

Differences between fixed day shift workers and rotating shift workers in gastrointestinal problems: a systematic review and meta-analysis

Wen-Pei CHANG^{1, 2*} and Yu-Xuan PENG³

¹School of Nursing, College of Nursing, Taipei Medical University, Taiwan

²Department of Nursing, Shuang Ho Hospital, Taipei Medical University, Taiwan

³Department of Nursing, College of Nursing, Tzu Chi University, Taiwan

Received July 23, 2020 and accepted December 25, 2020

Published online in J-STAGE January 7, 2021

Abstract: This study comprised a review and compilation of literature to gain an in-depth understanding of the impact of rotating shift work on gastrointestinal health. PubMed, CINAHL, and the Cochrane Library were searched for studies published between January 1, 1985, and June 30, 2020. Fixed day shifts were defined as work shifts that began between 7:00 and 9:00 in the morning. Shifts beginning at any other time were classified as rotating shifts. A meta-analysis was performed using Comprehensive Meta-Analysis Software (CMA) version 3. In the end, 16 studies were included in the meta-analysis. An odds ratio (OR) of 1.56 (95% confidence interval (CI): 1.24–1.95), indicating that gastrointestinal problems are more common in rotating shift workers than in fixed day shift workers. Four gastrointestinal problems, namely, irritable bowel syndrome, constipation, indigestion, and peptic ulcers, were then analyzed separately. Significant differences between rotating shift workers and fixed day shift workers were found only for indigestion and peptic ulcers. For indigestion, the OR was 1.72 (95% CI: 1.28–2.30). For peptic ulcers, the OR was 1.66 (95% CI: 1.19–2.30). Thus, research indicates that rotating shift work may increase the risk of gastrointestinal problems, particularly indigestion and peptic ulcers.

Key words: Fixed day shift, Rotating shift, Worker, Gastrointestinal problems, Meta-analysis

Introduction

Rotating shift work refers to a situation when over half of the working period falls outside of the period beginning between 7:00 and 9:00 in the morning and ending between 6:00 and 8:00 in the evening^{1, 2}. It is a challenge to an individual's biological rhythms due to disruptions to the body's circadian rhythms and effects on hormone secretion

and regulation³. For the sake of their jobs, rotating shift workers must be active during time periods when they should normally be resting or sleeping. As a consequence, their physiological systems must readjust; however, whether a new steady state can be achieved is still inconclusive⁴.

Gastrointestinal activity and functions in the human body are regulated by circadian rhythms 24 h a day⁵. Gastrointestinal motility and gastric acid secretion are both associated with the biological clock. Rotating shift workers often have irregular daily routines, often resulting in irregular meals and high fat intake as well as increasing the risk of gastrointestinal diseases^{6, 7}. In another aspect, rotating

*To whom correspondence should be addressed.

E-mail: 10479@s.tmu.edu.tw

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shift workers are likely to change the time, frequency, and contents of their meals⁸). Gastrointestinal dysfunction are more common among rotating shift workers than among fixed day shift workers⁹). Examples include constipation due to altered bowel habits, or functional dyspepsia, the symptoms of which include upper abdominal pain, flatulence, loss of appetite, nausea, and vomiting. Severe cases may involve peptic ulcers^{10, 11}).

The large intestine has its own biological clock. Upon waking, gastrointestinal motility increases and tends to trigger the need to defecate¹²). However, long-term rotating shift work often disrupts these physiological rhythms, which severely affects this biological clock and is associated with intestinal maladjustment, resulting in unpleasant symptoms such as diarrhea, flatulence, constipation, and abdominal pain^{13, 14}). Nojkov *et al.* observed that gastrointestinal complaints which overlap with irritable bowel syndrome (IBS) occur more frequently in rotating shift workers than in fixed day shift workers (48% vs. 31%, $p < 0.01$)¹⁴).

In summary, we derive that IBS, peptic ulcers, constipation, and indigestion are gastrointestinal problems from which rotating shift workers often suffer. The impact of rotating shift work on worker health has been receiving more attention from experts and researchers in recent years, and a substantial amount of empirical data have been used to explore this issue¹⁵⁻¹⁷). Gastrointestinal problems are likely to further contribute to decreased levels of alertness and increased irritability, which are already known to negatively impact the behavior of shift workers¹⁶). The authors thus aimed to systematically compile relevant research to examine existing evidence regarding the influence of rotating shift work on the gastrointestinal tract, including gastrointestinal problems such as IBS, peptic ulcers, constipation, and indigestion.

Subjects and Methods

Literature search and quality

This study involved a systematic review of literature obtained from the Cochrane Library, PubMed, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework¹⁸). The literature search was conducted using synonyms of gastrointestinal* in coordination with Boolean logic skills and the keyword string (((((((shift work) OR (rotating shift)) AND (gastrointestinal*)) OR (irritable bowel syndrome)) OR (peptic ulcer)) OR

(constipation)) OR (indigestion)) OR (dyspepsia). Figure 1 presents the screening process. Studies on rotating shift workers (defined as individuals working shifts other than fixed day shifts) over the age of 20 and published between January 1, 1985, and June 30, 2020, were included. No gender restrictions were applied. Although minors (i.e., under the age of 20) working rotating shifts may also experience specific health considerations, we focused only on rotating shift workers over the age of 20. Fixed day shifts in our meta-analysis were permanent shifts in which work shifts began between 7:00 and 9:00 in the morning, whereas rotating shifts were not permanent or began at other times. Studies with inadequate raw data (studies that did not provide the numbers of fixed day shift or rotating shift workers), studies not published in English, duplicates, and argumentative or systemic reviews were excluded. The quality of the selected studies was assessed using the critical appraisal instruments developed by the Joanna Briggs Institute (JBI)¹⁹). We reviewed whether the studies met the following criteria: (1) the criteria for inclusion in the sample were clearly defined (fixed day shifts and rotating shifts were clearly defined), (2) the study subjects and the setting were described in detail, (3) the exposure was measured in a valid and reliable way, (4) objective and standard criteria were used for the measurement of the condition (clear diagnostic methods were used for IBS, peptic ulcers, constipation, and indigestion; and the numbers of patients diagnosed with each condition were clearly stated), (5) confounding factors were identified, (6) strategies to deal with confounding factors were stated, (7) the outcomes were measured in a valid and reliable way, and (8) appropriate statistical analysis was used. Only studies that met six or more of these eight criteria were included in our meta-analysis. The appraisals were done by the two authors separately. The response for each item was “No”, “Yes”, or “Unclear”. “Yes” responses received 1 point, and 0 points were given for any other response.

Data analysis

Data analysis was performed using the software package Comprehensive Meta-Analysis (CMA) 3.0. The variance among the results of the 16 studies (heterogeneity or homogeneity) was examined using Cochran's Q test, and the relative importance and direction of the research outcomes of the studies were displayed using forest plots, with the fixed effect model or the random effects model chosen to calculate the pooled odds ratio (OR). Subgroup analysis was applied to studies that were found to have heterogeneity, meaning that separate meta-analyses were used for the

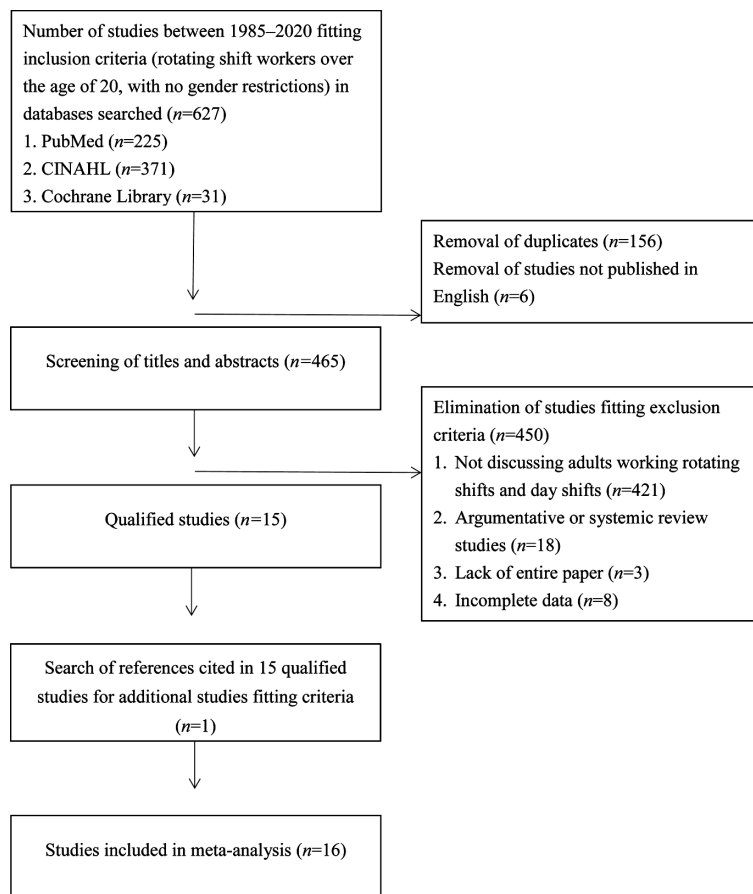


Fig. 1. Flowchart of literature screening process.

four types of common gastrointestinal problems (namely IBS, peptic ulcers, constipation, and indigestion). Furthermore, sensitivity analysis was conducted in the event that a study was found to have heterogeneity. Sensitivity analysis was conducted to determine whether the elimination of any study would influence the overall results. Funnel plots and Egger's test were employed to test for publication bias. Funnel plots were used to examine whether the positive or negative effects of the various study results were symmetric, and then Egger's regression was applied.

Results

We obtained a total of 627 studies. After eliminating duplicates and studies not published in English, we derived 465 studies. We then screened the studies by title and abstract and examined them using our inclusion and exclusion criteria, which resulted in 16 studies. Figure 1 displays the search process. The selected studies were appraised using the instruments developed by JBI. The total scores of all 16 studies were 6–7 points, so no studies were

eliminated following the appraisal process. The Kappa value for the inter-rater reliability of the two experts was 0.897, thereby indicating extremely high consistency and significant correlation between the ratings given by the experts. Extraction of the research data was conducted using a standard form, and the research designs and data compilation in the 16 studies are presented in Table 1.

Overall analysis

Focusing on rotating shifts and fixed day shifts in different types of occupations, assessing different gastrointestinal problems, and using different methods to confirm gastrointestinal problems all may have led to the high heterogeneity among the 16 studies ($I^2: 73.16\%$ $p < 0.001$); thus, the random effects model was used. The OR presented by the forest plot was 1.56 (95% confidence interval: 1.24–1.95, $p < 0.001$), meaning that rotating shift workers were more likely to suffer from gastrointestinal problems such as IBS, peptic ulcers, constipation, and indigestion than were fixed day shift workers (Fig. 2). Furthermore, the sensitivity analysis indicated that the elimination of

Table 1. Summary of Literature included in Meta-analysis

First author (yr)	Country	Design	Subjects	Gender	Age (Mean, SD)	Definition of shift work	GI problem	GI problem confirmation standard or instrument	Shift work		Quality score		
									Total	case			
Abedini (2015) ⁽²⁰⁾	Iran	Cross-sectional	Hospital security	M	Day: 35.12 (8.90) Shift: 36.57 (9.68)	Non-permanent day shifts; working for 12 h and then resting for 24 h, working for 8 h and then resting for 16 h, or working from 7:00 in the evening to 7:00 in the morning	Indigestion Peptic ulcers	Shift-workers Questionnaire ^a Shift-workers Questionnaire ^a	209 209	22 26	207 207	7 21	6/8
Ahmed (2017) ⁽²¹⁾	Egypt	Cross-sectional	Nurses	M/F	34.7 (10.2)	Non-permanent day shifts; both fixed shifts and non-fixed shifts	Indigestion Constipation	Gastrointestinal Symptom Rating Scale ^b	112 112	34 18	51 51	8 7	6/8
Buja (2013) ⁽²²⁾	Italy	Cross-sectional	Nurses	M/F	38.04 (8.2)	Non-permanent day shifts; both with night shifts (alternating among morning, afternoon, and night shifts) and without night shifts (alternating between morning and afternoon shifts)	Indigestion Constipation	Job Content Questionnaire ^c Job Content Questionnaire ^c	394 394	264 210	46 46	25 18	6/8
Fido (2008) ⁽²³⁾	Kuwait	Cross-sectional	Oil factory workers	M	Day: 34.5 (7.4) Shift: 34.2 (7.3)	Alternating among morning, afternoon, and night shifts	Constipation	Self-created general health and work performance Questionnaires ^d	200	83	200	15	7/8
Ibrahim (2016) ⁽²⁴⁾	Saudi Arabia	Cross-sectional	Nurses	M/F	36.5 (9.2)	Working in alternating shifts after day shift	IBS	Rome III Questionnaire ^e IBS Severity Scoring System ^f	152	15	77	18	6/8
Jang (2017) ⁽²⁵⁾	Korea	Cross-sectional	Firefighters	M/F	44% were 40–49 yr old	Any form of work except for daytime work	IBS	Rome III Questionnaire ^e	1,039	97	178	14	6/8
Kim (2013) ⁽³⁾	Korea	Cross-sectional	Nurses	M/F	32.3 (7.8)	Any form of work except for daytime work	Indigestion IBS	Short-Form Bowel Disease Questionnaires ^g Rome III Questionnaire ^e	147 147	29 48	60 60	12 10	7/8
Koh (2014) ⁽⁶⁾	Korea	Cross-sectional	Nurses	M/F	GI problems: 28.12 (4.88) No GI problems: 29.48 (6.43)	Any form of work except for daytime shifts	Indigestion IBS	Rome III Questionnaire ^e	203 203	45 33	98 98	14 12	6/8
Liu (2014) ⁽²⁷⁾	China	Cross-sectional	Nurses	M/F	31.47 (7.59)	Working night shifts at least 5 nights a month	IBS	Rome III Questionnaire ^e	73	7	267	52	6/8
Mendes (2012) ⁽²⁸⁾	Brazil	Cross-sectional	Nurses	M/F	33.1	Working night shifts for 12 h each shift	Indigestion	Self-created Questionnaire ^h	52	26	84	34	6/8
Nejafimehr (2019) ⁽²⁹⁾	Iran	Cross-sectional	Auto factory workers	M	36.46 (4.90)	Alternating among morning, afternoon, and night shifts each week	Constipation	Rome IV Questionnaire ⁱ	3,170	320	379	24	6/8

Table 1. Continued

First author (yr)	Country	Design	Subjects	Gender	Age (Mean, SD)	Definition of shift work	GI problem	GI problem confirmation		Shift work		Day work		Quality score
								standard or instrument		Total	case	Total	case	
Nojkov (2010) ⁴⁾	USA	Cross-sectional	Nurses	M/F	Day: 45.6 (9.3) Night Shift: 41.5 (11.0) Rotating shift: 37.3 (10.8)	Fixed night shifts or alternating between day and night shifts	IBS	Rome III Questionnaire ^e	185	80	214	66	6/8	
Pietroiusti (2006) ³⁰⁾	Italy	Cross-sectional	Not specified	M/F	Day: 39.13 (9.88) Shift: 40.54 (10.20)	Night shifts or working night shifts at least 4 nights a month	Constipation Peptic ulcers	Endoscopic examination	101	29	247	23	6/8	
Saberi (2010) ³¹⁾	Iran	Cross-sectional	Nurses	M/F	Day: 35 Shift: 38.5	Any form of work except for fixed day shifts	Constipation	Gastrointestinal Symptom Questionnaire ^f	133	50	27	10	6/8	
Segawa (1987) ³²⁾	Japan	Cross-sectional	Finance/public sector employees	-	43% were 40–49 yr old	Night shifts	Peptic ulcers	Endoscopic examination	2,269	103	6,525	225	6/8	
Sugisawa (1998) ³³⁾	Japan	longitudinal	Not specified	M	46.7 (range30–59)	Including fixed night shifts; alternating between morning and afternoon shifts; alternating among morning, afternoon, and night shifts; alternating between day and night shifts; and irregular shifts	Peptic ulcers	Endoscopic examination	4,321	249	4,684	180	7/8	

GI problems: gastrointestinal problems; IBS: irritable bowel syndrome; M: male; F: female.

^aConfirmation of indigestion and peptic ulcers in Shift-workers Questionnaire: A total score of 2 or higher from subjective responses to question items regarding gastrointestinal problems in the previous weeks and measured on a four-point Likert scale (1–4 points).

^bConfirmation of constipation and indigestion in Gastrointestinal Symptom Rating Scale: Subjective responses to question items regarding gastrointestinal problems in the previous weeks and measured on a four-point Likert scale (1–4 points).

^cConfirmation of constipation and indigestion in Job Content Questionnaire: Response selected for whether constipation or indigestion was often experienced during the past 12 months in the physical demand scales.

^dConfirmation of constipation in self-created General Health and Work Performance Questionnaire: A “usually”, “sometimes”, or “none” response selected for whether constipation was experienced during the past three months.

^eConfirmation of IBS in Rome III Questionnaire: Repeated abdominal pain or discomfort associated with changes in stool frequency and/or form during the past six months and symptoms continuing for three days or more each month during the past three months.

^fConfirmation of IBS in IBS Severity Scoring System: Responses regarding abdominal pain, duration of abdominal pain in days, severity of abdominal distention, satisfaction with bowel habits, and interference with quality of life over the past 10 d; the total score of the system was 500 points, where 75–175 points indicated mild IBS, 175–300 points indicated moderate IBS, and 301 points or higher indicated severe IBS.

^gConfirmation of indigestion in Short-Form Bowel Disease Questionnaires: Discomfort or stomach pain after meals during the past three months but with endoscopic inspections revealing no structural diseases.

^hConfirmation of constipation in Gastrointestinal Symptom Questionnaire: Subjective responses to question items regarding constipation in the past four weeks and measured on a seven-point Likert scale (0–6 points).

ⁱConfirmation of indigestion in self-created questionnaire: A “no”, “seldom”, or “always” response selected for the indigestion question item in health symptoms of nurses who had worked for at least a month.

^jConfirmation of constipation in Rome IV Questionnaire: Experiencing straining, hard stools, sensation of incomplete evacuation, use of digital evacuation, and fewer than three spontaneous bowel movements per week at least a quarter of the time in at least three months during the past six months; not passing soft stools without laxatives and not meeting symptoms of IBS.

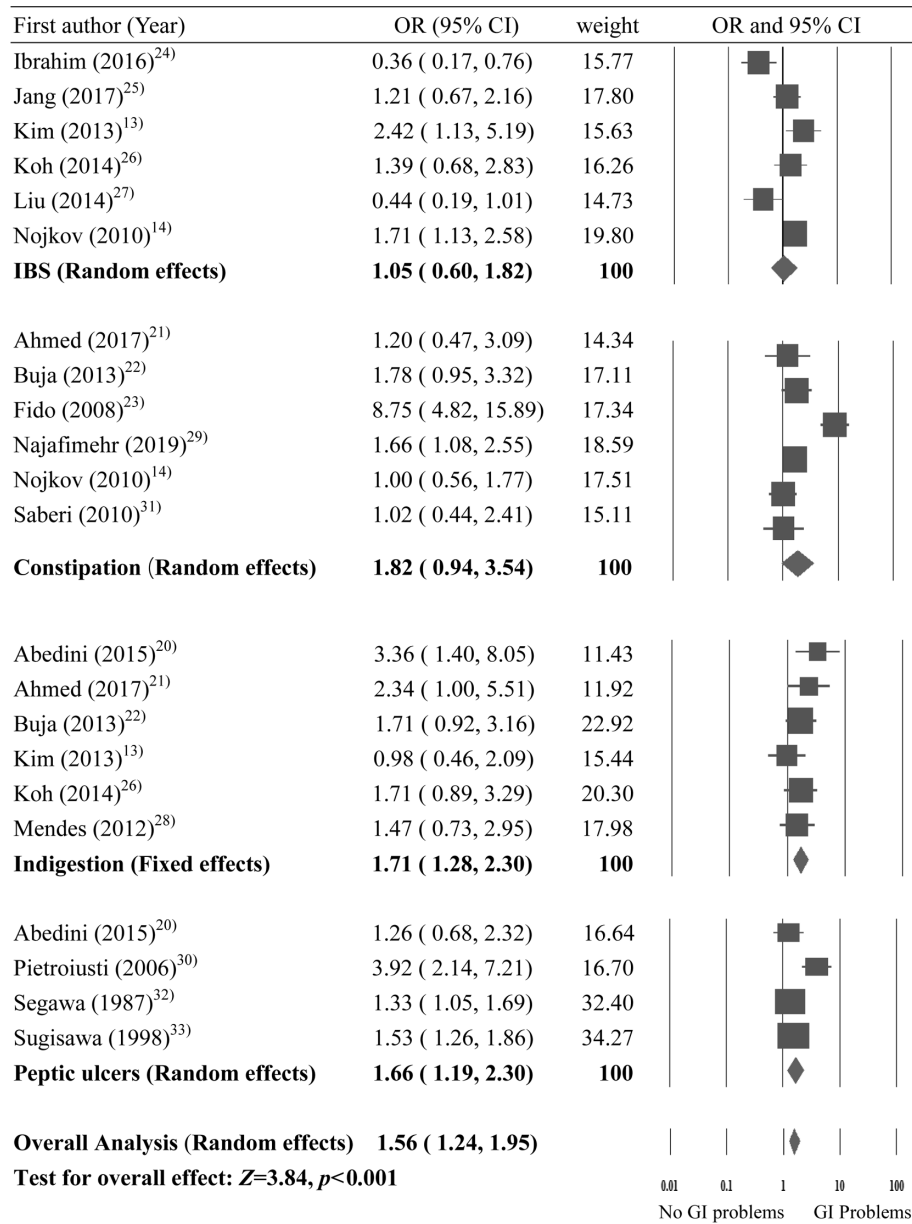


Fig. 2. Differences in overall and individual gastrointestinal problems between fixed day shift workers and rotating shift workers.

■Single Study Result; —confidence interval; ♦Combined Effect.

IBS: Irritable bowel syndrome.

any study did not exert a significant impact on the pooling OR (95% CI: 1.24–1.95) (Fig. 3). Our funnel plot (Fig. 4) and linear regression (Egger’s) analysis ($p=0.915$) showed no evidence of publication bias among the studies included in our meta-analysis.

Subgroup analysis: Irritable Bowel Syndrome (IBS)

All six studies involving IBS used the Rome III Questionnaire to confirm IBS diagnoses; however, these studies focused on rotating shift and fixed day shift workers in

different occupations, which may have led to the high heterogeneity ($I^2: 77.07\%, p=0.001$). Thus, the random effects model was used. The OR presented by the forest plot was 1.05 (95% CI: 0.60–1.82, $p=0.863$) (Fig. 2). The ORs derived by Ibrahim *et al.*²⁴⁾ and Liu *et al.*²⁷⁾ were 0.36 and 0.44, respectively, which were higher than those obtained by Jang *et al.*²⁵⁾, Kim *et al.*¹³⁾, Koh *et al.*²⁶⁾, and Nojkov *et al.*¹⁴⁾. The relative weight derived by Nojkov *et al.*¹⁴⁾ was 19.80%, which was greater than those obtained by Jang *et al.*²⁵⁾, Kim *et al.*¹³⁾, Koh *et al.*²⁶⁾, and Nojkov *et al.*¹⁴⁾. Furthermore, our

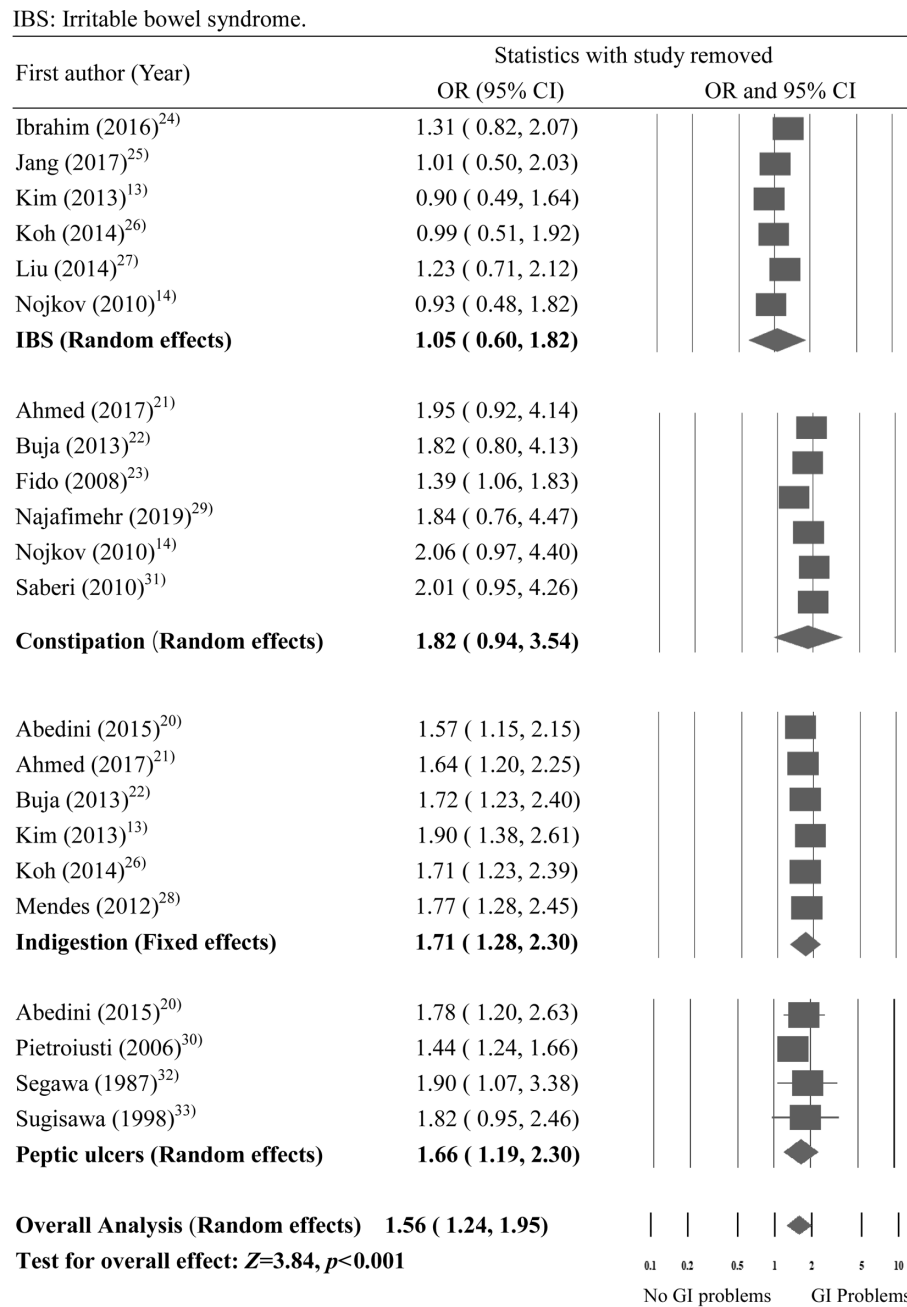


Fig. 3. Sensitivity analysis of differences in gastrointestinal problems between fixed day shift workers and rotating shift workers.

■ Single Study Result; — confidence interval; ◆ Combined Effect.

IBS: Irritable bowel syndrome.

sensitivity analysis revealed that the removal of any study did not significantly change the pooling OR (95% CI: 0.60–1.82) (Fig. 3).

Subgroup analysis: constipation

All six studies involving constipation focused on rotating shift and fixed day shift workers in different occupations, which may explain the high heterogeneity (I^2 :

84.99%, $p < 0.001$). Thus, the random effects model was used. The OR presented by the forest plot was 1.82 (95% CI: 0.94–3.54, $p = 0.078$) (Fig. 2). The OR derived by Fido *et al.*²³⁾ was 8.75, which was higher than those obtained by Ahmed and Oraby²¹⁾, Buja *et al.*²²⁾, Najafimehr *et al.*²⁹⁾, Nojkov *et al.*¹⁴⁾, and Saberi and Moravveji³¹⁾. The relative weight derived by Najafimehr *et al.*²⁹⁾ was 18.59%, which was greater than those obtained by Ahmed and Oraby²¹⁾,

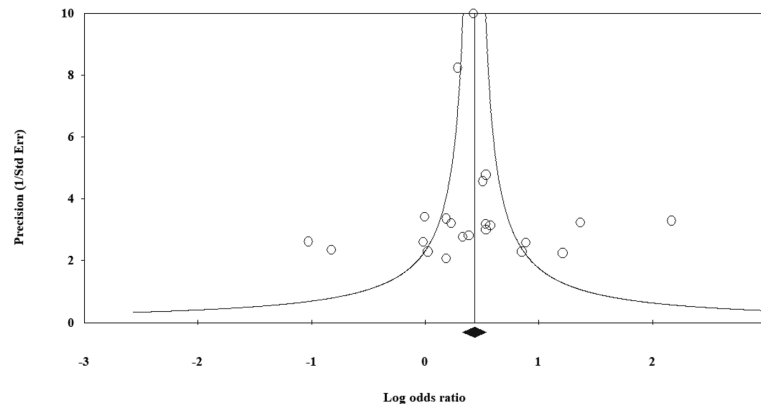


Fig. 4. Funnel Plot of differences in gastrointestinal problems between fixed day shift workers and rotating shift workers.

Buja *et al.*²²⁾, Fido *et al.*²³⁾, Nojkov *et al.*¹⁴⁾, and Saberi and Moravveji³¹⁾. Furthermore, our sensitivity analysis revealed that the removal of any study did not significantly change the pooling OR (95% CI: 0.94–3.54) (Fig. 3).

Subgroup analysis: indigestion

All six studies involving constipation focused on indigestion in nurses, and the heterogeneity test showed no significant differences (I^2 : 1.63%, $p=0.406$). Thus, the fixed effect model was used. The OR presented by the forest plot was 1.71 (95% CI: 1.28–2.30, $p<0.001$) (Fig. 2). The ORs derived by Abedini *et al.*²⁰⁾ and Ahmed and Oraby²¹⁾ were 3.36 and 2.34, respectively, which were higher than those obtained by Buja *et al.*²²⁾, Kim *et al.*¹³⁾, Koh *et al.*²⁶⁾, and Mendes and De Martino²⁸⁾. The relative weights derived by Buja *et al.*²²⁾ and Koh *et al.*²⁶⁾ were 22.92% and 20.30%, respectively, which were greater than those obtained by Abedini *et al.*²⁰⁾, Ahmed and Oraby²¹⁾, Kim *et al.*¹³⁾, and Mendes and De Martino²⁸⁾. Furthermore, our sensitivity analysis revealed that the removal of any study did not significantly change the pooling OR (95% CI: 1.28–2.30) (Fig. 3).

Subgroup analysis: peptic ulcers

All four studies involving peptic ulcers focused on rotating shift and fixed day shift workers in different occupations, which may explain the high heterogeneity (I^2 : 72.45%, $p=0.012$). Thus, the random effects model was used. The OR presented by the forest plot was 1.66 (95% CI: 1.19–2.30, $p=0.003$) (Fig. 2). The OR derived by Pietroiusti *et al.*³⁰⁾ was 3.92, which was higher than those obtained by Abedini *et al.*²⁰⁾, Segawa *et al.*³²⁾, and Sugi-sawa and Uehata³³⁾. The relative weight derived by Sugi-sawa and Uehata³³⁾ was 34.27%, which was greater than

those obtained by Abedini *et al.*²⁰⁾, Pietroiusti *et al.*³⁰⁾, and Segawa *et al.*³²⁾. Furthermore, our sensitivity analysis revealed that the removal of any study did not significantly change the pooling OR (95% CI: 1.19–2.30) (Fig. 3).

Discussion

The meta-analysis in this study indicated that rotating shift work may increase the risk of gastrointestinal problems. Regarding four gastrointestinal problems, namely, IBS, constipation, indigestion, and peptic ulcers, indigestion and peptic ulcers have the only significant impact on rotating shift workers.

Although a number of past studies found a higher incidence of IBS in rotating shift workers than in fixed day shift workers, the results of our meta-analysis revealed no significant differences between rotating shift workers and fixed day shift workers with regard to IBS^{13, 14, 25, 26)}. IBS is a chronic-recurrent functional inflammatory bowel disease, the main symptoms of which include abdominal pain, bloating or abdominal discomfort, and changes in bowel habits and/or movements. However, the above symptoms are often underestimated, ignored, or mistaken for chronic constipation or diarrhea caused by spoiled or contaminated food, all of which can lead to a delayed diagnosis³⁴⁾. This could explain why the rotating shift workers and fixed day shift workers in this meta-analysis displayed exhibited no significant differences in IBS symptoms. Furthermore, the symptoms of IBS are very similar to those of inflammatory bowel disease (IBD). Whereas the inflammation of the intestinal mucosa caused by IBD often results in intestinal mucosal ulcers and may even cause structural damage to the intestines, the intestinal mucosa of IBS patients usually show no substantial abnormalities. Therefore, a correct di-

agnosis is imperative in order for the administration of an appropriate treatment because there is a marked difference in treatment methods between these two diseases³⁵).

IBS is a chronic-recurrent functional inflammatory bowel disease. The main symptoms include abdominal pain, bloating or abdominal discomfort, and changes in bowel habits. Despite the obvious intestinal dysfunction in IBS patients, there are currently no instruments or inspections that can accurately diagnose IBS. In clinical practice, the diagnosis of IBS is therefore mostly based on subjective symptom descriptions. However, the above symptoms are often underestimated, ignored, or mistaken for chronic constipation or diarrhea caused by food poisoning. This may explain why the rotating shift workers and fixed day shift workers in this meta-analysis displayed no significant differences in IBS symptoms³⁴).

The incidence of IBS is highly associated with autonomic dysfunction and stress³⁶). Rotating shift work may cause workers to not only have poorer sleep quality but also poorer physical fitness compared to fixed day shift work, which results in physical and mental fatigue as well as interferes with the normal gastrointestinal motility, thereby increasing the chance of IBS³⁷). In addition, the cycles of behavioral changes induced by rotating shift work may also interrupt circadian rhythms and in particular cortisol secretion, leading to the hyperactivity of the hypothalamic-pituitary-adrenal axis and increased cortisol levels. This also implies that rotating shift workers are under long-term stress. Exposure to increased cortisol levels for prolonged periods of time has negative impacts on the body, which include changes in gastrointestinal functions³⁸). Irregular work hours of rotating shift work also affect eating behaviors, such as food choice and meal-times. Food options are more limited during night shift, which means an increased intake of convenient foods such as processed foods and foods that are high in sugar or fat, all of which can cause gastrointestinal problems³⁹). A number of studies included in our meta-analysis also speculated that the IBS in rotating shift workers is associated with their irregular eating patterns^{7, 12}).

Constipation is directly associated with living habits⁴⁰). The internal clocks of rotating shift workers may not match the required schedules of their external environment, which leads to constipation. Irregular routines, altered meal times, a lack of regular exercise, and diet changes that lean towards fast food, junk food, and sugary beverages can also alter bowel rhythms⁴¹). The studies included in our meta-analysis did not completely control for life or dietary habit-related factors, and the results of our

analysis indicate no significant differences between rotating shift workers and fixed day shift workers with regard to constipation or IBS. However, IBS involves chronic or recurrent changes in bowel habits³⁴) in which constipation is a common symptom⁴²). Both can easily be overlooked and not be readily dealt with, and this may explain why the rotating shift workers and fixed day shift workers in this meta-analysis displayed no significant differences in IBS and constipation. It is, however, still recommended that corporations and organizations help to promote the health of their employees. For example, holding symposiums, displaying posters, promoting information on websites, or handing out health manuals in the workplace are all ways to remind workers to take note of any long-term abdominal pain, diarrhea, or constipation as well as to not neglect any symptoms and to get regular health checkups in order to prevent delaying IBS diagnosis or treatment. Moreover, because we defined rotating shift work as any type of work besides fixed day shift work in our meta-analysis, we suggest that future studies further divide rotating shift work into fixed evening/night shifts and rotating evening/night shifts or even divide rotating shifts into clockwise (i.e., a rotation from evening shift to night shift) and counter-clockwise (i.e., a rotation from night shift to evening shift) rotating shifts for comparison, to demonstrate that IBS is more common among rotating shift workers than among fixed day shift workers.

However, our meta-analysis did reveal that the incidences of indigestion and peptic ulcers were significantly higher among rotating shift workers than among fixed day shift workers. We speculate that this is because gastric acid secretion has regular circadian rhythms. The consumption of food by rotating shift workers during the night coincides with slow gastrointestinal motility, delayed emptying, and increased gastric acid secretion, all of which can lead to poor digestion and peptic ulcers. This could explain the differences between the findings for poor digestion and peptic ulcers and those for constipation and IBS^{30, 43}).

The effects on indigestion may relate to an acid-base imbalance in the body as well as changes in digestive enzyme function, which increase the risk of digestive dysfunction, such as peptic ulcers and functional dyspepsia in rotating shift workers⁴⁴). Our meta-analysis revealed significant differences between rotating shift workers and fixed day shift workers in terms of indigestion and peptic ulcers. Fixed day shift workers eat their meals more regularly and at more regular times, and endogenous rhythms will prompt movements and secretions in the digestive tract to automatically exhibit anticipatory reactions in the

time period before meals in order to provide optimal conditions for the digestion, absorption, and emptying of food that is consumed⁷⁾. In contrast, rotating shift work often results in irregular meals and irregular mealtimes. Regular meals stimulate conditioned reflexes in the cerebral cortex, which induce digestive secretions that facilitate digestion^{16, 45)}.

Grant *et al.*⁴⁶⁾ investigated the influence of mealtimes during night shifts on work performance and subjective complaints. They found that a lack of eating at night was correlated with increased hunger and with a significant increase in stomach upsets during the night ($p=0.026$). Some studies have noted that the higher incidence of peptic ulcers in rotating shift workers may be due to circadian rhythm disorders delaying gastric emptying, increased coffee intake, or increased smoking⁴⁷⁾. The systematic review conducted by Knutsson and Bøggild also indicated that rotating shift work increases the occurrence of peptic ulcers, but further meta-analysis was not conducted⁴⁸⁾.

Conclusion

Our meta-analysis identified a significantly higher incidence of indigestion and peptic ulcers among rotating shift workers than among fixed day shift workers. Although maintaining regular mealtimes is more difficult for rotating shift workers, it is still suggested that regular eating habits be established as much as possible to reduce the incidence of indigestion or peptic ulcers.

Limitations and future directions

A high degree of heterogeneity existed among the studies included in this meta-analysis. The causes of the heterogeneity may be attributed to the age, years of rotating shift work experience, the rotating shift method, and the number of days off. Due to this heterogeneity, we conducted a sensitivity analysis on the combined analysis results, removing one study at a time and examining its impact on the meta-analysis results. We also alternated between the fixed effect model and the random effects model. The directions of the ORs in the subgroup analyses did not change, thereby demonstrating the stability of this meta-analysis.

Studies have indicated that working rotating shifts may increase the risk of indigestion and peptic ulcer; however, these problems are also associated with lifestyle, such as BMI and physical activity. The data compiled in this study indicate that most of the studies examined did not rigorously consider nor control for these interference factors.

Hence, more research is required to answer the question of whether rotating shift work is a direct hazard to gastrointestinal health.

Author Contributions

Wen-Pei Chang and Yu-Xuan Peng performed the literature search and helped write the manuscript; Wen-Pei Chang conceived and revised the article; and Wen-Pei Chang and Yu-Xuan Peng approved the final version of the manuscript.

Financial Support

None.

Conflicts of Interest

None.

References

- 1) Åkerstedt T (1990) Psychological and psychophysiological effects of shift work. *Scand J Work Environ Health* **16** Suppl 1, 67–73.
- 2) Hedges JN, Sekscenski ES (1979) Workers on late shifts in a changing economy. *Mon Labor Rev* **102**, 14–22.
- 3) James SM, Honn KA, Gaddameedhi S, Van Dongen HPA (2017) Shift work: disrupted circadian rhythms and sleep-implications for health and well-being. *Curr Sleep Med Rep* **3**, 104–12.
- 4) Haus EL, Smolensky MH (2013) Shift work and cancer risk: potential mechanistic roles of circadian disruption, light at night, and sleep deprivation. *Sleep Med Rev* **17**, 273–84.
- 5) Voigt RM, Forsyth CB, Keshavarzian A (2019) Circadian rhythms: a regulator of gastrointestinal health and dysfunction. *Expert Rev Gastroenterol Hepatol* **13**, 411–24.
- 6) Khan S, Duan P, Yao L, Hou H (2018) Shiftwork-mediated disruptions of circadian rhythms and sleep homeostasis cause serious health problems. *Int J Genomics* **2018**, 8576890.
- 7) Gupta CC, Centofanti S, Dorrian J, Coates AM, Stepien JM, Kennaway D, Wittert G, Heilbronn L, Catcheside P, Noakes M, Coro D, Chandrakumar D, Banks S (2019) Subjective hunger, gastric upset, and sleepiness in response to altered meal timing during simulated shiftwork. *Nutrients* **11**, 1352.
- 8) Atkinson G, Fullick S, Grindley C, Maclaren D (2008) Exercise, energy balance and the shift worker. *Sports Med* **38**, 671–85.
- 9) Souza RV, Sarmento RA, de Almeida JC, Canuto R (2019)

- The effect of shift work on eating habits: a systematic review. *Scand J Work Environ Health* **45**, 7–21.
- 10) Khanijow V, Prakash P, Emsellem HA, Borum ML, Doman DB (2015) Sleep dysfunction and gastrointestinal diseases. *Gastroenterol Hepatol (N Y)* **11**, 817–25.
 - 11) Vaughn B, Rotolo S, Roth H (2014) Circadian rhythm and sleep influences on digestive physiology and disorders. *ChronoPhysiology Ther* **2014**, 67–7.
 - 12) Hoogerwerf WA (2010) Role of clock genes in gastrointestinal motility. *Am J Physiol Gastrointest Liver Physiol* **299**, G549–55.
 - 13) Kim HI, Jung SA, Choi JY, Kim SE, Jung HK, Shim KN, Yoo K (2013) Impact of shiftwork on irritable bowel syndrome and functional dyspepsia. *J Korean Med Sci* **28**, 431–7.
 - 14) Nojkov B, Rubenstein JH, Chey WD, Hoogerwerf WA (2010) The impact of rotating shift work on the prevalence of irritable bowel syndrome in nurses. *Am J Gastroenterol* **105**, 842–7.
 - 15) Ferguson JM, Costello S, Neophytou AM, Balmes JR, Bradshaw PT, Cullen MR, Eisen EA (2019) Night and rotational work exposure within the last 12 months and risk of incident hypertension. *Scand J Work Environ Health* **45**, 256–66.
 - 16) Perrin SL, Dorrian J, Gupta C, Centofanti S, Coates A, Marx L, Beyne K, Banks S (2019) Timing of Australian flight attendant food and beverage while crewing: a preliminary investigation. *Ind Health* **57**, 547–53.
 - 17) Omid L, Zare S, Rad RM, Meshkani M, Kalantary S (2017) Effects of shift work on health and satisfaction of workers in the mining industry. *Int J Occup Hyg* **9**, 21–5.
 - 18) Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* **151**, 264–9, W64.
 - 19) Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Qureshi R, Mattis P, Lisy K, Mu PF (2017) Chapter 7: Systematic reviews of etiology and risk. In: Aromataris E, Munn Z (Eds.), *Joanna Briggs Institute Reviewer's Manual*. The Joanna Briggs Institute, 2017. <https://reviewersmanual.joannabriggs.org/>.
 - 20) Abedini R, Soltanzadeh A, Faghih MA, Mohammadi H, Kamalinia M, Mohraz MH, Arassi M, Veysseh PP, Aghaei H, Hosseini SY (2015) Health consequences of shift-work: the case of Iranian hospital security personnel. *Work* **50**, 305–11.
 - 21) Ahmed AS, Oraby EE (2017) Gastrointestinal disorders among shift work nurses at a governmental hospital, Zagazig city. *Egypt J Occup Med* **41**, 475–87.
 - 22) Buja A, Zampieron A, Mastrangelo G, Petean M, Vinelli A, Cerne D, Baldo V (2013) Strain and health implications of nurses' shift work. *Int J Occup Med Environ Health* **26**, 511–21.
 - 23) Fido A, Ghali A (2008) Detrimental effects of variable work shifts on quality of sleep, general health and work performance. *Med Princ Pract* **17**, 453–7.
 - 24) Ibrahim NK, Al-Bloushy RI, Sait SH, Al-Azhary HW, Al Bar NH, Mirdad GA (2016) Irritable bowel syndrome among nurses working in King Abdulaziz University Hospital, Jeddah, Saudi Arabia. *Libyan J Med* **11**, 30866.
 - 25) Jang SH, Ryu HS, Choi SC, Lee SY (2017) Psychological factors influence the irritable bowel syndrome and their effect on quality of life among firefighters in South Korea. *Psychiatry Investig* **14**, 434–40.
 - 26) Koh SJ, Kim M, Oh DY, Kim BG, Lee KL, Kim JW (2014) Psychosocial stress in nurses with shift work schedule is associated with functional gastrointestinal disorders. *J Neurogastroenterol Motil* **20**, 516–22.
 - 27) Liu L, Xiao QF, Zhang YL, Yao SK (2014) A cross-sectional study of irritable bowel syndrome in nurses in China: prevalence and associated psychological and lifestyle factors. *J Zhejiang Univ Sci B* **15**, 590–7.
 - 28) Mendes SS, Martino MM (2012) [Shift work: overall health state related to sleep in nursing workers]. *Rev Esc Enferm USP* **46**, 1471–6 (in Portuguese).
 - 29) Najafimehr H, Yadegari H, Taherinejad H, Manhoie K, Rasooli SR, Moradi A, Akbariju MJ, Mohseni H, Ghadimi S, Mohaghegh Shalmani H (2019) The effect of working in an auto factory on functional constipation and bowel habits. *Gastroenterol Hepatol Bed Bench* **12** Suppl1, S101–7.
 - 30) Pietroiusti A, Forlini A, Magrini A, Galante A, Coppeta L, Gemma G, Romeo E, Bergamaschi A (2006) Shift work increases the frequency of duodenal ulcer in *H pylori* infected workers. *Occup Environ Med* **63**, 773–5.
 - 31) Saberi HR, Moravveji AR (2010) Gastrointestinal complaints in shift-working and day-working nurses in Iran. *J Circadian Rhythms* **8**, 9.
 - 32) Segawa K, Nakazawa S, Tsukamoto Y, Kurita Y, Goto H, Fukui A, Takano K (1987) Peptic ulcer is prevalent among shift workers. *Dig Dis Sci* **32**, 449–53.
 - 33) Sugisawa A, Uehata T (1998) Onset of peptic ulcer and its relation to work-related factors and life events: a prospective study. *J Occup Health* **40**, 22–31.
 - 34) Card TR, Siffledeen J, Fleming KM (2014) Are IBD patients more likely to have a prior diagnosis of irritable bowel syndrome? Report of a case-control study in the General Practice Research Database. *United European Gastroenterol J* **2**, 505–12.
 - 35) Spiller R, Major G (2016) IBS and IBD—separate entities or on a spectrum? *Nat Rev Gastroenterol Hepatol* **13**, 613–21.
 - 36) Qin HY, Cheng CW, Tang XD, Bian ZX (2014) Impact of psychological stress on irritable bowel syndrome. *World J Gastroenterol* **20**, 14126–31.
 - 37) Wang XS, Armstrong ME, Cairns BJ, Key TJ, Travis RC (2011) Shift work and chronic disease: the epidemiological evidence. *Occup Med (Lond)* **61**, 78–89.
 - 38) Manenschijn L, van Kruysbergen RG, de Jong FH, Koper JW, van Rossum EF (2011) Shift work at young age is associated with elevated long-term cortisol levels and body

- mass index. *J Clin Endocrinol Metab* **96**, E1862–5.
- 39) Waterhouse J, Buckley P, Edwards B, Reilly T (2003) Measurement of, and some reasons for, differences in eating habits between night and day workers. *Chronobiol Int* **20**, 1075–92.
- 40) Dukas L, Willett WC, Giovannucci EL (2003) Association between physical activity, fiber intake, and other lifestyle variables and constipation in a study of women. *Am J Gastroenterol* **98**, 1790–6.
- 41) Ebrahim A, Fredericks S (2017) Working irregular shift patterns is associated with functional constipation among healthy trainee nurses. *Gastroenterol Insights* **8**, 32.
- 42) Wright PS, Thomas SL (1995) Constipation and diarrhea: the neglected symptoms. *Semin Oncol Nurs* **11**, 289–97.
- 43) Chung TH, Lee J, Kim MC (2016) Impact of night-shift work on the prevalence of erosive esophagitis in shipyard male workers. *Int Arch Occup Environ Health* **89**, 961–6.
- 44) Caruso CC, Lusk SL, Gillespie BW (2004) Relationship of work schedules to gastrointestinal diagnoses, symptoms, and medication use in auto factory workers. *Am J Ind Med* **46**, 586–98.
- 45) Jung HS, Lee B (2016) Factors associated with the occurrence of functional dyspepsia and insomnia in shift-working nurses. *Work* **54**, 93–101.
- 46) Grant CL, Dorrian J, Coates AM, Pajcin M, Kennaway DJ, Wittert GA, Heilbronn LK, Vedova CD, Gupta CC, Banks S (2017) The impact of meal timing on performance, sleepiness, gastric upset, and hunger during simulated night shift. *Ind Health* **55**, 423–36.
- 47) Lowden A, Moreno C, Holmbäck U, Lennernäs M, Tucker P (2010) Eating and shift work—effects on habits, metabolism and performance. *Scand J Work Environ Health* **36**, 150–62.
- 48) Knutsson A, Bøggild H (2010) Gastrointestinal disorders among shift workers. *Scand J Work Environ Health* **36**, 85–95.