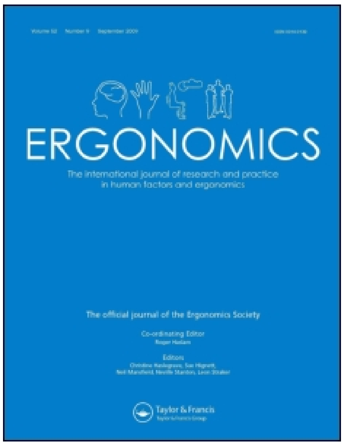

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Effects of the new fast forward rotating five-shift roster at a Dutch steel company

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This article reports a field study of a shift roster change in a large steel producer. The changes in the roster are threefold: (1) from backward rotating to forward rotating; (2) from rather slow (three) to fast rotating (two consecutive shifts); (3) the number of days off after the night shifts was changed from two to three. Company data cover 1 year before and 1 year after the implementation of the new roster and involve all employees in the five-shift system (4600 workers) and all daytime workers (1450 workers) in technical and maintenance jobs as a control group. The study reports a decrease in absence figures (particularly on midterm sickness absence) of in total 0.6%. Furthermore, improvements in health indicators are presented, such as fatigue, musculoskeletal complaints, relationship work and health and workload in the year after implementation of the new roster. These positive effects are stronger for older workers (50 + years old). The results were significantly more positive for the shift workers compared with the control group.

Statement of Relevance: This article reports an evaluation study of the largest continuous roster change in the Netherlands for decades: 4600 employees at Corus changed from a slowly backward rotating schedule to a fast forward rotating schedule. The effects are mainly positive (0.6% less absence in the first year; less fatigue). A positive association with age was also found: older workers benefit more.

Keywords: absenteeism; effect evaluation; fatigue; health; shift roster design

1. Introduction

In this article the new five-shift roster at Corus steel in The Netherlands is evaluated. Corus is a British/Dutch steel company that merged in 2000. Since 2007 the company has been part of the Indian Tata group. Corus is Europe's second largest steel producer and Corus in The Netherlands employs about 10,000 people. The company manufactures, processes and distributes steel products to worldwide customers. It produces steel and aluminium by means of washing and extracting the metal from the raw ore and rolling it into large plates to be applied as a semi-manufactured product by other metal processing industries, such as the automotive and railway industries and shipyards.

Corus Netherlands (plant IJmuiden; known as 'Corus' herein) used to have a backward rotating NNNXXEEEXXMMM roster (three night shifts, 2 d off, three evening shifts, 2 d off, three morning shifts, 2 d off). Because of health risks in this roster, the Medical Department proposed a new forward rotating roster. Several forward rotating shift rosters were discussed in a large project group consisting of employees, management, medical staff, unions and experts. Finally, four different forward rotating schedules were offered to the whole population of shift workers. They elected one schedule: the MMEEXNNX roster (two morning shifts, two evening shifts, 1 d off, two night shifts, 3 d off). Both the starting times of the shifts and the number of working hours (33.6 h per week) remained the same. The new roster was implemented as an experiment and was introduced on 1 September 2006. The first evaluation 6 months after implementation of the new roster revealed positive effects. These results were fed back to the organisation and an opinion poll among all involved shift workers favoured the new system that is now applied permanently in the organisation.

1.1. *Existing research concerning the risks related to the old and new rosters*

Employee risks of shift work systems are described systematically by Knauth (1998) and Knauth and Hornberger (2003). These authors apply the results of many years of working time research and translate it to practical guidelines for constructing rosters. Other researchers also reviewed the literature and came to similar sets of recommendations (Jansen and Kroon 1995, Colquhoun *et al.* 1996, Rosa and Colligan 1997, Folkard and Tucker 2003, Spencer *et al.* 2006). In fact, there is not only a considerable amount of consensus

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among researchers on the way rosters should be made, but also on the need for more precise additional research (Folkard and Tucker 2003, Spencer *et al.* 2006). Four recommendations related to the Corus roster change are elaborated here.

1.2. Maximum number of consecutive night shifts

Lowering the number of consecutive night shifts will cause fewer disturbances of the circadian physiological functions and no significant accumulation of sleep deficits (Knauth and Hornberger 2003). These authors cite evidence that the worst solution is a weekly backward rotating roster with first 1 week of five night shifts, followed by 1 week of five evening shifts and then 1 week of five morning shifts (see also Janssen and Nachreiner 2001, van Amelsvoort *et al.* 2004). Knauth and Hornberger (2003) maximise to three the number of shifts in succession, for all types of shifts, including the night shift (see also Fletcher and Dawson 2001). They consider a fast forward rotating roster with only two shifts of the same kind in succession (two morning shifts, two evening shifts, two night shifts) as the best solution for rotating shift systems. Other recommendations for a roster schedule are at least 2 d off after the last night shift, no days off between night shifts and avoiding single working days between days off.

1.3. Direction of rotation

Forward rotation is generally related to more positive health effects (Knauth and Hornberger 2003), but employees often prefer backward rotation, because of the extra day off (Knauth 2001). However the positive effects of forward rotation are also questioned (Fletcher and Dawson 2001, Åkerstedt 2003, Spencer *et al.* 2006).

1.4. Positioning of the working time

Starting the morning shift late, for instance, at 07.00 hours instead of 06.00 hours reduces sleeping problems, because the natural sleep rhythm is less disturbed. However, ending the evening shift at 10.00 hours would be better then ending at 11.00 hours (Knauth and Hornberger 2003). Free weekends included in the roster, with at least two consecutive days off at the weekend, are also recommended by Knauth and Hornberger (2003).

1.5. Duration and distribution of working time

Duration and distribution of working time concerns the number of hours between shifts and the number of days off between shift sequences. The minimum number of hours between two shifts is recommended as at least 11, the maximum number of consecutive working days should be five to seven and extended shifts ($>$ 8 h) should be avoided (Knauth and Hornberger 2003).

The Corus roster can be evaluated against these recommendations, suggesting the extent to which the roster is improved according to the current state of knowledge. This is shown in Table 1. The conclusion is that the new roster reduces the shift work burden since the change, and also that the old roster is not a really bad one. The major differences are the reduction of the maximum number of consecutive night shifts from three to two, the increase of the number of days off after the last night shift from two to three and the change in rotation direction from backward to forward. However, the speed of rotation (two instead of three consecutive shifts) is not seen as a big change; nevertheless, it is a change in the recommended

Table 1. Comparison of some aspects of the new and old rosters.

Aspects	Old roster NNNxx EEExxMMMxx	New roster MMEExNNxxx	Change?
Night shifts			
Maximum number of consecutive night shifts	3	2	Recommended
At least 2 d off after last night shift	2	3	Recommended
Avoid single shifts between days off	no	no	No change
Rotation			
Direction	backward	forward	Recommended
Speed (number of similar shifts in a row)	3	2	Recommended
Position of working time			
Starting time morning shift	06.00 hours	06.00 hours	No change
Full weekends off	8	8	No change
Half weekends off	20	20	No change
Duration/distribution of working time			
Hours between shifts > 11	16	16	No change
Maximum number of consecutive working days <5	3	4	Not worsened
Avoid extended shifts (>8 h)	no	no	No change

direction. Also, the increase in the number of consecutive working days from three to four remains under the recommendation of < 5, according to Knauth and Hornberger (2003).

1.6. *Negative effects of shift work*

There is extensive literature on the negative effects of shift work and in particular night work. Only three of them (occupational accidents, health-related problems and sickness absence) are used to evaluate the Corus case. Occupational accidents increase with successive night shifts, with increasing hours on duty and between successive night breaks (Folkard and Tucker 2003). Negative effects on health are often related to fatigue and sleeping problems (Åkerstedt 1998, Fletcher and Dawson 2001, Åkerstedt 2003). Negative health effects should also be visible in sickness absence patterns, but due to healthy worker effects, these patterns are often not observed, even in extensive longitudinal research (Klein Hesselink *et al.* 1995).

1.7. *Age*

Age is an additional factor that is strongly related to and increases the burden of night and shift work. Åkerstedt (1998) and Åkerstedt *et al.* (2002) indicate age as one of the significant and independent predictors of disturbed sleep, together with female gender, present illness, hectic work, physically strenuous work and shift work. This article focuses on age. Older shift workers may have shorter and more disturbed periods of day sleep between the consecutive night shifts compared to the younger shift workers. Although there is a need for more research on the relationship between age and shift work, it appears that older workers are prone to more safety problems during night shifts (Folkard 2008) and that cognitive performance decreases for ageing shift workers (Rouch *et al.* 2005). Therefore, the number of consecutive night shifts is an important characteristic of shift work schedules, especially for older workers, in order to reduce the risks of fatigue, less alertness, health problems, injury and accidents.

1.8. *Hypotheses*

Evaluation of the Corus rosters from the current state of knowledge favours the new system, which complies with most recommendations. With the new roster, there are improvements that should become visible in the new health and safety situation of employees. For that reason, in this article, two hypotheses are formulated and tested:

(1) The implementation of the new five-shift roster leads to less occupational accidents, less sickness absence and better health conditions.
(2) The most positive effects of the implementation of the new five-shift roster will be found in the eldest age groups.

2. Method

A 'case–control group pre- and post test design' is used to evaluate the roster change. There is no question of randomisation, because the whole population of shift workers working with the five-shift system and day workers in production locations is investigated. The five-shift roster group consists of 45% of all 10,400 Corus employees in the years of the study. Another 14% of the employees work in technical and maintenance daytime jobs, 38% are office workers and 3% are employed in two- and three-shift systems. Both last groups are not included as a control group, because the situation of these groups differs too much from the situation of the case group. The privileged and sheltered working situation of the office workers far away from the furnaces does not permit comparison with the tough daily working conditions of the five-shift workers and the day workers in technical and maintenance jobs.

Data were used from three employee databases present at the Corus site: occupational accidents; health data; sickness absence.

2.1. *Occupational accidents*

The occupational accident database contains information of all people who have had an accident at the Corus site. This also includes the accidents of subcontractor personnel and visitors. Only the accidents of Corus employees working in the five-shift group and the day worker group are analysed. The term 'accident' means all accidents treated by the First Aid Department. Data are analysed cross-sectionally because of the too rare occasions of repeated accidents at the individual level in a period of 2 years.

2.2. *Health data*

Every 3 years the Medical Department of Corus offers a health check to all employees by means of health interviews. Data of these interviews are processed by an independent external service bureau that also produces the company reports. All data are stored in a database containing the data of many other Dutch organisations. There is no routine of organisations asking to return the system file with the raw data. Data of the 3 years preceding the experiment could only be retrieved partially, therefore, and data are only analysed cross-sectionally because of the omission of identification numbers.

Table 2 gives the number of respondents per experimental group in the year before and the year after implementation of the new roster and the composition of these groups by means of four variables. The mean age of both groups of employees (45–47 years) is quite high for a Dutch organisation: 40 years in the whole Dutch population and 42 years in industry (van den Bossche *et al*. 2007). The groups consist primarily of men working full time. Many employees have supervisory tasks (6.5% in The Netherlands, 8.5% in industry; van den Bossche *et al*. 2007). There are two significant differences in time, in the year after the intervention there are more women and the mean age of the groups is lower than in the year before intervention. The employees in the five-shift group are significantly younger. There are no significant interaction effects.

Five health variables are used as dependent variables in the study. The variables are constructed from a list of questions that were completed during the health interview (van Veldhoven *et al*. 2002). All questions ask for a particular health problem that can be answered by yes (= 1) or no (= 0). Five new scales were constructed by means of principal component analysis and reliability analysis.

- Fatigue is constructed as the total number of seven health complaints that may be related to tiredness and loss of sleep because of being involved in night and shift work: 'are you often tired?'; 'are you often sleepy or drowsy?'; 'do you sleep badly?'; 'do you often have the feeling that you are facing too many obstacles?'; 'do you often have nervous complaints?'; 'do you often have concentration problems?'; 'do you often have trouble in remembering things?'. The Cronbach alpha of this scale is 0.76.
- Musculoskeletal complaints is a factor that is computed as the total number of seven health complaints: 'do you often have pain or stiffness in the neck, shoulders or arms?'; 'do you often have pain or stiffness in the back or legs?'; 'do you often have pain or stiffness in the hips, legs or feet?'; 'do you often have pain or stiffness in the neck?'; 'do you often have pain or stiffness in the lower back?'; 'do you have muscle or joint complaints?'; 'do you have long-term back or neck complaints?'. The Cronbach alpha of this scale is 0.80.
- Flu complaints may indicate loss of physical condition due to working at night or in shift work systems. The five items of the scale are: 'do you often have a sore throat?'; 'do you often have problems with your nose (clogged, sniffles, sneezing)?'; 'do you often have bronchial complaints (coughing, etc.)?'; 'do you often have breathing problems when involved in physical exercise?'; 'do you have bronchitis?'. The Cronbach alpha of this scale is 0.55.
- The health and work relationship is a scale constructed from a positive answer to three questions: complaints are possibly related to work; complaints are produced or worsened by the work; complaints hinder work. The Cronbach alpha is 0.82.
- Workload implies a positive answer to five health questions: work is mentally exhaustive; work implies much and long-term concentration; work often implies time pressure; work mounts up too often; work often implies tasks not belonging to my job. The Cronbach alpha is 0.56.

2.3. *Sickness absence*

Sickness absence data are administered by the organisation and are analysed longitudinally. Six measures are computed from the date of beginning and the date of full recovery of all absence cases in the year

Table 2. Composition of the five-shift group and the group of day workers who participated in the health interviews in the year before and the year after implementation of the new roster.

Variable	Year before intervention		Year after intervention		Tests of significance (*p* value)		
	Five-shift group	Day workers	Five-shift group	Day workers	Time	Group	Interaction
Mean age	45.0	46.8	44.7	45.4	0.024	0.000	0.164
Men	99.0%	99.1%	96.9%	98.0%	0.002	0.218	0.324
Part-timers	1.5%	1.1%	1.6%	0.5%	0.637	0.144	0.427
Supervisor	24.0%	24.3%	22.5%	22.3%	0.322	0.979	0.896
Number of subjects	1679	1184	549	549	–	–	–

before and the year after implementation of the new roster. Information at the absence case level is aggregated to the level of individual employees, because employees can have more absence cases per period. Figures are computed for the following six measures for the exact year preceding and the exact year following the implementation date of the new roster (1 September 2006).

- Spell frequency is the mean number of spells per individual per period.
- Absence duration is the mean number of calendar days of absence between the first absence day and the first day of 100% work resumption. Absence duration is only calculated for completed absence cases per individual in a period. Employees with no absence cases are excluded.
- Absence percentage is the total number of calendar days of absence in a period, divided by the total number of calendar days of that period and multiplied by 100.
- Absence percentages are also computed for the cases of 1–7 d, 8–28 d and 29 d or longer.

Raw sickness absence data are corrected for personnel turnover and 'return to work' activities of the Medical Department, in order to guarantee full participation of all employees in the groups during both years of analysis. Three corrections are carried out before analysis.

- Employees entering the five shifts or the day worker group in the year before or in the year after implementation of the new roster are excluded from the analyses.
- Employees leaving the five shifts or the day worker group in the year before or in the year after implementation of the new roster are excluded from the analyses.
- Employees temporarily reintegrated after a period of sickness absence into day service (five-shift group) and/or in an office job (both groups) in the year before and/or after implementation of the new roster are excluded from the analyses.

These corrections may have a strong selection effect on the absence data. This effect cannot be avoided, however, because the deselected group is not exposed fully to the experimental conditions during the entire period of the experiment. Table 3 gives the total numbers, percentages and absence percentages of employees entering and leaving the job and the employees temporarily reintegrated into less strenuous work in the years before and/or after implementation of the new roster.

Personnel turnover is not high at Corus. Only 3.5% of the employees left the company in a period of 2 years. In Dutch companies, personnel turnover in 2004 was about 10.8% and 10.3% in industry (Bekker *et al.* 2007). Also, the inflow figures are not high. In Dutch companies this was 8.7% in 2004 and 4.6% in industry (Bekker *et al.* 2007). More day workers entered service. Shift workers are reintegrated somewhat more often by means of offering them temporary less strenuous work in day work and/or in

Table 3. Total numbers, percentages and absence percentages (uncorrected and corrected for partly return to work) of employees entering and leaving the job and employees subjected to temporarily less strenuous work in the years before and after the implementation of the new roster.

Measure/roster	Entering service	Leaving service	Temporary less strenuous work	Group excluded from analysis	Group analysed	Total group
Number of employees						
Five-shift workers	120	171	565	840	3784	4624
Day workers	129	43	137	303	1145	1448
Both groups	249	214	702	1143	4929	6072
Percentage of employees						
Five-shift workers	2.6%	3.7%	12.2%	18.2%	81.8%	100.0%
Day workers	8.9%	3.0%	9.5%	20.9%	79.1%	100.0%
Both groups	4.1%	3.5%	11.6%	18.8%	81.2%	100.0%
Absence percentage (uncorrected)						
Five-shift workers	0.8%	10.5%	21.9%	16.8%	4.8%	7.0%
Day workers	1.2%	11.9%	23.1%	12.6%	6.0%	7.4%
Both groups	1.0%	10.8%	22.2%	15.7%	5.1%	7.1%
Absence percentage (corrected)						
Five-shift workers	0.7%	9.8%	12.3%	10.3%	4.3%	5.4%
Day workers	1.2%	10.2%	11.7%	7.2%	5.0%	5.5%
Both groups	1.0%	9.9%	12.2%	9.4%	4.5%	5.4%

office jobs. In total, 18.8% of the employees are excluded from the sickness absence analyses.

The selection effects of the three processes are remarkable. Personnel entering the company generally have a very low absence percentage (1.0), but personnel leaving the company on average have a high absence percentage (10.8). The highest absence percentage, however, is found in the group temporarily placed in less strenuous working situations (22.2).

2.5. *Partial return to work after illness*

All analyses are recalculated for the percentage of those who partly returned to work, when this return is in the same roster condition. This is a reintegration activity of the Medical Department. For instance, when an employee returns to work after a period of 2 weeks of 100% absence for another 2 week period of half day work, the total number of corrected days is recalculated to 21 instead of 28. The last three rows of Table 3 give the absence percentages corrected for the percentage of partly return to work. There is hardly a correction effect visible on the absence percentages of the employees entering the service, a bigger effect on the absence percentages of personnel leaving the service and a strong effect on the absence percentages of the employees temporarily replaced in less strenuous work. Also, in the group of workers participating in the experiment a correction effect is visible. The absence percentage is 5.1 uncorrected and 4.5 corrected. The mean absence percentage (uncorrected) in the Dutch population is 4.5 in 2006 and 5.1 in industry (van den Bossche *et al.* 2007). Because of these differences, both types of percentages are presented in the tables.

2.6. *Age*

The health and sickness absence data in the datasets also contain exact information on the age of the employees. In order to test for the influence of age, the group of employees is divided into two subgroups from 15 to 50 years and from 50 to 65 years of age.

2.7. *Statistical methods*

All indicators are computed for the year before and the year after implementation of the roster. A statistical comparison of the accident and health data is made by two-way (time × group) and three-way (adding age) ANOVA for independent samples. Age as a variable is not present in the accident database. Sickness absence data are available for all employees in the entire pre- and post test periods. Tests of significance are done by two-way (time × group) and three-way (adding age) ANOVA for paired samples.

For all statistical tests *p*-values of 0.05 or less are regarded as significant. Cohen's d is used for evaluating the size of the differences (Cohen 1977). It is computed by using the partial eta squared in the SPSS ANOVA output by means of the formula $d = (2r)/(\text{square root}(1-r^2))$ (Rosenthal and Rosnow 1991). The classification of Cohen is used to evaluate the size of the differences (a d-value of 0.20 indicates a small difference, a d-value of 0.50 a medium difference and a d-value of 0.80 a large difference).

3. Results

3.1. *Occupational accidents*

Occupational accidents (first four rows of Table 4) increased in the five-shift group from 4.1 per 100 employees in the year before the implementation of the new roster to 4.5 accidents per 100 employees in the year after. In the day worker group, there was an increase from 3.0 to 4.2 accidents per 100 employees in the same period. This is an increase of 9.3% in the five-shift worker group and an increase of 41.9% in the day worker group. Only the main effect of roster is significant, there are more accidents in the five-shift group. The Cohen's d values are very low, however, indicating that the size of the differences within and between the groups is only very small.

3.2. *Health data*

The last column of Table 4 indicates that three of the five health measures differ significantly between the groups in time. All significant differences are in favour of the five-shift group. Fatigue increases in the day worker group, but does not change in the five-shift group. Musculoskeletal complaints and work stress decrease in the five-shift group but increase in the day worker group. No interaction effects of flu complaints and the perceived relationship between work and health were found. Again, the size of the differences within and between the groups is very small to small, according to the Cohen classification.

The relationship with age is given in Table 5. Only the test results related to age effects are given. Four of the five variables have a significant relationship with age at the 0.000 level (see age column in Table 5). Elder workers report more fatigue, musculoskeletal complaints, flu complaints and blame their work more often as a factor affecting their health. Only work stress levels are the same for both age groups. Three-way interactions are found in musculoskeletal complaints and in the relationship between work and health. Older workers in the five-shift group reported significantly less musculoskeletal complaints in the year after the roster was implemented. They also

Table 4. Scores on the percentages of occupational accidents plus the scores on five health variables of the five-shift group and the control group of day workers in the year before and the year after implementation of the new roster.

Measure/roster	Roster	Intervention: Year before	Intervention: Year after		Tests of significance: Roster	Time	Time × Roster
Accident data							
Percentage of accidents	Shift work	4.1%	4.5%	F	3.72	2.48	1.05
	Day work	3.0%	4.2%	Sig.	0.054	0.116	0.305
				d	0.035	0.028	0.019
Number of respondents	Shift work	4723	4723	–	–	–	–
	Day work	1440	1440	–	–	–	–
Health data							
Fatigue	Shift work	1.05	1.03	F	2.56	3.03	4.48
	Day work	0.83	1.06	Sig.	0.110	0.082	0.034
				d	0.052	0.056	0.069
Musculoskeletal complaints	Shift work	1.96	1.55	F	13.37	2.44	12.42
	Day work	1.97	2.13	Sig.	0.000	0.118	0.000
				d	0.119	0.051	0.114
Flu complaints	Shift work	0.57	0.59	F	3.41	0.28	0.02
	Day work	0.50	0.52	Sig.	0.065	0.594	0.896
				d	0.060	0.017	0.004
Relationship of health and work	Shift work	0.63	0.64	F	9.32	4.23	3.04
	Day work	0.68	0.83	Sig.	0.002	0.040	0.082
				d	0.099	0.067	0.056
Work stress	Shift work	1.56	1.44	F	44.21	1.50	13.49
	Day work	1.70	1.94	Sig.	0.000	0.221	0.000
				d	0.216	0.040	0.119
Number of subjects	Shift work	1679	1184	–	–	–	–
	Day work	549	399	–	–	–	–

Table 5. Scores on five health variables of the five-shift group and the control group of day workers in the year before and the year after implementation of the new roster for two age groups.

Measure/ roster	18–50 years: Before intervention	18–50 years: After intervention	50–64 years: Before intervention	50–64 years: After intervention		Tests of significance: Age	Time × age	Roster × age	Time × roster × age
Fatigue									
Shift work	0.84	0.90	1.42	1.28	F	67.88	0.00	0.08	2.84
Day work	0.65	0.82	1.06	1.43	Sig.	0.000	0.995	0.773	0.092
					d	0.267	0.000	0.009	0.055
Musculoskeletal complaints									
Shift work	1.59	1.31	2.62	2.02	F	112.6	0.00	0.01	3.89
Day work	1.67	1.73	2.36	2.74	Sig.	0.000	0.996	0.906	0.049
					d	0.344	0.000	0.004	0.064
Flu complaints									
Shift work	0.48	0.53	0.71	0.71	F	23.08	0.31	0.97	0.01
Day work	0.44	0.47	0.59	0.59	Sig.	0.000	0.577	0.324	0.936
					d	0.156	0.018	0.032	0.003
Relationship Health work									
Shift work	0.53	0.58	0.81	0.76	F	33.38	0.78	0.04	4.50
Day work	0.63	0.69	0.75	1.06	Sig.	0.000	0.378	0.845	0.034
					d	0.187	0.029	0.006	0.069
Work stress									
Shift work	1.52	1.36	1.64	1.60	F	1.44	0.12	5.79	2.22
Day work	1.69	2.00	1.72	1.85	Sig.	0.230	0.724	0.016	0.136
					d	0.039	0.011	0.078	0.048
Number of subjects									
Shift work	1075	785	604	399	–	–	–	–	–
Day work	309	240	240	159	–	–	–	–	–

reported significantly less often that their work affects their health in the year after the implementation of the new roster. No three-way interaction effects are found considering fatigue, flu complaints and work stress. Again, the d-values are small.

3.3. *Sickness absence*

Table 6 gives the results related to sickness absence. Spell frequency and absence percentage are significantly higher in the day worker group, which is reflected by the higher absence percentages of the 1–7 d and 29 + d cases in the same group. For all six measures there is a significant main effect of time. Spell frequency and the 1–7 d and 8–28 d absence percentages decrease, while the mean number of absence days, the absence percentage and the 29 + d absence percentage increase in the year after intervention. There are three 3-way interaction effects. In the five-shift worker group the number of absence days increases, but significantly less than in the day worker group. The absence percentage of the 8–28 d decreases significantly more in the five-shift worker group. The absence percentage of the 1–7 d cases decreases in the day worker group.

In the second part of Table 6, the absence measures are corrected for percentages for partly return to work. There are no figures for spell frequency, because this

Table 6. Scores on six sickness absence variables of employees in the five-shift work group and the control group of day workers in the year before and the year after implementation of the new roster and data corrected for percentages for partially return to work (bottom part of the table).

		Intervention		Tests of significance			
Measure/roster	Roster	Before	After		Roster	Time	Time* Roster
Spell frequency	Shift work	1.20	1.14	F	14.84	12.90	0.30
	Day work	1.35	1.26	Sig.	0.000	0.000	0.587
				d	0.110	0.102	0.015
Absence days	Shift work	10.3	10.9	F	0.99	8.37	0.00
	Day work	9.7	12.9	Sig.	0.319	0.004	0.044
				d	0.019	0.058	0.041
Percentage	Shift work	4.7%	5.0%	F	10.52	7.92	2.36
	Day work	5.5%	6.5%	Sig.	0.001	0.005	0.125
				d	0.092	0.080	0.044
1–7 d	Shift work	0.7%	0.7%	F	69.84	7.80	11.28
	Day work	1.0%	0.9%	Sig.	0.000	0.005	0.001
				d	0.238	0.080	0.096
8–28 d	Shift work	1.4%	1.0%	F	0.29	19.61	4.50
	Day work	1.3%	1.2%	Sig.	0.589	0.000	0.034
				d	0.015	0.126	0.060
29 + d	Shift work	2.6%	3.2%	F	6.42	15.34	1.92
	Day work	3.1%	4.4%	Sig.	0.011	0.000	0.166
				d	0.072	0.112	0.039
Corrected values							
Absence days	Shift work	9.8	10.0	F	0.17	6.24	0.01
	Day work	8.9	11.3	Sig.	0.685	0.013	0.037
				d	0.005	0.064	0.051
Percentage	Shift work	4.1%	4.5%	F	6.09	10.45	2.01
	Day work	4.6%	5.5%	Sig.	0.014	0.001	0.156
				d	0.070	0.092	0.040
1–7 d	Shift work	0.7%	0.7%	F	69.52	7.70	11.13
	Day work	1.0%	0.9%	Sig.	0.000	0.006	0.001
				d	0.238	0.079	0.095
8–28 d	Shift work	1.4%	1.0%	F	0.19	20.53	3.92
	Day work	1.3%	1.2%	Sig.	0.667	0.000	0.048
				d	0.012	0.129	0.056
29 + d	Shift work	2.0%	2.7%	F	0.01	21.23	1.66
	Day work	2.2%	3.4%	Sig.	0.000	0.000	0.198
				d	0.046	0.131	0.037
Number of subjects	Shift work	3784	3784	–	–	–	–
	Day work	1145	1145	–	–	–	–

measure is not influenced by the correction. Comparison of the figures in the lower part of Table 6 with the figures in the top part shows that the mean number of absence days, the absence percentage and the absence percentage of the 29 + d cases are affected by the correction. This is not the case for absence percentages of the 1–7 d and 8–28 d cases. This indicates that the Medical Department intervenes in cases of long-term sickness absence. Interestingly, the patterns of the figures, the patterns of significance and the d-values do not change, indicating that the sickness absence interventions of the Medical Department concentrate on all employees with long absence cases and not only on, for instance, the five-shifts worker group. Again, the d-values are to small.

Table 7 gives the results of the sickness absence data related to age. Again, only the test results of the age-related effects are given. In all cases, the main age effect is significant. The absence percentage of the 1–7 d cases is lower in the older group of employees, but the spell frequency, the mean number of absence days, the absence percentage and the absence percentage of the 8–28 d cases and the $\geq$ 29 d cases is higher in this group. There are no significant three-way interaction effects. However, the fact that the absence percentage and the absence percentage of the cases of 29 d and longer have a tendency to increase less strongly in the five-shift worker group of 50 + years of age and older may indicate a small positive effect of the roster change. D-values are very low, however.

The second part of Table 7 gives the results of the absence figures corrected for part-time return to work. Again, the corrected numbers for the mean number of absence days, the absence percentages and the absence percentages of the 29 + d cases are lower than the uncorrected figures in the top part of the table. The patterns of significance are almost the same, however, with the exception of the three-way interaction effects that are not significant even at the 10% level after the correction. This may reflect the effect of the interference of the Health Department with the long-term absence cases that occur more often in the older age group.

4. Discussion

On 1 September 2006, a new MMEEXNNXXX roster replaced the old NNNXXEEEXXMMM roster of the five-shift group at Corus Steel in The Netherlands. The roster was implemented as an experiment for 1 year. Based on the results of an opinion poll among employees and the positive results of an initial evaluation of 6 months of Corus administration data on health and sickness absence, the employees and the company decided to continue with the roster. A period of 1 year after the implementation of the new roster, the results of the effect evaluation were computed again and are reported in this article. Again, there are positive effects of the roster, in particular for the employees of 50 years and older. The company employs many of these older workers and the implementation of the new roster was also meant to alleviate the roster burden for this particular group.

Considering the occupational accidents data, no significant result is found. Although an increase in accidents occurred during the experimental period, this cannot be attributed to the roster; on the contrary, within the control group the number of accidents was also higher. However, the differences are not significant. So this part of the first hypothesis is neither supported nor rejected.

Considering the health data, particularly musculoskeletal complaints and work stress declined in the five-shift worker group 1 year after the implementation. Fatigue did not change in the five-shift worker group, but increased in the day worker group. One would expect these indicators to increase also in the five-shift worker group, because these employees work under the same harsh conditions as the day worker group. Probably the new roster does not add to the burden of night and shift work in these cases. The positive effects of the health measures are reflected by the sickness absence data, where absence duration, in particular, is positively affected in the group of employees working with the five-shift roster. It is tempting to conclude therefore that employees in the five-shift group benefit from the new roster considering their health and return to work, because they experience the roster as less burdening.

The data also indicate that older employees benefit more from the roster change than the younger workers below 50 years of age. The older roster group reports less musculoskeletal complaints and perceives the relationship between work and health as less burdening. In the case of sickness absence, the rise of sickness absence in all groups (general percentage and percentage of 29 + d cases) is the strongest in the older daytime workers. Probably, the older employees in the five-shift group are less vulnerable, due to the new roster.

Thus, mainly positive effects are found, but there are some restrictions to be made on the quality of the data. A strong advantage is that the data are retrieved from the company databases and not from surveys held by the researchers. Certainly the absence data are valid and complete, because they are the main working tool for the Medical Department. A problem, however, is that the health and sickness absence databases do not contain enough additional variables to verify the effects further. Pairing of the health and sickness

Table 7. Scores on six sickness absence variables of employees in the five-shift work group and the control group of day workers and for two age groups in the year before and the year after implementation of the new roster and data corrected for percentages partially return to work (bottom part of the table).

	18–50 years		50–64 years		Tests of significance				
Measure/ roster	Before intervention	After intervention	Before intervention	After intervention		Age	Time × age	Roster × age	Time × roster × age
Spell frequency									
Shift work	1.18	1.12	1.25	1.18	F	8.78	0.01	1.40	0.02
Day work	1.28	1.19	1.43	1.34	Sig.	0.003	0.925	0.238	0.890
					d	0.084	0.003	0.034	0.004
Shift work	8.96	9.22	12.71	13.84	F	23.60	0.86	0.62	0.07
Day work	8.60	11.00	10.83	14.80	Sig.	0.000	0.354	0.432	0.786
					d	0.310	0.025	0.003	0.056
Shift work	3.4%	3.7%	6.9%	7.2%	F	109.20	3.44	0.41	3.47
Day work	4.0%	4.2%	7.1%	9.0%	Sig.	0.000	0.064	0.524	0.063
					d	0.298	0.053	0.018	0.053
Shift work	0.8%	0.8%	0.6%	0.7%	F	8.33	1.38	1.16	0.09
Day work	1.1%	0.9%	1.0%	0.9%	Sig.	0.004	0.240	0.281	0.761
					d	0.082	0.033	0.031	0.009
Shift work	1.1%	0.9%	1.8%	1.3%	F	97.27	7.79	0.81	0.26
Day work	0.9%	0.9%	1.7%	1.5%	Sig.	0.000	0.005	0.367	0.610
					d	0.281	0.080	0.026	0.015
Shift work	1.6%	2.1%	4.5%	5.2%	F	82.92	5.20	1.54	3.08
Day work	2.0%	2.3%	4.3%	6.6%	Sig.	0.000	0.023	0.695	0.079
					d	0.260	0.065	0.011	0.050
Corrected figures									
Absence days									
Shift work	8.41	8.51	12.21	12.64	F	31.15	0.15	1.17	0.01
Day work	7.70	9.84	10.13	12.76	Sig.	0.000	0.702	0.279	0.940
					d	0.319	0.039	0.008	0.028
Percentage									
Shift work	3.1%	3.3%	5.9%	6.5%	F	107.28	4.85	0.04	1.36
Day work	3.4%	3.6%	5.8%	7.4%	Sig.	0.000	0.028	0.843	0.243
					d	0.295	0.063	0.006	0.033
1–7 d									
Shift work	0.8%	0.8%	0.6%	0.7%	F	8.25	1.35	1.14	0.10
Day work	1.1%	0.9%	1.0%	0.9%	Sig.	0.004	0.245	0.286	0.749
					d	0.082	0.033	0.030	0.009
8–28 d									
Shift work	1.1%	0.9%	1.8%	1.3%	F	98.82	8.09	0.93	0.23
Day work	0.9%	0.9%	1.7%	1.5%	Sig.	0.000	0.004	0.335	0.629
					d	0.283	0.081	0.027	0.014
29 + d									
Shift work	1.3%	1.7%	3.5%	4.5%	F	77.07	7.51	0.16	1.15
Day work	1.4%	1.9%	3.1%	5.1%	Sig.	0.000	0.006	0.900	0.285
					d	0.250	0.078	0.004	0.031
Number of subjects									
Shift work	2440	2440	1334	1334	–	–	–	–	–
Day work	591	591	554	554	–	–	–	–	–

absence data at the individual level was not possible, because the health survey dataset did not contain the identification codes.

Another restriction is that the effect size of the results is small according to Cohen's d-values. This means that the significant differences must be evaluated very carefully, also when the significance levels are 0.000, which is related to the large size of the samples under study. Also, the interpretation of the effects needs some discussion. Ideally, the effectiveness of the new shift schedule should be reflected in a time × roster interaction, where there is no impact of time on the control group. However, for some of the results, the five-shift group does not improve but their scores become less negative compared with the control group. There is no explanation for these results. The office workers cannot be used as a control group because their working situation is too different. But one cannot exclude the fact that unknown changes in the working situation of the control group may be related to the changes in the dependent variables. The only indication to conclude is that there is a positive effect is that all effects are in the same direction. There are no significant effects in favour of the control group.

The data also contain selection effects, as was shown in Table 3. Correction for these effects did not reduce the explanatory power of the data, however, as was seen in the absence data. Only the three-way interaction effect related to age disappeared, but this is related to the fact that the Health Department interferes in the case of long-term sickness absence, which occurs more often in the older age group. Selection effects certainly are also present in the health and accident data. In these data there is no possibility to correct for personnel turnover and inflow, however, but these healthy worker effects will certainly influence the outcome of these data in an unknown way.

The effect of the interventions of the Medical Department in the case of long-term sickness absence is implicitly evaluated by means of the analysis of sickness absence data in this study. All in all, the efforts of the Medical Department related to partial return to work of the employees who are absent for more than 4 weeks reduced the sickness absence levels by, on average, 0.6% in both groups and in both years. Recalculated to the number of employees, this is about 31 full-time employees. This certainly is a remarkable result, which can also be generalised to the part of the organisation not under study.

The theoretical implications of these findings are threefold. First, the results support the recommendations of the literature on shift work schedules. The recommendations of Knauth and Hornberger (2003) were used. The number of consecutive night shifts has to be as low as possible, not more than three. In the new Corus roster this was reduced to two. No permanent night shifts are applied and also no single days off between night shifts. Increasing the speed of rotation is supposed to be beneficial, although mixed results are shown (Tucker and Knowles 2008). The direction of rotation (forward) is generally related to better sleep and less fatigue. The present study confirmed the positive effects of these recommendations, since it showed higher improvements for the shift workers compared to the day workers. It cannot be concluded, however, which of the three major differences are related to the improvements and which is the most important one. Is it the direction of rotation? Is it the faster cycle? Is it the two instead of three consecutive night shifts? Or the 3 d off after the night shift? Thus, the present study is not able to determine the exact basis of the positive results. The data measure the effects of the entire new roster, with all the characteristics of the schedule, and they were compared with the entire old schedule. Nevertheless, this is a common confounder of studies in the 'real world'. Given the size of the current sample, the results are still relevant.

Second, the present study provides evidence for the age-relatedness of the beneficial effects of the new shift system schedule. Older workers (> 50 years) experience more improvement than do younger workers. Hakola and Harma (2001) found the same effect in their evaluation of the change from a slowly backward rotating system toward a fast forward rotating system. Their study – also performed in the steel industry – proved that older workers report more improvement in sleep quality than do younger workers. A study among rail employees found significant interactions between the direction of shift rotation, the number of consecutive shifts and the age of the respondents (Ryan *et al.* 2008). The study of Baker *et al.* (2004) indicated that preferred hours of work fluctuate for shift workers depending on years of experience. After 13 years of shift work, individuals may choose alternative hours. Therefore, it is not surprising that age differences were found in the effects of rosters. Apparently, older workers benefit more from the reduction in consecutive night shifts, there is less possibility to accumulate fatigue and at the same time the recovery periods in the new schedule are better. Maybe the older workers use their opportunities to sleep, while the younger workers do other things. There are no data on this issue, so further research might figure out the question why older workers benefit more from ergonomic improvements. The present authors think that these age effects are important, however. Ergonomic improvements in shift systems should first benefit the workers who are most vulnerable to the negative effects of shift work.

Third, the process of redesign and implementation of a new shift work system reflected the importance of participation of employees. The process of changing the existing schedule (which lasted for almost 25 years!) is quite a project in such a large site. The process was carried out carefully, with the participation of unions and experts. The most important aspect is the involvement of all employees in selecting the new schedule. Two voting cycles were organised to support the selection process and there was a voting cycle at the end of the experiment. In addition, although such a change caused quite a lot of hassle, the majority (56%) voted in favour of the new scheme. Involvement seems to be helpful to employees in accepting the change, in line with other research (Smith *et al.* 1998). The general idea of employee participation in the decision of a new working time schedule is an important step in smoothly implementing new initiatives such self-scheduling or self-rostering (Beltzhoover 1994, Thornthwaite and Sheldon 2004). In self-rostering, employees not only can influence the design and selection of the new schedule, but also their exact personal working times once a schedule is implemented. Perhaps, a first step toward self-rostering at such a large plant such as Corus is to introduce different schedules for specific groups; that might be a logical next step in the history of the Corus rosters.

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