



National Research Centre  
for the Working Environment

# **Health and Safety Risks Related to Specific Characteristics of Shift Work Scheduling**

Anne Helene Garde

24th International Symposium on Shiftwork and Working Time  
Idaho, USA

Guidelines for the European Foundation  
Br... for the Improvement of  
17675... and Working Conditions

# GUIDELINES FOR SHIFTWORKERS

*Bulletin of European Shiftwork Topics  
Bulletin Européen sur le Travail posté  
Bulletin für europäische Schichtarbeitsfragen*

Available in English, French and German

Number 3, 1991

BEST

## What is BEST?

**BEST** is a Bulletin of European Shiftwork Topics, offering condensed and practical information on important developments in the field of work organisation and shiftwork.

**BEST** is published twice yearly in English, French and German.

## Who is BEST?

A European network of experts, set up by the **European Foundation for the Improvement of Living and Working Conditions** to monitor developments, is responsible for the content of the bulletin.

### Members of the network:

- Giovanni COSTA
- Ben JANSEN
- Peter KNAUTH
- Robert LÉONARD
- Charles GADBOIS
- Alexander WEDDERBURN

## Whom does BEST address?

The bulletin is aimed at those who are interested in keeping abreast of developments in the field of work organisation and shiftwork in the Member States of the Community. It especially addresses: decision makers at policy level; organizations representing employers and workers; managers and workers within firms.

## Suggestions? Comments? Enquiries? Further copies?

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Catalogue Number SY-AB-91-001-ENC

RIKSDAGSBIBLIOTEKET



0 000 000 006 4741

Shiftwork Topics is published under the auspices of the European Foundation and Working Conditions. The opinions expressed in it are those of the contributors and do not necessarily reflect the opinion of the Foundation.

ISSN 1017-4877 EF/91/03/EN

## Guidelines for a good shift system

Fourteen rules were given in BEST 3, Guidelines for shiftworkers, reprinted in Appendix 2 of BEST 7, and are worth repeating here.

1. Minimise permanent nights
2. Minimise sequence of nights: only 2-4 night shifts in succession should be worked
3. Avoid fast double-backs

8. Rotate forward

### Carcinogenicity of night shift work

In June, 2019, a Working Group of 27 scientists from 16 countries met at the International Agency for Research on Cancer (IARC) in Lyon, France, to finalise their evaluation of the carcinogenicity of night shift work. This assessment will be published in volume 124 of the IARC Monographs.<sup>1</sup>

Night shift work involves work,

lifestyle, and environmental factors might mediate, confound, or moderate potential cancer risk in night shift workers.

The Working Group concluded there was limited evidence that night shift work causes breast, prostate, and colorectal cancer. This evaluation was based on comprehensive searches of

provided evidence for positive associations between night shift work and breast cancer risk, particularly among premenopausal women. The associations were strongest for high-intensity, long-duration night shift work. The variation in findings between studies could be attributed to differences in exposure assessment



**Lancet Oncol 2019**

Published Online  
July 4, 2019  
[http://dx.doi.org/10.1016/S1470-2045\(19\)30455-3](http://dx.doi.org/10.1016/S1470-2045(19)30455-3)

For more on the IARC  
**Monographs** see <http://monographs.iarc.fr/>

**Upcoming meetings**  
Nov 5–11, 2019, volume 125:  
Some industrial chemicals



## Night shift work and cancer

### Carcinogenicity

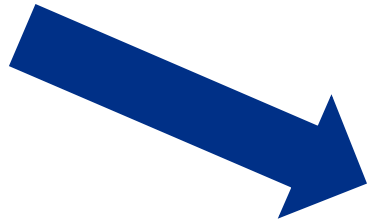
In June

"In sum, the Working Group classified night shift work in Group 2A, "probably carcinogenic to humans", based on limited evidence of cancer in humans, sufficient evidence of cancer in experimental animals, and strong mechanistic evidence in experimental animals."

# Overview

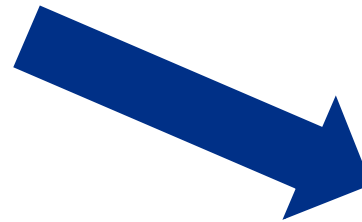
## Scheduling characteristics

- Number of consecutive night shifts
- Rotating vs permanent night work
- Forwards/backwards rotation or quick returns
- Night work during pregnancy



## Suggested mechanisms

- Light at night (melatonin hypothesis)
- Circadian disruption
- Sleep



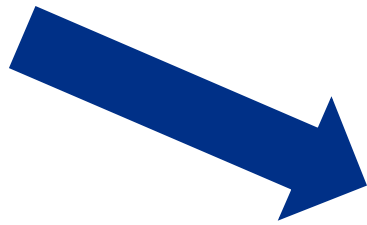
## Health and safety

- Sickness absense
- Injuries
- Pregnancy related illness

# Overview

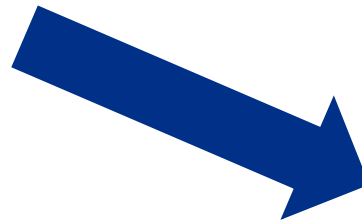
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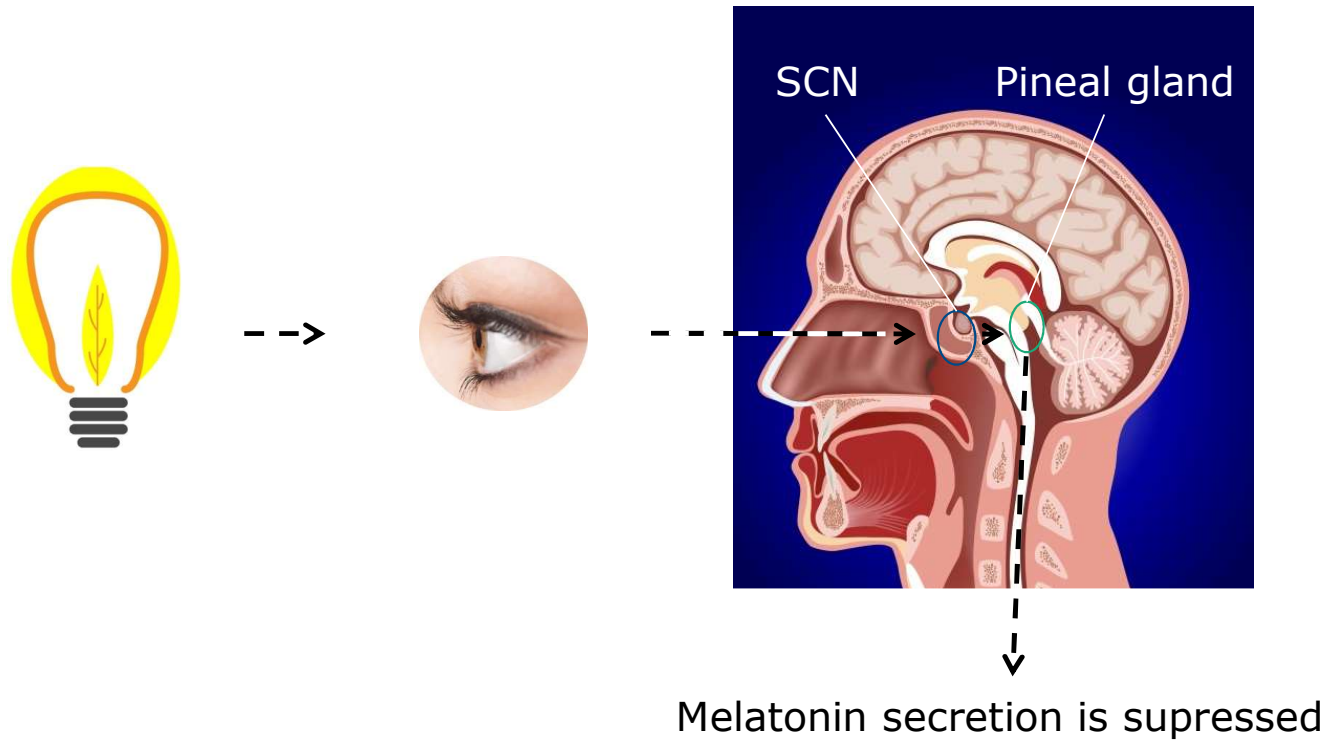
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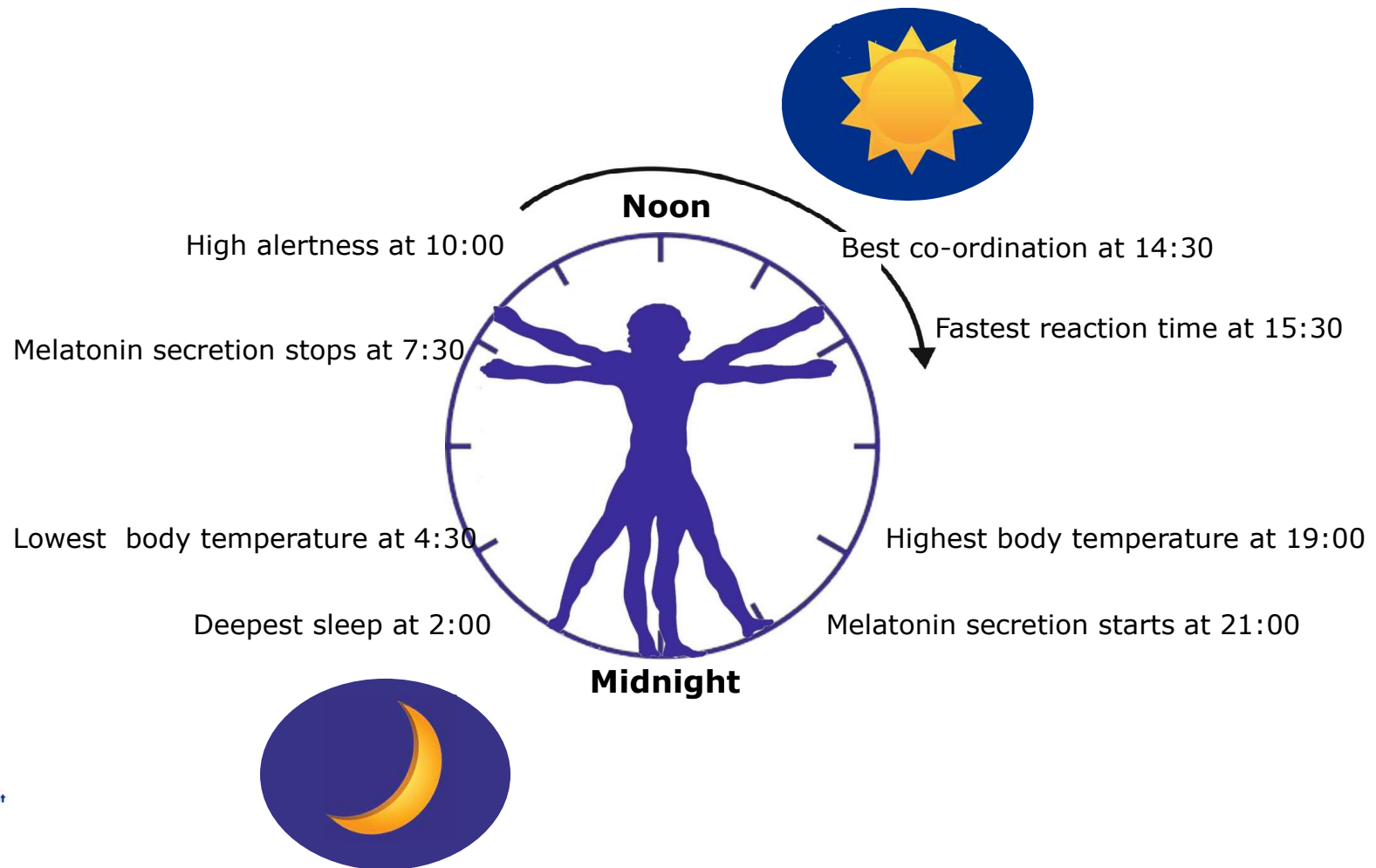
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## Suggested mechanisms - Light at night (melatonin)

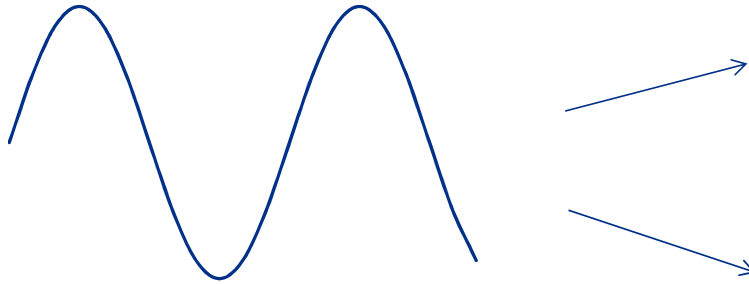




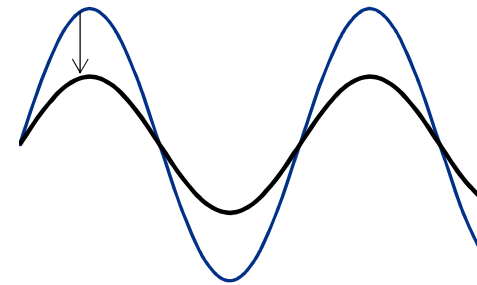
## Suggested mechanisms - Disruption of circadian rhythms



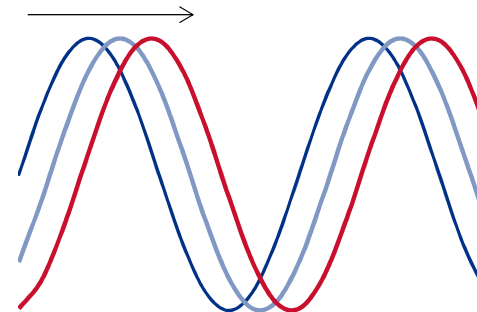
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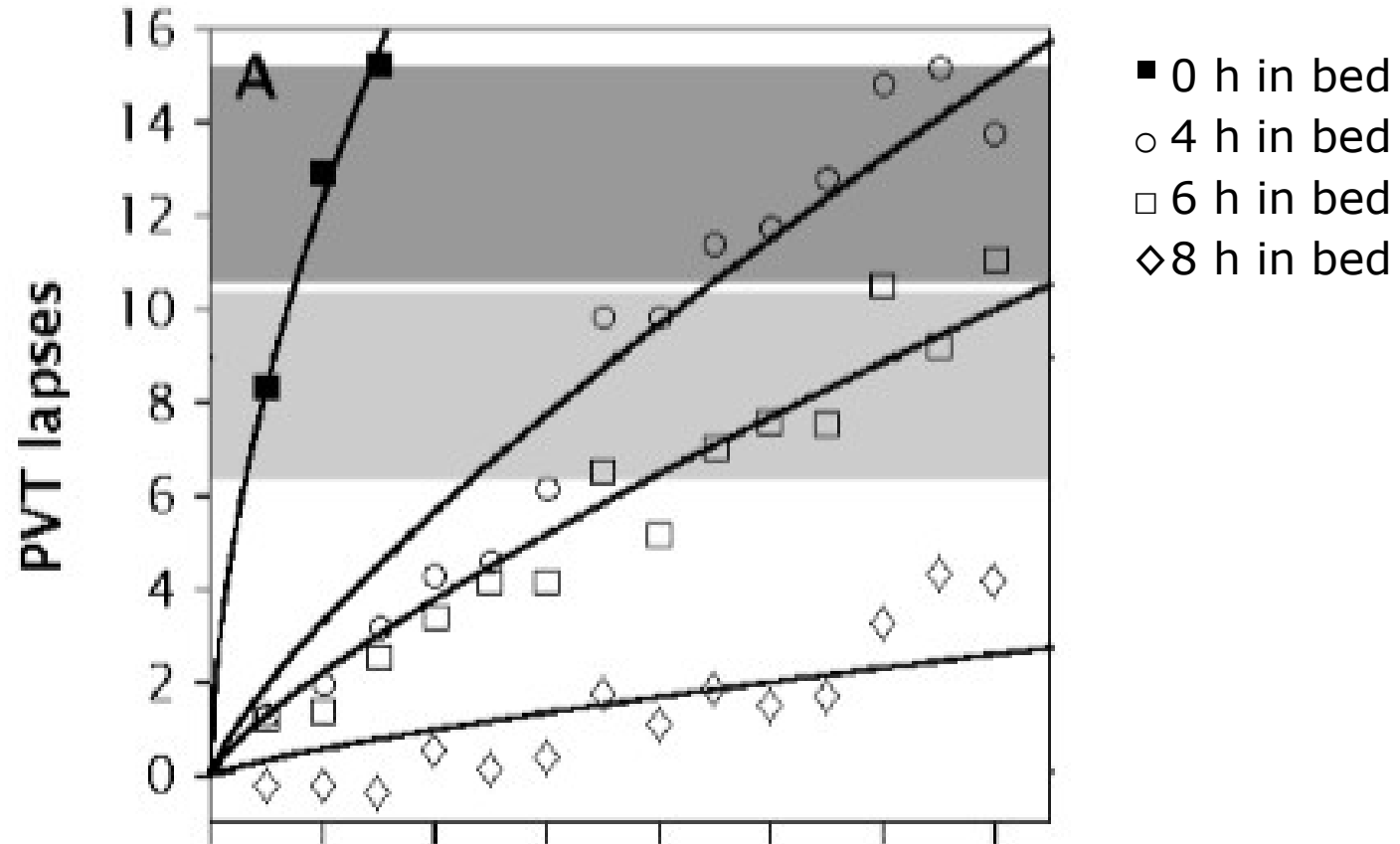
Amplitude



Phase delay

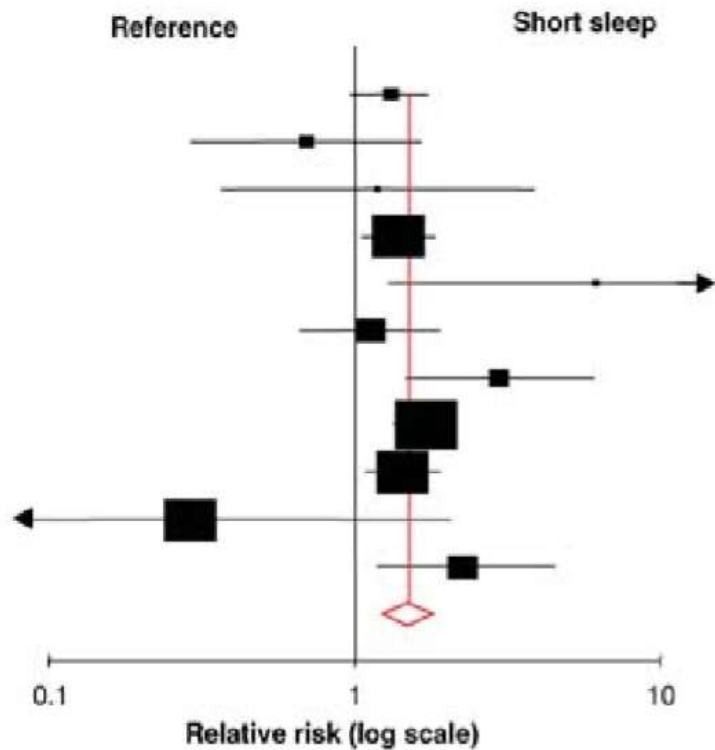


## Suggested mechanism: Short sleep

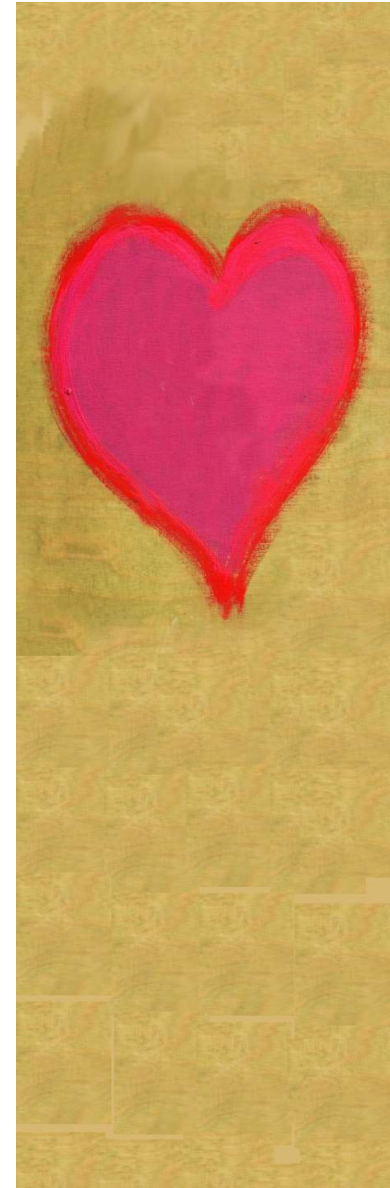


(Van Dongen et al Sleep, 2003)

## Suggested mechanism: Short sleep duration



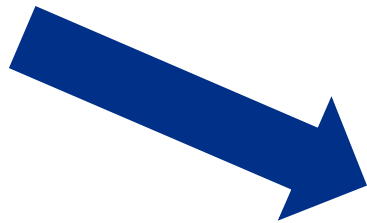
- Shift work and night work in particular is associated with short and poor sleep (Åkerstedt, OEM, 2003)
- Short sleep is in turn associated with increased risk of disease e.g. diabetes, coronary heart disease (RR=1.48) and all-cause mortality (Cappuccio et al. Diabetes Care, 2010; Cappuccio Eur Heart J, 2011; Cappuccio et al. Sleep, 2010)



# Overview

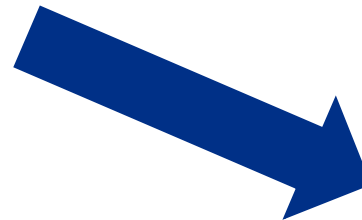
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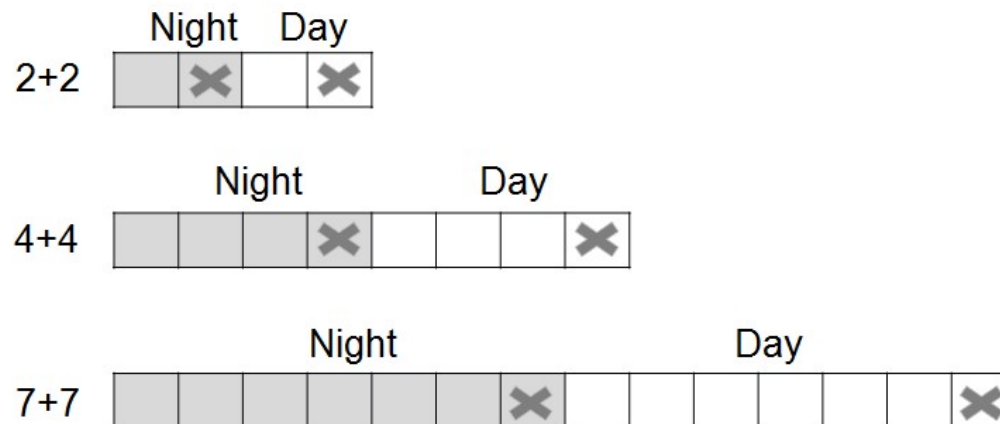
## Number of consecutive night shifts

- Exposure to 2, and especially 4 consecutive night shifts is associated with an increased likelihood of **short term sickness absence** (Ropponen, Int J Nurs studies, 2019)
- Compared to first shift in a block of consecutive shifts, risk of **occupational injuries** increased exponentially for night shifts (Fischer et al. Chronobiol Int (2017))
- Significantly increased risks of **breast cancer** were seen in nurses who worked  $\geq 5$  years with  $\geq 6$  consecutive night shifts (JA Lie et al. Am J Epidemiol. (2011)).

## 'In the middle of the night'



- Aimed to investigate consequences of the number of consecutive night shifts on different outcomes related to potential health risks
- 73 male police officers from five police districts
- The participants was exposed to three interventions:

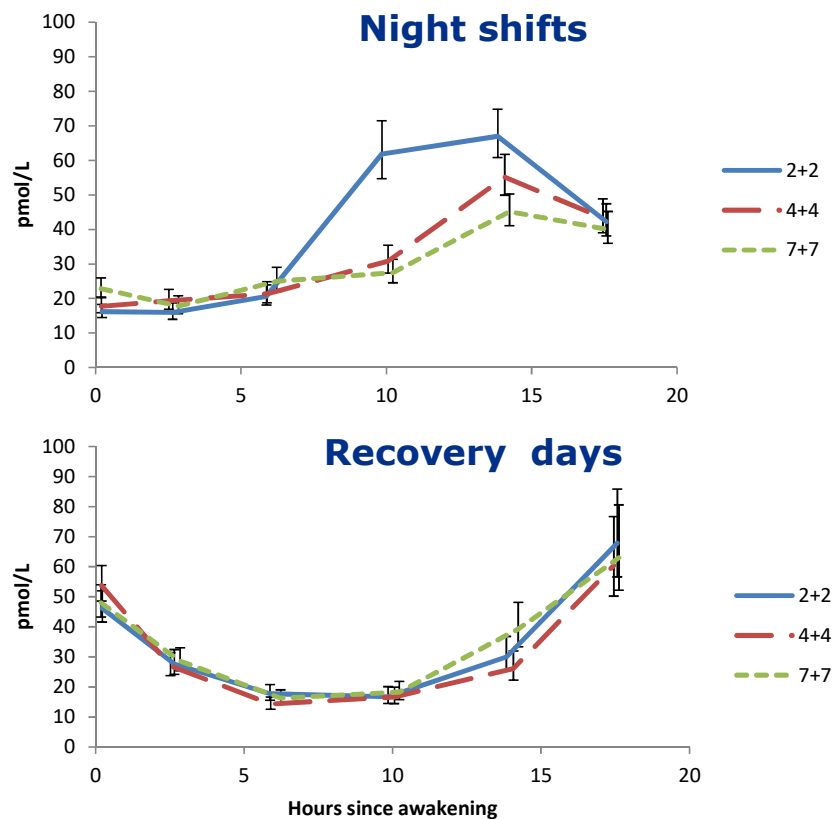




# Methods



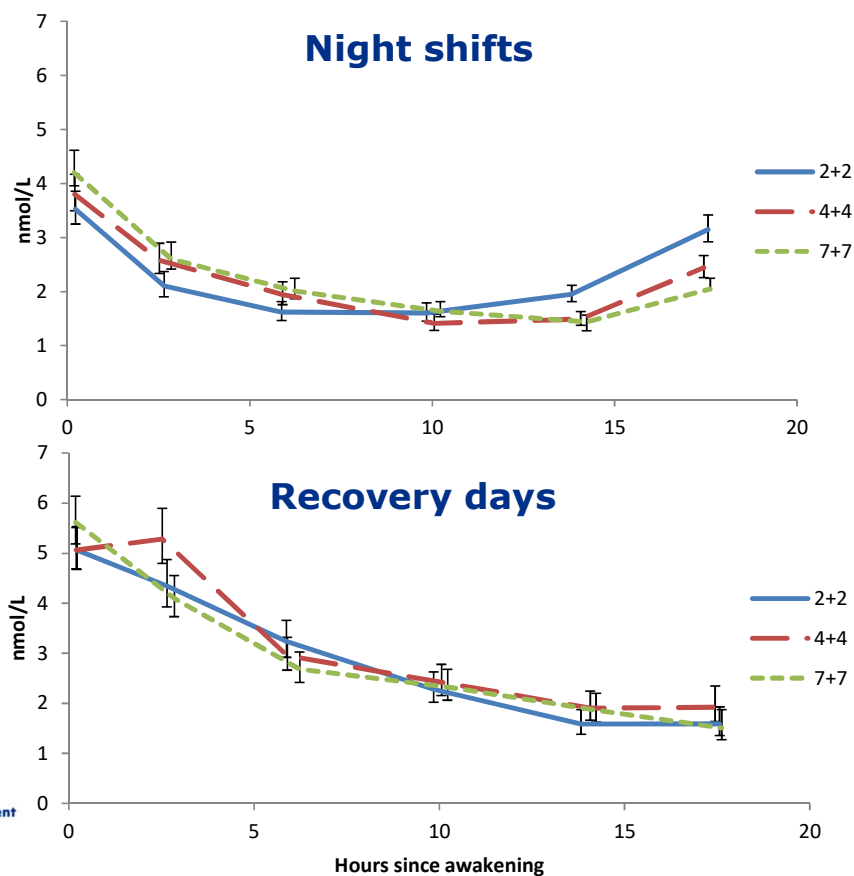
# Melatonin



- The amplitude of melatonin was suppressed 4,9% per night shift
- The melatonin rhythm was not adapted to night shifts after 7 consecutive night shifts
- No difference between the interventions on recovery days

Jensen et al. Chronobiol. Int. (2017)

# Cortisol

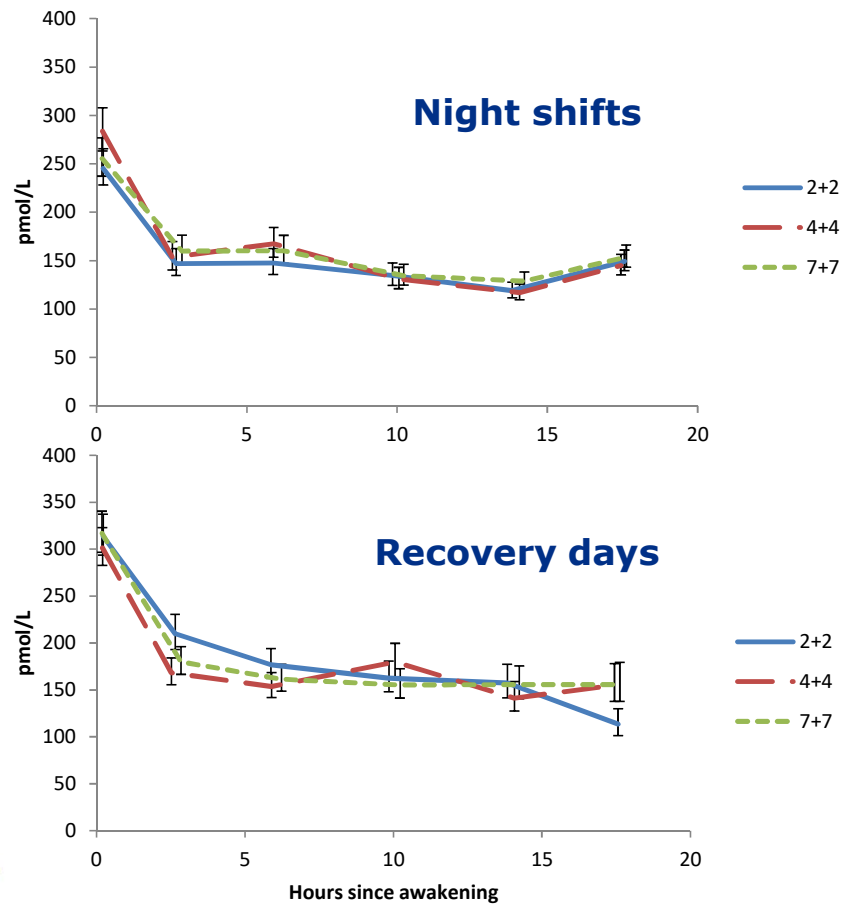


- The phase of the cortisol rhythm was delayed 33 minutes per night shift
- The cortisol rhythm was not adapted to night shifts after 7 consecutive night shifts.
- No difference between the interventions on recovery days.

Jensen et al. Chronobiol. Int. (2017)



# Testosterone



- No difference between the interventions on night shifts
- No difference between the interventions on recovery days
- The testosterone rhythm followed the sleep pattern

Jensen et al. Chronobiol. Int. (2017)



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## Only few adjust to permanent night work

**TABLE 1** Summary of the Results of the Studies Pertaining to the Adjustment of the Melatonin Rhythm to Permanent Night Work

Study	Lighting conditions	Number of participants		Number showing adjustment	
		Male	Female	Substantial <sup>a</sup>	Complete
Waldhauser et al. (1986)	Normal	2	0	1	0
Sack et al. (1992)	Dim	2	8	3	0
Roden et al. (1993)	Normal	9	0	1	0
Koller et al. (1994)	Normal	14	0	2	1
Weibel et al. (1997)	Dim	11	0	4	0
Dumont et al. (2001)	Dim	3	27	5	1
Total		41	35	16	2

<sup>a</sup>This figure includes those showing “complete” adjustment.

- In normal environments, permanent night shift systems are unlikely to result in sufficient circadian adjustment in most individuals to benefit health and safety

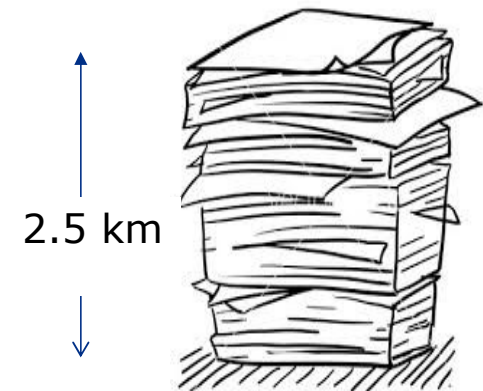
## Minimise permanent night shift

- 6.0% of permanent night workers have **shift work disorder** (Vanttola et al, J Sleep Res, 2019)
- Working permanent nights was associated with a moderately increased risk of **miscarriage** (Bonde et al, SJWEH, 2013)
- Long duration of permanent night work in combination with a long shift length or at least six consecutive nights may be associated with **prostate cancer** (Wendeu-Foyet et al, OEM, 2018)

# Danish Working Hour Database (DWHD)



- Pay-roll data from all employees in all Danish regions including daily starting and ending times for work
- All public hospitals in Denmark incl. administration
- 2007-2015, 265,898 persons (79% women)
- Approx. 300.000.000 observations
- Questionnaire: Previous night work and lifestyle (N=37,077 (56%))



## Starting time vs. duration of shift (nursing personnel, 2013)

Shift duration n (h)	Starting time																			Total (%)
	5:00-5:59	6:00-6:59	7:00-7:59	8:00-8:59	9:00-9:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59	
0	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0,4
1	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,4
2	0	0	0,1	0	0	0	0	0	0,1	0	0,1	0	0	0	0	0	0	0	0	0,5
3	0	0	0,1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5
4	0	0	0,3	0,3	0,1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0,8
5	0	0,1	0,6	0,5	0,1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	1,5
6	0	0,1	1,1	1,2	0,2	0,1	0	0,1	0	0,1	0,1	0	0	0	0	0	0	0	0	3,1
7	0,1	1,5	12,9	18,2	0,4	0,1	0,2	0,2	0,2	0,7	0,6	0,3	0	0	0	0	0	0	0,2	39,8
8	0	0,4	23,7	4,4	0,4	0,3	0,2	0,2	0,1	0,9	11,1	0,1	0	0	0	0	0	0,1	7,4	49,5
9	0	0,1	1,5	0,4	0,1	0	0	0	0,1	0,3	0,3	0	0	0	0	0	0,1	0,2	0,1	5,2
10	0	0	0,6	0,2	0	0	0	0	0,1	0,1	0,1	0	0	0	0	0	0	0	0	1,2
11	0	0	0,2	0,1	0	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0,4
12	0	0	0,9	0,1	0,1	0,1	0,1	0	0	0	0	0	0	0	0,7	0	0	0	0	2,0
13	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1
15	0	0	0,1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2
16	0	0	0,2	0	0	0	0	0	0	0	0,1	0	0	0	0	0	0	0	0	0,3
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0
Total	0,2	2,4	42,1	25,5	1,4	0,8	0,5	0,7	0,7	2,3	12,6	0,6	0,1	0,1	0,8	0,1	0,2	0,7	7,9	100,0

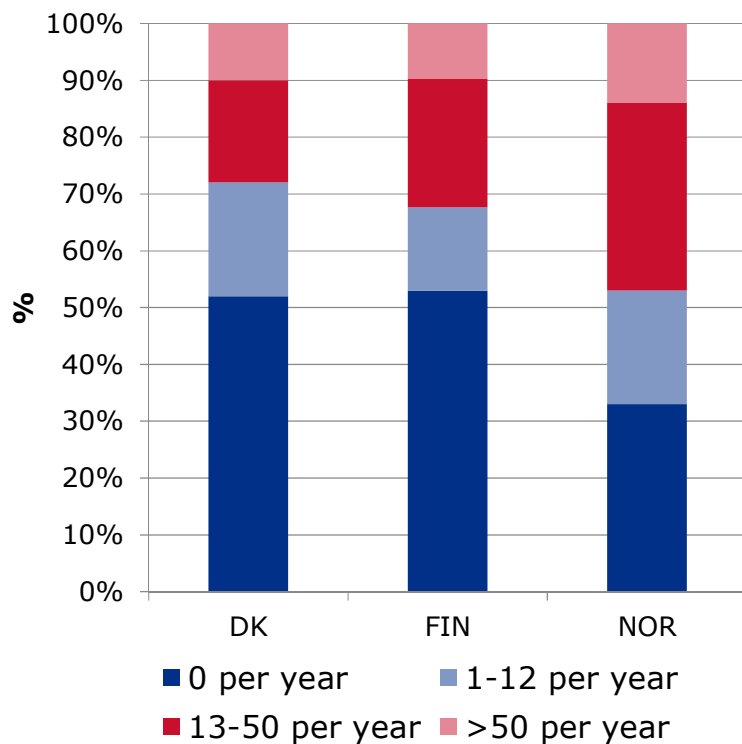
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0	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1	0,4
1	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,4
2	0	0	0,1	0	0	0	0	0	0,1	0	0,1	0	0	0	0	0	0	0	0	0,5
3	0	0	0,1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5
4	0	0	0,3	0,3	0,1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0,8
5	0	0,1	0,6	0,5	0,1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	1,5
6	0	0,1	1,1	1,2	0,2	0,1	0	0,1	0	0,1	0,1	0	0	0	0	0	0	0	0	3,1
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9	0	0,1	1,5	0,4	0,1	0	0	0	0,1	0,3	0,3	0	0	0	0	0	0,1	0,2	0,1	5,2
10	0	0	0,6	0,2	0	0	0	0	0,1	0,1	0,1	0	0	0	0	0	0	0	0	1,2
11	0	0	0,2	0,1	0	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0,4
12	0	0	0,9	0,1	0,1	0,1	0,1	0	0	0	0	0	0	0	0,7	0	0	0	0	2,0
13	0	0	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,1
15	0	0	0,1	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2
16	0	0	0,2	0	0	0	0	0	0	0	0,1	0	0	0	0	0	0	0	0	0,3
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0
Total	0,2	2,4	42,1	25,5	1,4	0,8	0,5	0,7	0,7	2,3	12,6	0,6	0,1	0,1	0,8	0,1	0,2	0,7	7,9	100,0

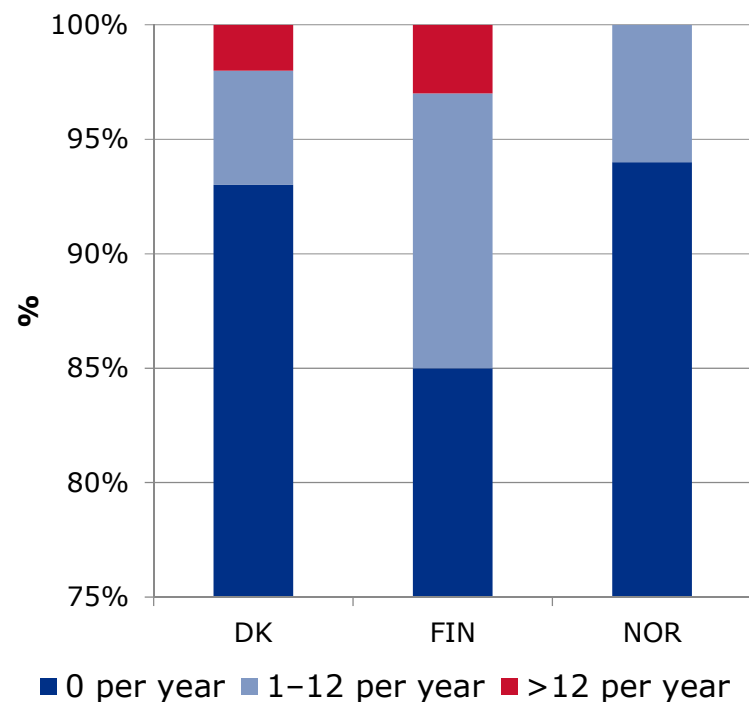


# Scheduling of night work among nurses in Nordic countries

Number of night shifts



Periods of  $\geq 5$  consecutive night shifts



- Most nurses with >50 night shifts per year in the Norwegian sample
- None of the have  $\geq 5$  consecutive night shifts

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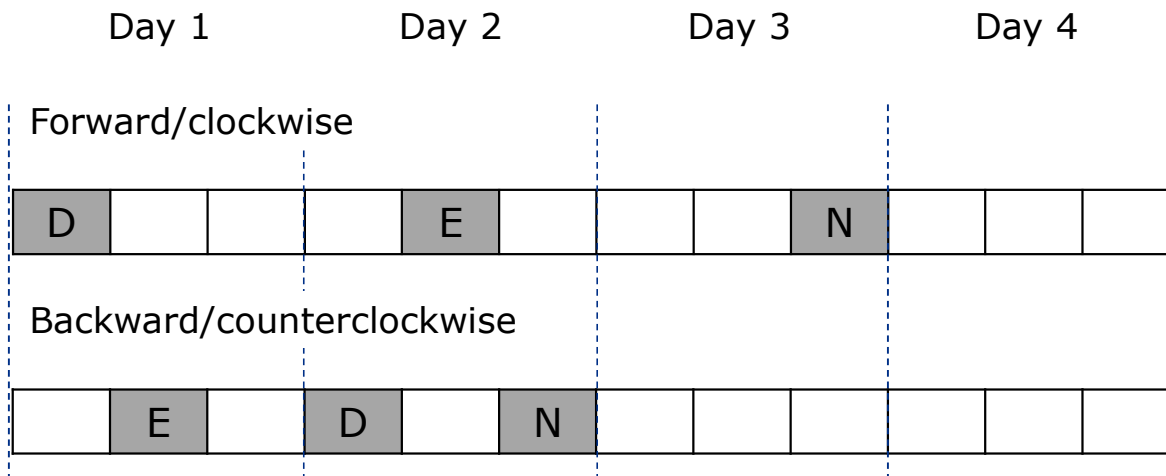
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## **Rotate forward e.g. day -> evening -> night**

- Changing from backward to forward rotation is associated with beneficial effects on health based on two studies (Bambra et al, Am J Prev Med, 2008)
- Review provides support for the use of forward rotating shift systems in preference to backward rotating shift systems, at least as far as 8-h shifts are concerned (Driscoll et al, Sleep Med Rev, 2007).
- Overall, the review found there is insufficient evidence to support definitive conclusions regarding direction of rotation (Driscoll et al, Sleep Med Rev, 2007).

## Direction of rotation – a closer look



D – Day shift  
E – Evening shift  
N – Night shift

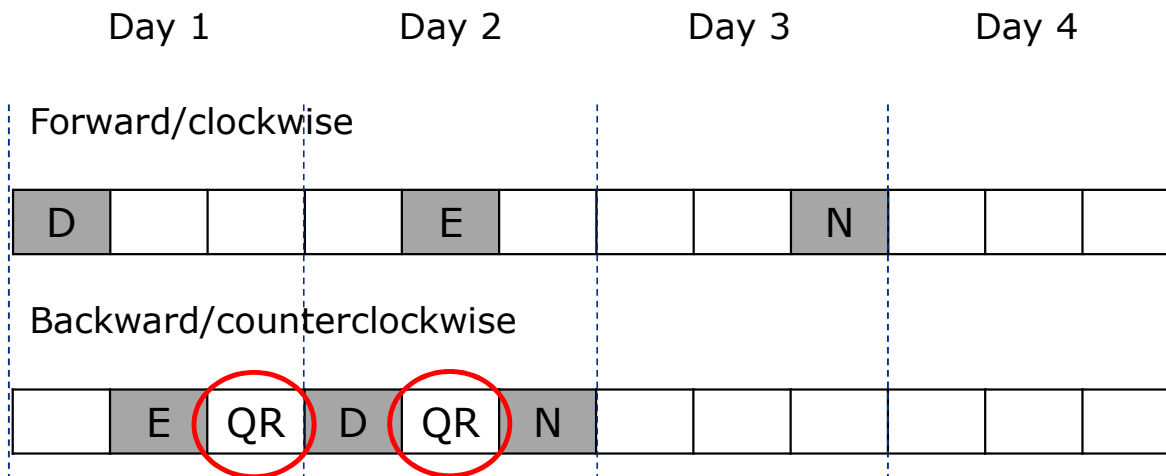


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## Direction of rotation – a closer look



D – Day shift  
E – Evening shift  
N – Night shift  
QR – Quick Return



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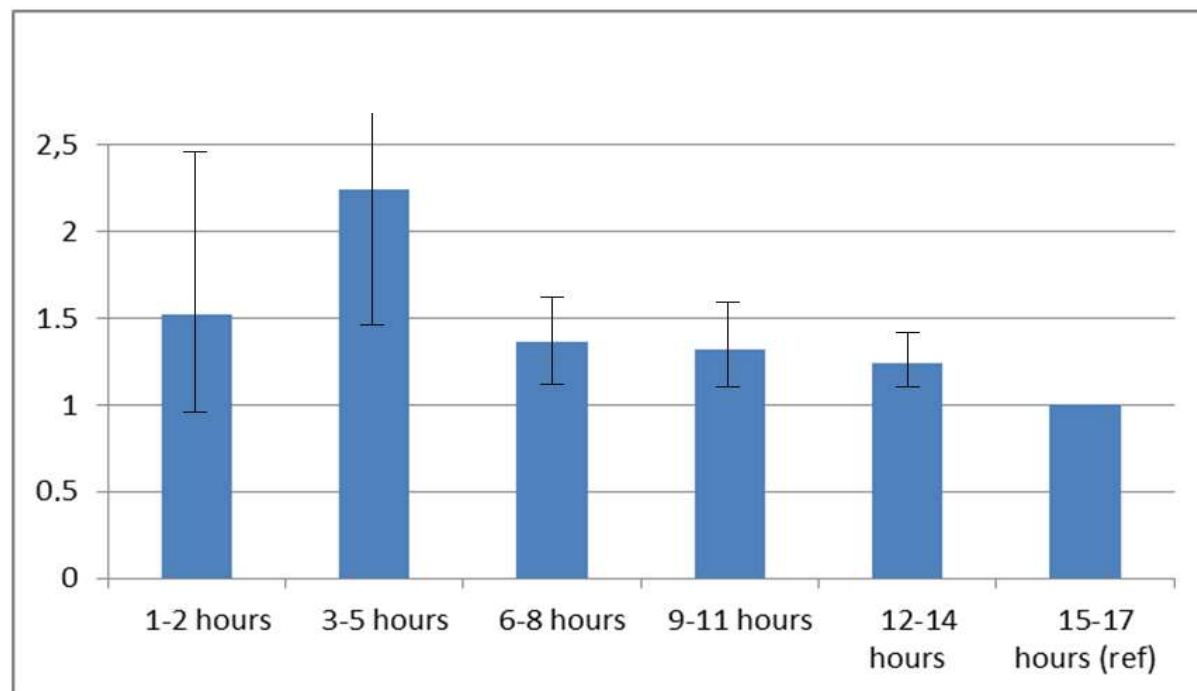
8. Rotate forward



## Quick returns (QR; $\leq 11$ hours between shifts)

- A review of 21 studies conclude that evidence regarding effects on chronic health was inconclusive (Vedaa et al, Ergonomics, 2016).
- Quick returns are associated with higher risk of sickness absence. The risk of sickness absence increases with more more QRs (Ropponen et al, Int J Nurs studies, 2019; Vedaa et al, OEM, 2017)

## Time between shifts and risk of injuries



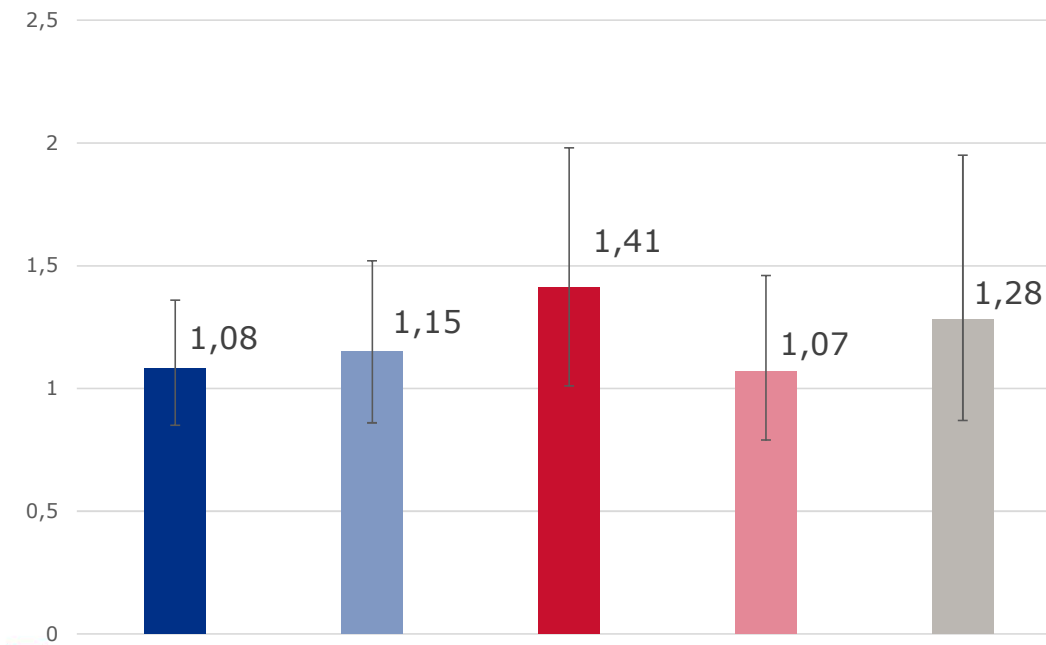
- The shorter time between two shifts the higher the risk of injury
- Risk of injury was 39% higher after a quick return ( $\leq 11$  hours) compared with a regular return (15-17 hours)
- Risk of injury was particularly high within the first two days following a quick return
- Risk of injury did not increase with more quick returns the past week

69,200 hospital employees (167 726 person years) 11 834 injury records filed with national hospital and death registers. Adjusted for year, season, age, sex and education

# Night work and hypertension disorders of pregnancy (first 20 weeks)



All women; N=11,193;  
Ref:  $\geq 1$  night shift

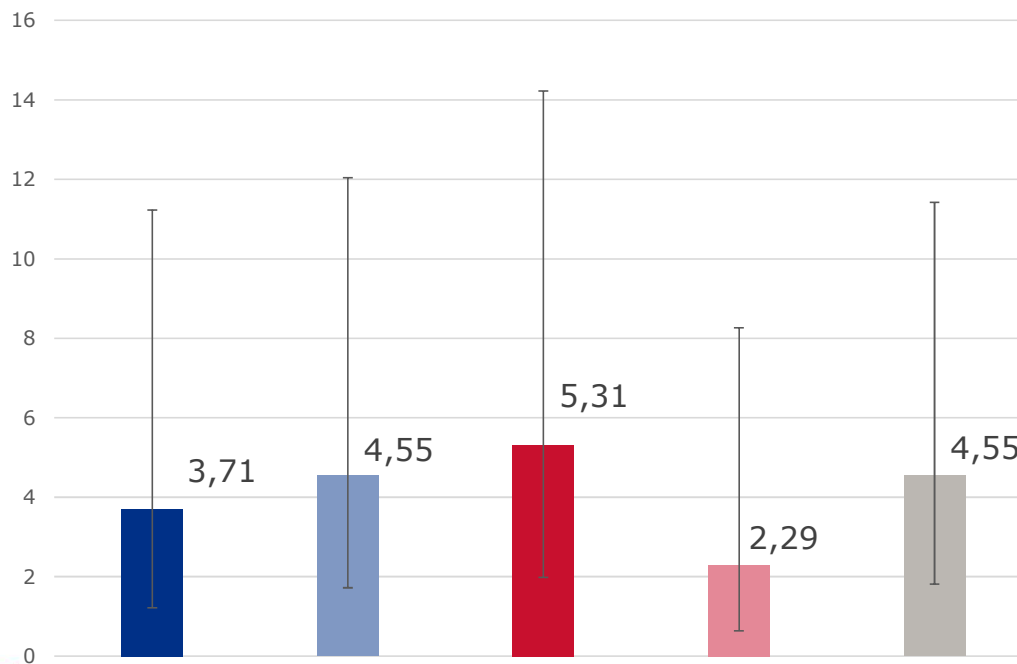


- $\geq 20$  night shifts
  - Night shifts  $> 12$  h
  - $\geq 4$  cons. night shifts
  - $\geq 5$  QR ( $< 11$  h)
  - $\geq 5$  QR after night shift ( $< 28$  h)
- 40% increased risk hypertension disorders of pregnancy with more than 3 consecutive night shifts: 1 extra case per 100 women

# Night work and hypertension disorders of pregnancy (first 20 weeks)



BMI > 30 kg/m<sup>2</sup>; N=1588;  
Ref: day only;



■ >= 20 night shifts

■ Night shifts > 12 h

■ >=4 cons. night shifts

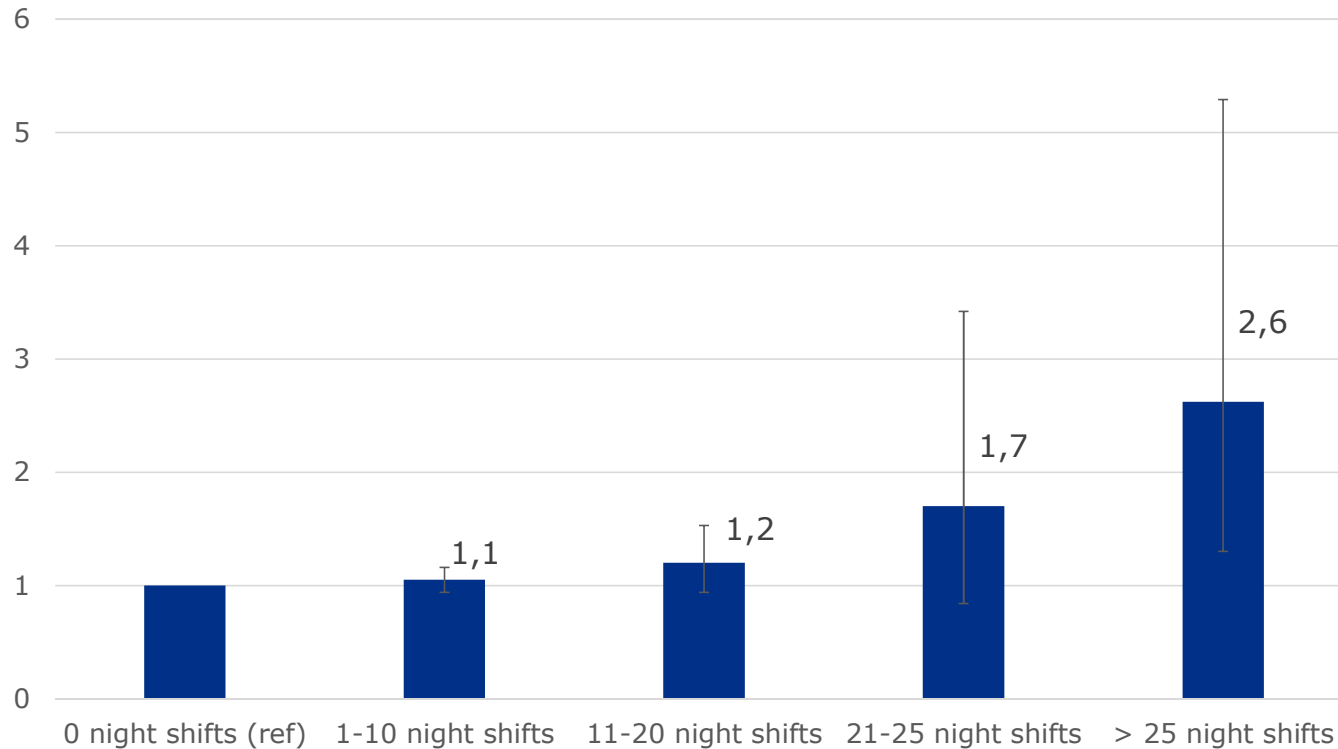
■ >= 5 QR (< 11 h)

■ >= 5 QR after night shift (<28 h)

- 4-5 fold increased risk of hypertension disorders among obese women compared to obese women with day work:  
3-4 extra cases per 100 women



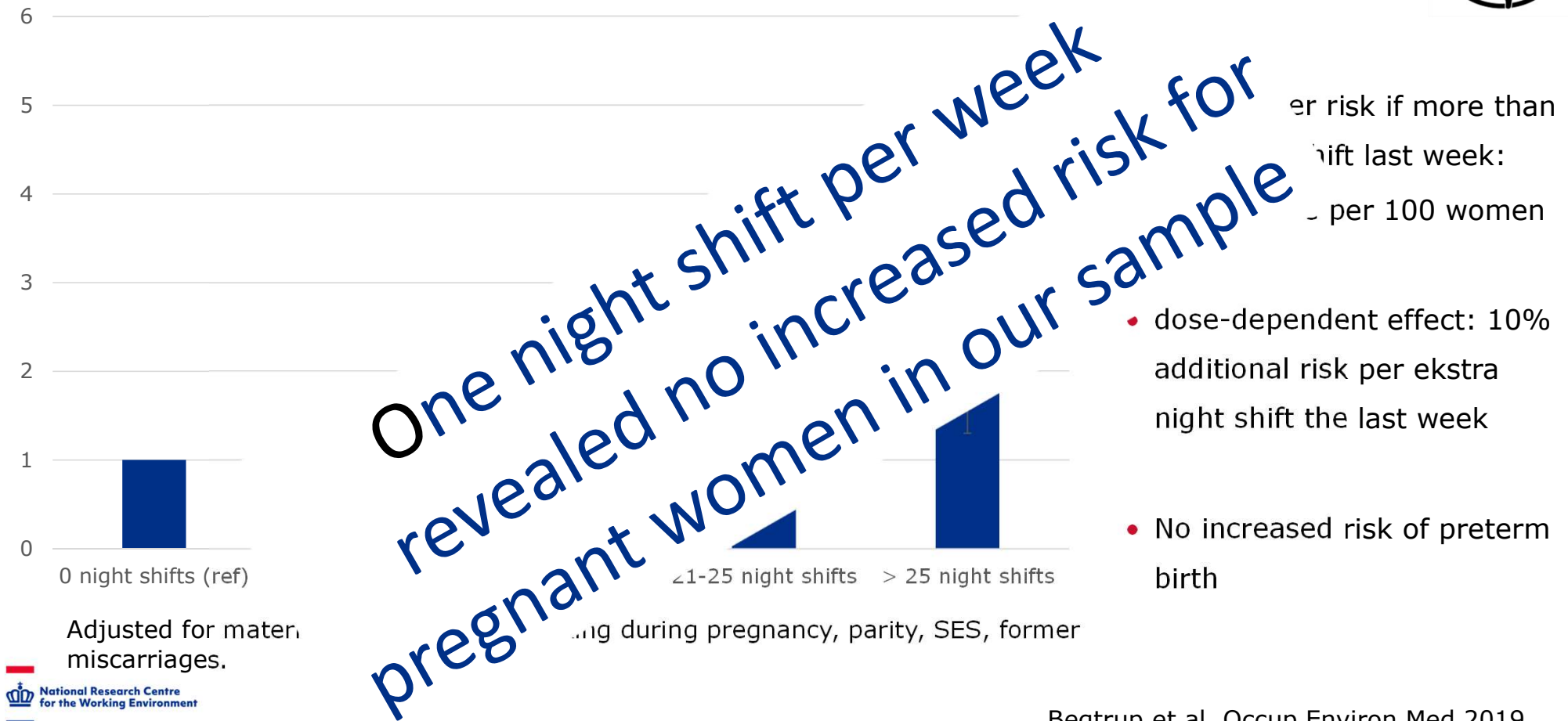
## Cumulated night work and miscarriage (weeks 4-22)



Adjusted for maternal age, BMI and smoking during pregnancy, parity, SES, former miscarriages.

- 30% higher risk if more than one night shift last week:  
1 extra case per 100 women
- Dose-dependent effect: 10% additional risk per ekstra night shift the last week
- No increased risk of preterm birth

## Cumulated night work and miscarriage (weeks 4-12)



Begtrup et al. Occup Environ Med 2019  
 Specht et al. PLoS One (2019)

## Guidelines for a good shift system

Fourteen rules were given in BEST 3, Guidelines for shiftworkers, reprinted in Appendix 2 of BEST 7, and are worth repeating here.

1. Minimise permanent nights
2. Minimise sequence of nights: only 2-4 night shifts in succession should be worked
3. Avoid fast double-backs

8. Rotate forward

- These overall recommendations still hold, although we may formulate them differently
- The level of evidence is higher
- The good news is that we have been giving consistent advice over decades



## Do we know it all?

- Still finetuning to do e.g. what is the optimal number of consecutive night shifts when considering different outcomes?
- Other work schedule characteristics e.g. shift duration and breaks
- Combinations of different shift schedule characteristics e.g. is the risk associated with 3\*8 hour night shift lower than the risk with 2\*12 hour night shifts?
- Scheduling and disease e.g. cardiovascular disease, diabetes, cancer
- Temporality – e.g. when and for how long?
- Vulnerable groups e.g. people with chronic diseases or high risk jobs

## Do we know it all?

- Still finetuning to do e.g. what is the optimal duration of consecutive night shifts
- Other work schedule characteristics e.g. breaks
- Combinations of different shift systems e.g. is the risk associated with 3\*8 hour night shift the same as 2\*12 hour night shifts?
- Scheduling and discipline e.g. disease, diabetes, cancer
- Temporality – e.g. how long?
- Vulnerable groups e.g. people with chronic diseases or high risk jobs

**There is still work to do**

# Thank you for your attention

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I declare no conflicts of interest