, 4 = much worse than usual. For remaining 3 items, two other types of response scales were used. An example of such item is "Have you recently thought of the possibility that you might make away with yourself?" Possible responses are 1 = definitely not, 2 = I don't think so, 3 = has crossed my mind, 4 = definitely has. Two main methods of scoring the GHQ exist, i.e., bimodal (0-0-1-1) and Likert (1-2-3-4) methods. Both bimodal and Likert methods were applied for total GHQ score, and recommended Likert method was used for subscales (Goldberg and Williams, 1991). The internal validity (Cronbach's alpha) for GHQ-28 in the current study was 0.90; for the subscales of somatic symptoms, anxiety-insomnia, social dysfunction, and severe depression, Cronbach's alphas were 0.82, 0.79, 0.77, and 0.89, respectively. We applied several cut-off points for GHQ scores to examine whether the association of smoking status and GHQ are consistent throughout the analyses (Goldberg *et al.*, 1997). Participants were classified into good or poor mental health status by GHQ-28 at threshold scores of 4/5, 5/6, 6/7, and 7/8 (bimodal method).

b) Depressive Symptoms

Depressive symptoms were measured by the Japanese version of CES-D (Shima, Shikano, Kitamura, and Asai, 1985). The 20-item depressive symptom scale measures the level of depressive symptoms experienced in the past week rated on a four-point scale running from "rarely or none of the time (less than 1 day)" to "most or all of time (5-7 days)." These items included "I was bothered by things that usually don't bother me", "I felt that I could not shake off the blues even with help from my family or friends" and "I felt hopeful about the future (reverse item)." The scores for 4 items are reversed so that in each case higher scores are associated with higher depressive symptoms. The CES-D scale cut-off score is 16, which differentiates between those exhibiting high levels of depressive symptoms (score, ≥ 16) from those with lower levels of such symptoms (score, ≤ 15). The internal consistency (Cronbach's alpha) of the CES-D scale for the study sample was 0.78.

c) Sleep Habits

The self-administered sleep questionnaire was based on our previous studies (Nakata *et al.*, 2000; Nakata *et al.*, 2001; Nakata, Haratani, Takahashi, Kawakami, Arito, Kobayashi, and Araki, 2004; Nakata, Haratani, Takahashi, Kawakami, Arito, Kobayashi, Fujioka *et al.*, 2004; Nakata *et al.*, 2005) and 6 questions about daily sleep habits during the previous 1-year period were included as follows:

1. How long does it usually take you to fall asleep in bed? (0-10 minutes / 11-30 minutes / 31-59 minutes / 1-2 hours / 2+ hours)
2. How often do you have difficulty staying asleep? (never or almost never / few times a year / more than once a month / more than once a week / more than three times a week / almost every day)
3. How often do you wake up too early and can't fall asleep again? (never or almost never / few times a year / more than once a month / more than once a week / more than three times a week / almost every day)
4. Do you find it difficult to wake up in the morning? (not at all / rarely / not very / a little / somewhat / considerably)
5. Do you usually sleep well at night? (very well / fairly well / not so well / very poorly)
6. On the average, how much sleep at night did you usually get during the last year? (5 hours / 6 hours / 7 hours / 8+ hours)

Difficulty initiating sleep was defined as present if the answer to the first question indicated "31-59 minutes," "1-2 hours" or "2+ hours." Difficulty maintaining sleep and early morning awakening were indicated by the answer "more than 3 times a week" or "almost every day" in response to the second and third questions. Difficulty awakening in the morning was indicated by an answer of "considerably," "somewhat" or "little" to the fourth question. Sleeping poorly at night was defined as present if the answer to the fifth question indicated "very poorly" or "not so well." Short sleep duration was defined as present if the answer to the sixth question indicated "5 hours" or "6 hours."

The reliability of sleep questions used in this survey was assessed in our previous study (Nakata *et al.*, *in press*). Briefly, test-retest over a 1 year period for above sleep questions were examined by Spearman's rank correlation coefficients and found that correlation coefficients were at least $r = .545$ with $p < .001$. The validity was estimated by calculating Spearman's rank correlation coefficients among demographic, lifestyle factors and sleep questions. The results revealed that all correlations were in the expected direction, and the sleep questions properly showed an almost zero correlation with a measure with which it was predicted to have no relationship (Nakata *et al.*, *in press*).

d) Self-Esteem

The Japanese version of Self-Esteem Scale, originally developed by Rosenberg, was used in this study (Rosenberg, 1965). It is composed of 10 items that are rated using a four-point Likert scale ranging from 1 = strongly agree to 4 = strongly disagree. Examples of the items are, "On the whole, I am satisfied with myself", "I am able to do things as well as most other

people” and “I feel I do not have much to be proud of (reverse item).” The scores for 5 items are reversed so that in each case higher scores are associated with higher self-esteem. Total scores of 10 items represent the degree of global self-esteem (total possible scores range from 10 to 40). This scale has been translated into considerable number of languages such as in Japanese (Kamakura, Jukoando, and Ono, 2001), Chinese (Farruggia, Chen, Greenberger, Dmitrieva, and Macek, 2004), Persian (Shapurian, Hojat, and Nayerahmadi, 1987), and French (Vallieres and Vallerand, 1990). A recent study comparing English and Japanese version of this scale applied to nursing and pharmacy students revealed a high reliability scores for both English (Cronbach’s alpha 0.89) and Japanese (Cronbach’s alpha 0.81) versions as well as the factorial agreement (Mimura and Griffiths, 2007). Studies using the Self-Esteem Scale in a sample of 53 different nations reported reliability ranged from 0.45 to 0.90 (Schmitt and Allik, 2005). For the present sample, the internal consistency was 0.85. Although there are no discrete cut-off points to delineate high and low-esteem, we assigned participants into very low self-esteem group (score $\leq 10\%$) and medium to high self-esteem group ($>10\%$) separately for women and men (cut-off points for women and men were ≤ 21 and ≤ 24 , respectively).

3. Sociodemographic and other Lifestyle Factors

Sociodemographic variables included age (in years) and educational level (high school, vocational/junior college, college/university/graduate school). Lifestyle condition included drinking habit (yes/no), habitual exercise (yes/no), and caffeine intake (cups of tea or coffee/day). Physical/psychological conditions included body mass index (calculated as weight in kilograms divided by the square of height in meters, BMI) and presence of self-reported physical/psychological disease(s) under treatment. We calculated BMI by measuring height and weight objectively. Types of physical/psychological diseases included diabetes mellitus, gout, hyperlipidemia, hypertension, arrhythmia, angina pectoris, cardiac infarction, fatty liver, hepatitis, cholecystolithiasis, gastric ulcer, duodenal ulcer, colon polyp, urinary calculus, kidney disease or uropathy, anemia, bronchial asthma, skin disease, rhinitis, cancer, back pain, accident/injury, women’s disease, other diseases by self-report. We counted the number of diseases in each subjects and included as a confounding factor.

Statistical Analyses

All analyses were carried out separately for women and men. Differences in sociodemographics, lifestyle, physical condition, and mental health indicators by smoking status (or by sex) were calculated using χ^2 test for categorical variables and analysis of variance (or Student’s t-test) with Bonferroni correction for multiple testing for continuous variables.

Risk of poor mental health by smoking status was estimated using univariate and multivariate logistic regression with ORs and 95% confidence interval (CI) as measures of association. The multivariate model adjusted for age in 10-year increments, educational level, drinking habit (yes/no), habitual exercise (yes/no), caffeine intake (almost none, 1 to 2, 3 or

more, cups of coffee or tea), BMI (in quartiles), and number of chronic disease(s) under treatment.

Spearman's rank correlation coefficients were calculated among all variables used in this study. Spearman's rank correlation coefficients were also calculated to examine the relationship between levels of exposure to passive smoking in never smokers and mental health indicators.

The significance level for all statistical analyses was $p < 0.05$ (two-tailed test). All data were analyzed using the Statistical Package for the Social Sciences version 14.0 (SPSS Inc., Chicago, USA).

Results

Characteristics of Study Participants

The characteristics of study participants stratified by smoking status and sex are shown in Table 1. Overall, 10.9% of women and 44.4% of men were current, 7.1% of women and 20.8% of men were former, and 82.1% of women and 34.7% of men were never smokers.

Gender Differences in Prevalence/Scores of Mental Health Indicators

Gender differences in mental health indicators are shown in Table 2. As can be seen in this table, almost all indicators showed that women had higher prevalence/scores of poor mental health indicators than men.

Prevalence of poor mental health as indicated by GHQ showed worse mental health in women. Except anxiety-insomnia subscale, other subscales had significantly increased scores in women. In addition, poor mental health outcome as indicated by CES-D also had higher scores and higher prevalence in women than in men.

Prevalence of sleep disturbances in women were 13.5% for difficulty initiating sleep, 1.3% for difficulty maintaining sleep, 2.6% for early morning awakening, 57.7% for difficulty awakening in the morning, 7.7% for sleeping poorly at night, and 71.2% for short sleep duration; for men, the prevalence were 7.9% for difficulty initiating sleep, 2.8% for difficulty maintaining sleep, 4.2% for early morning awakening, 46.2% for difficulty awakening in the morning, 7.2% for sleeping poorly at night, and 69.3% for short sleep durations. Women had significantly higher prevalence of difficulty initiating sleep and difficulty awakening in the morning than men, while other sleep behaviors did not show statistically significant differences between women and men.

Average self-esteem scale scores as well as prevalence (score, ≤ 20) were also lower in women compared to men.

Table 1. Descriptive statistics for demographics, lifestyle, and health-related variables of survey respondents according to smoking status stratified by sex^a

Variables	Women				<i>P</i> value ^c	Men				<i>P</i> value ^c
	Smoking status					Smoking status				
	Never	Former	Current			Never	Former	Current		
Number of respondents (%)^b	128 (82.1)	11 (7.1)	17 (10.9)		197 (34.7)	118 (20.8)	252 (44.4)			
Age group:				.195					.040	
22 to 29	40 (90.9)	2 (4.5)	2 (4.5)		41 (49.5)	8 (8.1)	50 (50.5)			
30 to 39	19 (90.5)	2 (9.5)	0 (0.0)		52 (33.5)	33 (21.3)	70 (45.2)			
40 to 49	23 (74.2)	4 (12.9)	4 (12.9)		44 (38.3)	26 (22.6)	45 (39.1)			
50 to 49	46 (75.4)	4 (6.6)	11 (18.0)		55 (29.4)	48 (25.7)	84 (44.9)			
60 to 74	0 (0.0)	0 (0.0)	0 (0.0)		5 (45.5)	3 (27.3)	3 (27.3)			
Mean [SD]	40.2 [12.1]	40.7 [11.2]	47.6 [9.8]	.053	40.8 [11.7]	45.2 [10.4]	41.2 [11.4]		.002	
Highest education:				.104					.155	
High school	32 (74.4)	4 (9.3)	7 (16.3)		4 (14.8)	5 (18.5)	18 (66.7)			
Vocational/junior college	42 (84.0)	2 (4.0)	6 (12.0)		0 (0.0)	0 (0.0)	2 (100.0)			

Table 1. (Continued)

College/university/graduate school	54 (85.7)	5 (7.9)	4 (6.8)	193 (35.9)	113 (21.0)	232 (43.1)	
Drinking habit:				.085			.866
No	87 (88.8)	3 (3.1)	8 (8.2)	23 (39.0)	10 (16.9)	26 (44.1)	
Yes	41 (70.7)	8 (13.8)	9 (15.5)	174 (34.3)	108 (21.3)	226 (44.5)	
Habitual exercise:				.051			.116
No	66 (88.0)	2 (2.7)	7 (9.3)	95 (30.9)	64 (20.8)	148 (48.2)	
Yes	62 (76.5)	9 (11.0)	10 (12.2)	102 (39.2)	54 (20.8)	104 (37.1)	
Caffeine intake (cups of coffee or tea/day):				.620			.530
Almost none	5 (55.6)	2 (22.2)	2 (22.2)	9 (30.0)	10 (33.3)	11 (36.7)	
1 to 2	57 (85.1)	4 (6.0)	6 (9.0)	98 (37.4)	52 (19.8)	112 (42.7)	
3 or more	66 (82.5)	5 (6.3)	9 (11.3)	90 (32.7)	56 (20.4)	129 (46.9)	
Body Mass Index (kg/height (m) ²) (in quartiles):				.705			.005
<25th	33 (84.6)	2 (5.1)	4 (10.3)	46 (32.6)	21 (14.9)	74 (52.5)	
>=25th-<50th	31 (79.5)	3 (7.7)	5 (12.8)	56 (38.6)	31 (21.4)	58 (40.0)	
>=50th-<75th	33 (86.8)	2 (5.3)	3 (7.9)	57 (42.9)	27 (20.3)	49 (36.8)	
>=75th-<100th	31 (77.5)	4 (10.0)	5 (12.5)	38 (25.7)	39 (26.4)	71 (48.0)	
Mean [SD]	20.3 [2.7]	20.9 [1.9]	20.6 [2.8]	.698	23.6 [2.5]	24.3 [2.8]	23.7 [3.1]

Table 1. (Continued)

No. of chronic diseases under treatment:							.963							.013
None	105	(83.3)	8	(6.3)	13	(10.3)	161	(36.2)	81	(18.2)	203	(45.6)		
1	20	(76.9)	2	(7.7)	4	(15.4)	29	(30.2)	25	(26.0)	42	(43.8)		
2	2	(66.7)	1	(33.3)	0	(0.0)	6	(30.0)	10	(50.0)	4	(20.0)		
3 or more	1	(100.0)	0	(0.0)	0	(0.0)	2	(28.6)	2	(28.6)	3	(42.9)		

aData may not total 100% due to rounding.

bPercent within smoking status.

cp value derived from chi-squared test for categorical variables and analysis of variance (with Bonferroni correction for multiple comparisons) for continuous variables (comparison within smoking status).

Table 2. Comparison of mental health indicators between women and men

Variables	Women		Men		<i>p</i> value ^a
Number of respondents (%)	156	(100.0)	567	(100.0)	
GHQ-28:					
GHQ-28 \geq 5 (bimodal method)	78	(50.0)	207	(36.5)	.004
GHQ-28 \geq 6 (bimodal method)	70	(44.9)	167	(29.5)	<.001
GHQ-28 \geq 7 (bimodal method)	57	(36.5)	137	(24.2)	.003
GHQ-28 \geq 8 (bimodal method)	43	(27.6)	104	(18.3)	.018
Total GHQ score (bimodal method)	5.6	[5.1]	4.2	[4.3]	.002
Total GHQ score (Likert method)	51.8	[10.9]	47.7	[9.5]	<.001
Somatic symptoms (Likert method)	14.7	[4.4]	12.6	[3.8]	<.001
Anxiety-Insomnia (Likert method)	13.3	[3.7]	12.9	[3.5]	.246
Social dysfunction (Likert method)	14.5	[2.3]	13.9	[2.6]	.011
Severe depression (Likert method)	9.2	[2.9]	8.3	[2.4]	.001
Depressive symptoms:					
CES-D score \geq 16	44	(28.2)	99	(17.5)	.006
Mean [SD]	12.4	[8.0]	10.2	[6.9]	.003
Sleep behaviors:					
Difficulty initiating sleep (yes)	21	(13.5)	45	(7.9)	.044
Difficulty maintaining sleep (yes)	2	(1.3)	16	(2.8)	.236
Early morning awakening (yes)	4	(2.6)	24	(4.2)	.439
Difficulty waking up in the morning (yes)	90	(57.7)	262	(46.2)	.018
Sleeping poorly at night (yes)	12	(7.7)	41	(7.2)	.803
Short sleep duration (yes)	111	(71.2)	393	(69.3)	.694
Self-Esteem:					
Rosenberg self-esteem scale score \leq 20	10	(6.4)	8	(1.4)	.001
Mean [SD]	27.8	[4.5]	30.2	[4.5]	<.001

^a*p* value derived from chi-squared test for categorical variables and Student's *t*-test (or Welch's test) for continuous variables.

Table 3. Odds ratios for poor mental health status assessed by GHQ (bimodal method) in former and current smokers compared to never smokers

	Smoking status				
	Never	Former		Current	
	OR (95% CI)	<i>p</i>		OR (95% CI)	<i>p</i>
Women	n = 128	n = 11		n = 17	
GHQ-28 cut-off score 4/5					
Unadjusted odds ratio	1.00	0.34 (0.07, 1.75)	.196	2.03 (0.66, 6.31)	.219
Adjusted odds ratio ^a	1.00	0.19 (0.02, 2.03)	.102	3.66 (0.77, 17.4)	.102
GHQ-28 cut-off score 5/6					
Unadjusted odds ratio	1.00	0.42 (0.08, 2.14)	.294	1.87 (0.63, 5.58)	.263
Adjusted odds ratio ^a	1.00	0.21 (0.02, 2.25)	.197	4.88 (1.02, 23.3)	.047
GHQ-28 cut-off score 6/7					
Unadjusted odds ratio	1.00	0.61 (0.12, 3.16)	.557	2.10 (0.71, 6.18)	.180
Adjusted odds ratio ^a	1.00	0.21 (0.02, 2.46)	.213	4.10 (0.91, 18.5)	.067
GHQ-28 cut-off score 7/8					
Unadjusted odds ratio	1.00	0.99 (0.19, 5.16)	.989	2.60 (0.87, 7.76)	.088
Adjusted odds ratio ^a	1.00	0.35 (0.03, 4.17)	.403	6.79 (1.45, 31.9)	.015
Men	n = 197	n = 118		n = 252	
GHQ-28 cut-off score 4/5					
Unadjusted odds ratio	1.00	1.48 (0.91, 2.43)	.117	1.33 (0.84, 2.10)	.225
Adjusted odds ratio ^a	1.00	1.51 (0.84, 2.71)	.167	1.51 (0.88, 2.58)	.132
GHQ-28 cut-off score 5/6					
Unadjusted odds ratio	1.00	2.16 (1.25, 3.74)	.006	1.97 (1.18, 3.31)	.010
Adjusted odds ratio ^a	1.00	2.29 (1.17, 4.47)	.016	2.27 (1.22, 4.23)	.010
GHQ-28 cut-off score 6/7					
Unadjusted odds ratio	1.00	2.03 (1.12, 3.67)	.020	2.01 (1.15, 3.52)	.020
Adjusted odds ratio ^a	1.00	2.15 (1.03, 4.49)	.041	2.32 (1.18, 4.57)	.015
GHQ-28 cut-off score 7/8					
Unadjusted odds ratio	1.00	2.30 (1.20, 4.43)	.013	1.80 (0.96, 3.38)	.068
Adjusted odds ratio ^a	1.00	2.08 (0.92, 4.69)	.079	2.03 (0.95, 4.33)	.067

^aAdjusted for age in 10-year increments, educational level, alcohol consumption, caffeine intake, exercise, BMI, and number of chronic diseases under treatment.
OR, odds ratio; CI, confidence interval.

Table 4. Comparison of mental health indicators between never, former and current smokers (mean scores with standard deviations in parentheses)

	Women			Men		
	Smoking status			Smoking status		
	Never	Former	Current	Never	Former	Current
Mental health indicators:	n = 128	n = 11	n = 17	n = 197	n = 118	n = 252
Total GHQ score (bimodal method)	5.3 (4.7)	4.6 (5.7)	8.5 (6.5)	3.6 (4.0)	4.6 (4.8)	4.2 (4.3)
Total GHQ score (Likert method)	51.0 (10.5)	52.3 (11.9)	57.5 (13.0)	46.7 (9.3)	48.7 (10.5)	47.6 (8.8)
Somatic symptoms (Likert method)	14.4 (4.4)	14.6 (4.0)	17.2 (4.1)	12.3 (3.6)	12.7 (3.9)	12.8 (3.8)
Anxiety-Insomnia (Likert method)	13.2 (3.8)	12.9 (1.9)	14.4 (3.9)	12.3 (3.1)	13.3 (3.9)*	12.9 (3.4)
Social dysfunction (Likert method)	14.4(2.1)	13.9 (2.9)	16.0 (3.2)*	13.7 (2.5)	14.1 (2.9)	13.8 (2.4)
Severe depression (Likert method)	9.1 (2.7)	10.9 (4.4)	9.9 (2.9)	8.3 (2.7)	8.5 (2.5)	8.1 (2.1)
CES-D score	11.8 (7.6)	10.8 (7.5)	17.3 (10.1)*	8.8 (7.5)	11.2 (7.4)*	10.2 (6.0)
Rosenberg self-esteem scale score	27.9 (4.4)	27.4 (1.8)	27.8 (4.5)	30.4 (4.6)	29.7 (4.3)	30.3 (4.4)

* $p < .05$ (Analysis of variance with Bonferroni correction for multiple comparisons; compared to never smoking counterparts).

Relationship between Smoking and Mental Health Assessed by GHQ

Compared to never smokers (referent group), current smokers had generally greater odds of GHQ scores in both women and men (Table 3). In women, current smokers showed significantly higher odds than never smokers at cut-off points of 5/6 and 7/8. In men, current smokers and former smokers showed significantly higher odds than never smokers at cut-off points of 5/6 and 6/7.

We also calculated total GHQ-28 scores and scores of 4 subscales by Likert method (Table 4). In women, social dysfunction score in current smokers were significantly higher than former smokers. In men, severe depression score was higher in former smokers than in never smokers.

Relationship between Smoking and Mental Health Assessed by CES-D

Prevalence of clinically relevant levels of depressive symptoms (CES-D score ≥ 16) as well as mean CES-D scores was significantly greater in women than in men (Table 2). Compared to never smokers, increased odds of high levels of depressive symptoms were found in current smoking women and men by multivariate logistic regression analysis (Table

5). Former smoking men also had higher prevalence of clinically relevant levels of depressive symptoms than never smokers. Similarly, average CES-D scores of current smoking women were higher than never smoking women whereas for men, former smokers had significantly higher score of CES-D than never smokers (Table 4).

Relationship between Smoking and Sleep Behaviors

Compared to never smokers (referent group), increased odds of difficulty initiating sleep, difficulty awakening in the morning, and sleeping poorly at night were found in current smoking women. Former smokers had increased odds of sleeping poorly at night than never smokers. In men, current smokers had increased difficulty awakening in the morning than never smokers, but no significant differences were found among other sleep behaviors.

Relationship between Smoking and Self-Esteem

No significant differences were found in average self-esteem scale scores by smoking status in both sexes (Table 4). However, current smoking women had significantly increased odds of lowest self-esteem compared to never smokers, while men did not have any significant differences by smoking status (Table 7).

Table 5. Odds ratios for a high levels of depressive symptoms (CES-D \geq 16) in former and current smokers compared to never smokers

	Smoking status				
	Never	Former		Current	
		OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Women	n = 128	n = 11		n = 17	
Unadjusted odds ratio	1.00	1.57 (0.37, 6.70)	.541	3.59 (1.20, 10.8)	.023
Adjusted odds ratio ^a	1.00	0.47 (0.04, 5.66)	.551	12.3 (2.28, 66.8)	.004
Men	n = 197	n = 118		n = 252	
Unadjusted odds ratio	1.00	3.22 (1.56, 6.63)	.002	2.33 (1.15, 4.72)	.019
Adjusted odds ratio ^a	1.00	2.75 (1.15, 6.55)	.023	2.53 (1.11, 5.77)	.027

^aAdjusted for age in 10-year increments, educational level, alcohol consumption, caffeine intake, exercise, BMI, and number of chronic diseases under treatment.

OR, odds ratio; CI, confidence interval.

Table 6. Odds ratios for poor sleep behaviors in former and current smokers compared to never smokers

Sleep variable:	Smoking status				
	Never	Former		Current	
		OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Women	n = 128	n = 11		n = 17	
Difficulty initiating sleep (yes vs. no)					
Unadjusted odds ratio	1.00	1.02 (0.12, 8.81)	.986	4.08 (1.21, 13.8)	.024
Adjusted odds ratio ^a	1.00	/	/	14.6 (2.42, 88.3)	.003
Difficulty maintaining sleep (yes vs. no)					
Unadjusted odds ratio	1.00	/	/	8.43 (0.50, 142)	.139
Adjusted odds ratio ^a	1.00	/	/	/	/
Early morning awakening (yes vs. no)					
Unadjusted odds ratio	1.00	/	/	2.76 (0.27, 28.4)	.393
Adjusted odds ratio ^a	1.00	/	/	/	/
Difficulty awakening in the morning (yes vs. no)					
Unadjusted odds ratio	1.00	6.88 (0.83, 56.7)	.073	2.36 (0.71, 7.85)	.160
Adjusted odds ratio ^a	1.00	7.78 (0.65, 93.8)	.106	11.0 (1.60, 75.5)	.015
Sleeping poorly at night (yes vs. no)					
Unadjusted odds ratio	1.00	2.35 (0.25, 22.0)	.453	6.85 (1.68, 28.0)	.007
Adjusted odds ratio ^a	1.00	77.2 (1.10, 5400)	.045	257 (6.04, 10980)	.004
Short sleep duration (yes vs. no)					
Unadjusted odds ratio	1.00	1.48 (0.29, 7.46)	.638	1.16 (0.35, 3.89)	.638
Adjusted odds ratio ^a	1.00	0.58 (0.07, 4.83)	.613	1.50 (0.25, 9.13)	.657
Men	n = 197	n = 118		n = 252	
Difficulty initiating sleep (yes vs. no)					
Unadjusted odds ratio	1.00	1.16 (0.45, 2.95)	.764	1.60 (0.69, 3.70)	.273
Adjusted odds ratio ^a	1.00	1.01 (0.36, 2.88)	.979	1.35 (0.54, 3.37)	.526
Difficulty maintaining sleep (yes vs. no)					
Unadjusted odds ratio	1.00	7.89 (0.99, 63.1)	.052	4.04 (0.49, 33.2)	.194
Adjusted odds ratio ^a	1.00	4.20 (0.46, 38.0)	.201	4.72 (0.55, 40.7)	.158
Early morning awakening (yes vs. no)					

Table 6. (Continued)

	Smoking status				
	Never	Former		Current	
Sleep variable:		OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Unadjusted odds ratio	1.00	2.29 (0.59, 8.80)	.229	2.11 (0.58, 7.70)	.259
Adjusted odds ratio ^a	1.00	0.97 (0.21, 4.55)	.964	1.19(0.29, 4.93)	.808
Difficulty awakening in the morning (yes vs. no)					
Unadjusted odds ratio	1.00	0.67 (0.42, 1.09)	.105	1.46 (0.95, 2.23)	.088
Adjusted odds ratio ^a	1.00	0.88 (0.49, 1.58)	.675	2.14 (1.26, 3.63)	.005
Sleeping poorly at night (yes vs. no)					
Unadjusted odds ratio	1.00	2.04 (0.76, 5.46)	.158	1.64 (0.63, 4.26)	.313
Adjusted odds ratio ^a	1.00	1.77 (0.53, 5.97)	.355	1.93 (0.64, 5.89)	.245
Short sleep duration (yes vs. no)					
Unadjusted odds ratio	1.00	0.59 (0.35, 0.98)	.043	0.78 (0.48, 1.26)	.310
Adjusted odds ratio ^a	1.00	0.93 (0.49, 1.75)	.821	0.95 (0.53, 1.71)	.858

^aAdjusted for age in 10-year increments, educational level, alcohol consumption, caffeine intake, exercise, BMI, and number of chronic diseases under treatment.

OR, odds ratio; CI, confidence interval; / Estimates could not be calculated.

Table 7. Odds ratios for low self-esteem in former and current smokers compared to never smokers

	Smoking status				
	Never	Former		Current	
		OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Women	n = 128	n = 11		n = 17	
Unadjusted odds ratio	1.00	/	/	2.46 (0.60, 10.0)	.212
Adjusted odds ratio ^a	1.00	/	/	10.4 (1.32, 81.9)	.026
Men	n = 197	n = 118		n = 252	
Unadjusted odds ratio	1.00	0.82 (0.37, 1.78)	.609	0.74 (0.36, 1.78)	.424
Adjusted odds ratio ^a	1.00	0.83 (0.30, 2.26)	.713	0.76 (0.31, 1.86)	.547

^aAdjusted for age in 10-year increments, educational level, alcohol consumption, caffeine intake, exercise, BMI, and number of chronic diseases under treatment.

OR, odds ratio; CI, confidence interval; / Estimates could not be calculated.

Table 8. Correlation matrix of smoking habits, mental health indicators, sociodemographic, and lifestyle variables (upper diagonal is women and lower diagonal is men)

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Smoking habit (1, never; 2, former; 3, current)		.754 ***	.114 NS	.159 NS	.164 NS	.132 NS	.163 NS	.104 NS	.132 NS	.196 *	.061 NS	.035 NS
2. Number of cigarettes smoked per day	.841 ***		.205 *	.197 *	.211 *	.143 NS	.267 **	.100 NS	.199 *	.311 ***	.070 NS	.050 NS
3. GHQ-28 score (bimodal method) ^a	.058 NS	.004 NS		.874 ***	.809 ***	.804 ***	.636 ***	.486 ***	.666 ***	.291 ***	.353 ***	.322 ***
4. GHQ-28 score (Likert method) ^a	.079 NS	.031 NS	.822 ***		.856 ***	.890 ***	.678 ***	.739 ***	.746 ***	.284 ***	.396 ***	.356 ***
5. GHQ somatic symptoms (Likert method) ^a	.085 NS	.056 NS	.729 ***	.822 ***		.644 ***	.494 ***	.447 ***	.576 ***	.121 ***	.259 **	.254 **
6. GHQ anxiety-insomnia (Likert method) ^a	.082 NS	.016 NS	.734 ***	.850 ***	.567 ***		.567 ***	.641 ***	.654 ***	.387 ***	.473 ***	.429 ***
7. GHQ social dysfunction (Likert method) ^a	.021 NS	.013 NS	.521 ***	.595 ***	.324 ***	.396 ***		.435 ***	.553 ***	.290 ***	.364 ***	.349 ***
8. GHQ severe depression (Likert method) ^a	.003 NS	-.046 NS	.358 ***	.615 ***	.350 ***	.521 ***	.267 ***		.664 ***	.213 *	.231 **	.201 *
9. CES-D score ^a	.121 **	.049 NS	.556 ***	.671 ***	.467 ***	.589 ***	.530 ***	.467 ***		.296 ***	.383 ***	.361 ***
10. Time to fall asleep ^a	-.003 NS	.033 NS	.136 **	.172 ***	.094 *	.212 ***	.173 ***	.079 NS	.205 ***		.492 ***	.365 ***
11. Frequency of difficulty maintaining sleep ^a	.008 NS	.003 NS	.316 ***	.365 ***	.245 ***	.437 ***	.235 ***	.161 ***	.307 ***	.356 ***		.715 ***
12. Frequency of early morning awakening ^a	-.032 NS	-.047 NS	.252 ***	.331 ***	.197 ***	.400 ***	.220 ***	.178 ***	.257 ***	.282 ***	.702 ***	
13. Frequency of difficulty awakening in the morning ^a	.132 **	.133 **	.260 ***	.261 ***	.282 ***	.184 ***	.132 **	.106 *	.231 ***	.129 **	-.047 NS	-.148 **
14. Overall nighttime sleep quality ^a	-.051 NS	-.072 NS	.289 ***	.371 ***	.249 ***	.394 ***	.267 ***	.214 ***	.347 ***	.416 ***	.526 ***	.460 ***
15. Habitual sleep duration (1, 5 hrs; 4, 8 hrs)	.046 NS	.003 NS	-.115 *	-.076 NS	-.107 *	-.056 NS	.015 NS	-.041 NS	-.086 NS	-.010 NS	.067 NS	.063 NS
16. Rosenberg self-esteem scale score ^b	-.012 NS	.025 NS	-.238 ***	-.383 ***	-.166 ***	-.311 ***	-.348 ***	-.510 ***	-.465 ***	-.129 **	-.184 ***	-.157 ***
17. Age (in years)	.081 NS	.056 NS	-.043 NS	.071 NS	-.002 NS	.060 NS	.130 **	.001 NS	.047 NS	.037 NS	.221 ***	.259 ***
18. Educational level (1, lowest; 3, highest)	-.130 **	-.148 **	.030 NS	-.015 NS	.049 NS	.011 NS	-.100 *	-.009 NS	-.074 NS	-.034 NS	-.050 NS	-.067 NS
19. Alcohol drinking (1, no; 2, yes)	-.019 NS	-.023 NS	.015 NS	-.021 NS	.015 NS	-.001 NS	-.030 NS	-.043 NS	-.032 NS	-.071 NS	.049 NS	.023 NS
20. Caffeine intake (cups of tea or coffee/day)	.075 NS	.123 **	.005 NS	.025 NS	.007 NS	.027 NS	.007 NS	-.019 NS	-.021 NS	-.020 NS	.015 NS	-.001 NS
21. Regular exercise (1, no; 2, yes)	-.076 NS	-.072 NS	-.157 ***	-.204 ***	-.130 **	-.186 ***	-.129 **	-.153 ***	-.217 ***	-.086 NS	-.035 NS	-.045 NS
22. Body mass index (BMI)	.042 NS	.037 NS	.005 NS	-.002 NS	.019 NS	-.005 NS	.021 NS	-.075 NS	-.014 NS	-.023 NS	-.013 NS	.010 NS
23. Number of chronic diseases under treatment	.049 NS	-.015 NS	.041 NS	.089 NS	.055 NS	.068 NS	.068 NS	.084 NS	.130 **	.002 NS	.115 *	.169 ***

* p<.05; ** p<.01; *** p<.001; NS, non significant (Spearman's rank correlation coefficients)

^a Higher scores indicate poor mental health.

^b Lower score indicates poor mental health.

Table 8. (Continued)

13	14	15	16	17	18	19	20	21	22	23
.159 NS	.273 **	-.061 NS	-.062 NS	.184 *	-.107 NS	.144 NS	.136 NS	.177 *	.063 NS	.003 NS
.148 NS	.252 **	-.104 NS	-.017 NS	.226 *	-.221 *	.071 NS	.099 NS	.123 NS	.003 NS	.032 NS
.290 ***	.407 ***	-.015 NS	-.397 ***	-.006 NS	-.045 NS	-.067 NS	.003 NS	-.047 NS	-.110 NS	.154 NS
.295 ***	.422 ***	-.051 NS	-.497 ***	.000 NS	-.048 NS	-.055 NS	-.022 NS	-.101 NS	-.062 NS	.164 NS
.303 ***	.327 ***	-.064 NS	-.292 ***	-.050 NS	.020 NS	-.110 NS	.046 NS	-.057 NS	-.094 NS	.092 NS
.267 **	.510 ***	-.044 NS	-.469 ***	.017 NS	-.060 NS	-.020 NS	-.050 NS	-.129 NS	-.023 NS	.170 NS
.106 NS	.295 ***	-.018 NS	-.377 ***	.176 *	-.194 *	-.067 NS	.067 NS	-.151 NS	.057 NS	.126 NS
.219 *	.228 **	.006 NS	-.582 ***	-.045 NS	.028 NS	-.010 NS	-.148 NS	-.079 NS	-.092 NS	.123 NS
.242 **	.303 ***	-.136 NS	-.063 ***	.092 NS	-.070 NS	-.053 NS	-.036 NS	-.020 NS	-.066 NS	.184 *
.224 *	.578 ***	-.065 NS	-.125 NS	.020 NS	-.087 NS	.109 NS	.133 NS	-.102 NS	.082 NS	.018 NS
.157 NS	.506 ***	.031 NS	-.198 *	.161 NS	-.204 *	-.071 NS	.083 NS	-.090 NS	.188 *	.090 NS
.054 NS	.398 ***	.012 NS	-.173 NS	.057 NS	-.121 NS	-.050 NS	.111 NS	-.106 NS	.062 NS	-.025 NS
	.204 *	.068 NS	-.177 *	-.175 *	.114 NS	.097 NS	.012 NS	-.101 NS	-.071 NS	.101 NS
.027 NS		-.068 NS	-.112 NS	.223 *	-.214 *	.102 NS	.192 *	-.130 NS	.070 NS	.025 NS
-.135 **	.015 NS		-.011 NS	-.177 *	.156 NS	-.089 NS	.101 NS	.016 NS	-.155 NS	-.124 NS
-.115 *	-.190 ***	.068 NS		.030 NS	.032 NS	.032 NS	.125 NS	.121 NS	-.019 NS	-.112 NS
-.338 ***	.158 ***	.337 ***	.011 NS		-.796 ***	-.151 NS	.158 NS	.016 NS	.422 ***	.292 ***
.110 *	-.034 NS	-.068 NS	.114 *	-.214 ***		.141 NS	-.164 NS	.055 NS	-.353 ***	-.324 ***
.022 NS	-.039 NS	-.024 NS	.027 NS	-.153 ***	.208 ***		.079 NS	.047 NS	.033 NS	-.208 *
-.052 NS	-.019 NS	-.036 NS	.002 NS	.143 **	-.027 NS	-.099 *		-.034 NS	.148 NS	.053 NS
-.045 NS	-.078 NS	.033 NS	.200 ***	.054 NS	.028 NS	.003 NS	.000 NS		-.030 NS	.049 NS
-.118 *	-.035 NS	.025 NS	.090 NS	.207 ***	-.036 NS	.002 NS	.038 NS	.002 NS		.088 NS
-.077 NS	.061 NS	.145 **	-.097 *	.367 ***	-.096 *	-.050 NS	.012 NS	.034 NS	.151 ***	

Correlations among Independent and Dependent Variables

Correlation matrix of independent and dependent variables are presented in Table 8. As can be seen from this table, the direction of correlations was mostly as expected. Specifically, number of cigarettes smoked per day was highly correlated with some mental health indicators in women. Men showed moderate correlations between cigarettes smoked per day and mental health indicators.

Table 9. Correlations between never smokers exposed to different levels^a of passive smoking at work and at home and mental health outcomes

Variables	Women		Men	
	n = 128		n = 197	
Total GHQ score (bimodal method) ^b	.127	NS	.086	NS
Total GHQ score (Likert method) ^b	.079	NS	.234	*
Somatic symptoms (Likert method) ^b	.147	NS	.181	NS
Anxiety-Insomnia (Likert method) ^b	.047	NS	.156	NS
Social dysfunction (Likert method) ^b	-.119	NS	.083	NS
Severe depression (Likert method) ^b	.013	NS	.281	**
CES-D score ^b	-.009	NS	.318	**
Time to fall asleep ^b	.102	NS	.020	NS
Frequency of difficulty maintaining sleep ^b	-.124	NS	.068	NS
Frequency of early morning awakening ^b	-.082	NS	-.049	NS
Frequency of difficulty awakening in the morning ^b	.202	*	.243	*
Overall nighttime sleep quality ^b	.031	NS	.022	NS
Habitual sleep duration (1, 5 hrs; 4, 8 hrs)	.058	NS	-.047	NS
Rosenberg self-esteem scale score ^c	.076	NS	-.196	NS

* $p < .05$; ** $p < .01$; NS, non significant (Spearman's rank correlation coefficients)

^a Levels of passive smoking exposure (1, no exposure; 2, occasional; 3, regular).

^b Higher scores indicate poor mental health.

^c Lower score indicates poor mental health.

Relationship between Passive Smoking Exposure at Work/Home in Never Smokers and Mental Health Outcomes

Relationship between exposure to different levels (never, occasional, and regular) of passive smoking in never smokers and mental health indicators are shown in Table 9. Due to a small sample size, we only examined the passive smoking exposure 'either at work or at home' in never smokers. Total GHQ score (bimodal method), severe depression, CES-D score, and frequency of difficulty awakening in the morning were significantly and positively correlated with level of passive smoking in men while in women difficulty awakening in the morning was the only indicator correlated with passive smoking exposure.

Discussion

The purpose of the present study was to know the effects of smoking and exposure to passive smoking on multiple mental health indicators. To know unique gender differences, we analyzed women and men separately. Following results were obtained from the analyses: 1) almost all mental health indicators were poorer in women than in men irrespective of smoking status, 2) compared to never smokers, both current smoking women and men had higher odds of possible psychiatric morbidity as denoted by GHQ and CES-D, but women had higher odds compared to men, 3) odds of psychiatric morbidity were higher in former smoking men but not in women, 4) poor sleep was observed in smokers but women suffered from various sleep problems than men, 5) smoking was weakly associated with reporting poor self-esteem in women but was not related to self-esteem in men, and 6) among never smokers, level of exposure to passive smoking moderately correlated with GHQ and CES-D scores in men while difficulty awakening in the morning correlated with passive smoking in both women and men. We conclude that smoking has a negative impact on various aspects of mental health in both women and men, but women seem to have tighter association between smoking and poor mental health than men. Exposure to passive smoking may also be a possible factor that associates with poor mental health status.

Before we interpret the results, some limitations and strengths of this study should be addressed. First, most obvious limitation is that our study design was cross-sectional; the inherent nature of this design does not permit the conclusion that smoking or passive smoking causes poor mental health or sleep problems. Second, the data in this study were derived from workers in a commercial industry with small subgroups of white-collar smokers and nonsmokers only, which may attenuate the power of statistical analysis. Third, the large set of statistical tests examined here may have increased the possibility of type I error; the statistical significance of the results should be interpreted carefully. Fourth, data on smoking status and mental health indicators were obtained by a self-reported questionnaire a means of obtaining information that could result in recall/reporting bias. Fifth, some confounding variables that may have an impact on both smoking and mental health, such as work organization and stress were not included in this study.

The strengths of our study are as many. First, we used well-established questionnaires to assess broad aspects of mental health. Using these questionnaires, we can understand the

relationship between smoking and mental health more comprehensively. Second, the response rate was extremely high for such a survey (>95%), decreasing the risk of response bias. Third, we evaluated the effects of passive smoking on mental health, which had rarely been done in previous studies. Fourth and finally, we included a broad range of confounding variables that are known to affect both smoking and mental health.

Poor mental health as denoted by GHQ and CES-D were more prevalent in current smokers than in never smokers in both women and men (Tables 3 and 5). In terms of GHQ, we introduced four different cutoff scores to identify potential psychiatric illnesses, since many previous studies used various cutoff thresholds. Simultaneous use of different cutoff criteria may provide further information about severity of mental illness. Smoking women tend to show a higher OR in accordance with increased GHQ cutoff thresholds, while odds of smoking men were relatively stable across all cutoff thresholds, suggesting that smoking women may suffer from severe type of mental illness than smoking men (Table 3). In particular, smoking may affect social function such as coping poorly with work stress, reduced concentration and motivation, and feeling incapable of making decisions since social dysfunction score was significantly increased in women (Table 4). As for depressive symptoms, we used only CES-D ≥ 16 to denote high depressive symptoms, and found that both smoking women and men had significantly higher odds of high depressive symptoms than never smokers. However, current smoking women had higher odds of high depressive symptoms than men, consistent with some previous reports (Benjet *et al.*, 2004; Duncan and Rees, 2005; Martini *et al.*, 2002; Perez-Stable *et al.*, 1990; Son *et al.*, 1997; Steuber and Danner, 2006). Another finding was that former smoking men had significantly increased poor mental health outcomes by GHQ and CES-D compared to never smokers, while in contrast, former smoking women had lower OR than never smoking women. Men may quit smoking because of serious health issues while women quit smoking before having health consequences. In addition, men may have difficulty in quitting smoking than women because they tend to smoke heavier and/or longer years. In the present sample, median number of cigarettes smoked for former smoking men was 20 per day while former smoking women was 3 per day before they quit smoking; median smoking duration was 10 years for men while it was 5 years for women. Smoking intensity and duration prior to quit smoking may influence prognosis of subjects with poor mental health status.

This study revealed that current smoking significantly increased difficulty awakening in the morning in both women and men, and increased difficulty initiating sleep and poor sleep at night in women (Table 6). Number of cigarettes smoked per day correlated with difficulty initiating sleep and poor sleep at night in women and difficulty awakening in the morning in men (Table 8). Possible mechanisms underlying the present findings could be explained as follows. First, exposure to nicotine stimulates the brain to enhance/maintain alertness, which keeps smokers from initiating sleep (Benowitz, 1996; Soldatos *et al.*, 1980; Takahashi *et al.*, 2005). This may result in a reduced total sleep time and thus could increase chances of difficulty awakening in the morning and poor sleep quality. That transdermal nicotine decreases total sleep time and reduces sleep efficiency and the percentage of rapid eye movement sleep support the above assumption (Boutrel and Koob, 2004; Davila, Hurt, Offord, Harris, and Shepard, 1994). Second, the nicotine level in the brain gradually decreases during sleep, and eventually induces smokers to exhibit nicotine deprivation

leading to difficulty awakening in the morning. Positive correlation between exposure to passive smoking and frequency of difficulty awakening in the morning may follow this mechanism as well, although passive smokers could be unaware of such effect (Table 9). Because of poor sleep and difficulty awakening in the morning, smokers may use nicotine to increase alertness and help them wake up, leading to nicotine dependent.

A weak association between current smoking and low self-esteem was found in women (Table 7). However, there were neither significant correlation with number of cigarettes smoked per day or smoking status and self-esteem scores nor differences in average self-esteem scores across smoking status (Tables 4 and 8). As expected, no significant association between exposure to passive smoking and self-esteem scores was found (Table 9). Previous studies in adolescents found that low self-esteem is common in smokers compared to never smokers as stated earlier, while there are studies also reporting weak evidence (Y. H. Kim, 2005; Kokkevi, Richardson, Florescu, Kuzman, and Stergar, 2007). A study by Mosbach and Leventhal (1988) even found that adolescents expressing not only low but high self-esteem seemed to be more likely to be a smoker (Mosbach and Leventhal, 1988). Among young adults, smoking was only weakly related to low self-esteem (Croghan *et al.*, 2006). The results suggest that smoking may be only weakly related to women with very low self-esteem.

The reasons why more women than men show a stronger relationship with mental illness from smoking may be explained as follows. In most Asian countries including Japan, women are exposed to greater social pressure not to smoke than are men (Mori *et al.*, 2003). This is reflected to a large gender differences in smoking prevalence among Asian countries. For example, the most recent survey conducted by Ministry of Health, Labor, and Welfare in Japan suggested that the prevalence for men and women were 39.3% and 11.3%, respectively in year 2005 (MHLW Japan, 2007). Women who persist in smoking despite such pressure may have more psychosocial stress, dissatisfaction with their life situation, negative emotion, and social isolation than those forgo smoking, which may subsequently induce serious mental health issues. Social undesirability associated with smoking may cause social pressure and development of poor mental health (Link, Struening, Cullen, Shrout, and Dohrenwend, 1989).

In the current study, we found a significant gender differences in mental health outcomes irrespective of smoking status. All of four different mental health indicators, i.e., GHQ, CES-D, sleep behavior questionnaire, and self-esteem scale, indicated that women have lower mental health status than men, in agreement with previous studies (Halbreich and Kahn, 2007; Kessler, 2003; Kling, Hyde, Showers, and Buswell, 1999; Krystal, 2004; Noble, 2005; Olf *et al.*, 2007). Smoking also had a significant effect on mental health indicators but women had more of a chance to aggravate their mental health from smoking than men. From the data we can conclude that women are more vulnerable to mental health problems than men in nature, but smoking could reinforce such vulnerability. Special attention should be paid on the mental health of smoking women.

Conclusion

Despite the fact that smoking status and mental health, as well as sleep behaviors were assessed by self-report, these data suggest that smoking is associated with mental health symptoms. Passive smoking was also related to some aspects of mental health that should not be ignored. This suggests that a smoking cessation program for current smokers needs to be supplemented with elimination of exposure to passive smoking for nonsmokers to reduce the risk of mental health symptoms. Although the small sample size suggests a need for replication, current results highlight the importance of the association of smoking and exposure to passive smoking with mental health, especially in women.

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