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European Commission

DG for Employment, Social Affairs and Equal Opportunities

Study to support an Impact Assessment on further action at European level regarding Directive 2003/88/EC and the evolution of working time organisation.

Annex 1 - Study on health and safety aspects of working time

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Contents

Full report

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1 Introduction

On 2005-03-23 at 01:20 pm an explosion occurred at the BP refinery at Texas City, USA, resulting in 180 injured and 15 killed persons, and financial losses exceeding 1.5 billion US $. The responsible board operator had been working for 29 consecutive 12 h shifts, without any day off. The US Chemical Safety and Hazard Investigation Board (2007), which analyzed the accident, came to the conclusion that "fatigue was a likely contributing factor".

This does not seem to be an exception but rather the rule in such accidents. Reviewing some disastrous accidents from 1976 (Seveso) until 2010 (Deepwater horizon) (see Table 1) shows that in most of these cases one or even several characteristics related to the arrangement of working hours can be found which may have contributed to the impaired performance of the operators; e.g. working at unusual hours (nights, shifts), working long hours (12h shifts), postponing rest periods (up to 37 shifts in a sequence), or using shift systems which violate ergonomic recommendations (e.g. Wedderburn, 1991).

Although such single events do not prove anything at all, it seems remarkable that the arrangement of working hours in the BP refinery case is an expedient illustration of at least two of the central problems in the organization of working hours addressed in the working time directive (WTD): working long hours, e.g. 12 h shifts, thus reducing the daily rest period and time for recuperation, and postponing weekly rest periods – although the working hours in this case would not have been covered by the WTD. The case clearly illustrates that long hours and insufficient rest can contribute substantially to the safety of operators, the plant and its environment, as well as the general public. Although it is no proof this case nicely demonstrates the findings of our review on the effects of the organization of working time on health and safety.

1.1 Methods

The findings and conclusions reported in this report on the effects of working hours on safety, health and work-life-balance are based on an updated review of the effects on long work hours, a special review on more recent results on the effects of different aspects of rest periods and their postponement, a review on the effects of working at unusual times, e.g. Saturdays, Sundays, or evenings, and a summary of the findings of the effects of working shifts and/or nights and/or flexible working hours, as well as on our expertise in the field of the ergonomics of working times. In the areas of long working hours and working at unusual hours additional statistical analyses of available data sets (European Working Conditions Survey, EWCS, and national German data) have been conducted.

Table 1: Disastrous incidents and working hours

Location	Date	Unusual hours			Long working hours	Rest periods
		Shift work	During night time	Weekend or public holiday		
Seveso (Meda), Italy	1976-07-10	X	-	Saturday		
Harrisburg, USA	1979-03-28	X	X	-		
Bhopal, India	1984-12-02/03	X	X	Sunday/Monday		
Pripyat, Ukraine (Chernobyl)	1986-04-26	X	X	Saturday		
Schweizerhalle, Switzerland	1986-11-01	X	X	Saturday		
Bligh Reef, USA	1989-03-24	X	X	Good Friday		
Milford Haven, Great Britain	1994-07-24	X	-	Sunday		
Texas City, USA	2005-03-23	X	-	-	12 h shifts	29 or more consecutive days
Gulf of Mexico	2010-04-20	X	21:45	-		

The literature review on working long hours is based on the review by Wirtz (2010) in the context of her dissertation and completed by an update of the evidence published since the closing of this review in 2009 until July 2010. This also applies to the effects of working unusual hours (evenings, Saturdays and Sundays). Bases for the literature search and survey were the relevant common databases, e.g. psychinfo, medline, PubMed, ILO publications, which were searched via online access, as well as individualized backward searches based on individual publications. A number of (more specialized) studies dealing with long work hours has thus not been referenced in the reference list of this report but can be found in the reference list in the study by Wirtz (2010), which is also available online under http://oops.uni-oldenburg.de/volltexte/2010/ 996/pdf/wirlan10.pdf

The literature review on rest periods and their postponement is also based on an online search, using the same databases for the more recent findings on this topic. Since the results, as expected, were rather scarce, the argumentation and the conclusions further had to rely on "classical" ergonomics argumentations concerning the mechanisms of strain, fatigue and rest, as well as on some findings in the context of other working time problems, e.g. shift work. All of the recent publications that were accessible have been referenced in the references of this report, while for the classical evidence in general only summarizing sources have been included, together with some rather old references, in order to demonstrate that a lot of the evidence concerning rest periods has already a long history from research, but not necessary from implementation.

The results on the effects of shift work are based on research in connection with a recent implementation of an internet platform (http://inqa.gawo-ev.de/cms/), giving guidance for the design of working hours (long working hours, flexible working hours and especially shift work). This has been complemented by a survey of very recent publications, especially concerning the association of shift work with cancer, since this is a rather new topic in the context of shift work research. The survey has not addressed differential effects of different shift systems but concentrated on the more general effects of shift work, so the references are mostly of the type of a survey. A complete review of the literature on shift work was neither requested nor possible in the context of the available resources.

Also for flexible working hours the results are based on earlier work and the above mentioned platform, in conjunction with an internet search for recent research on the effects of flexible working hours. This search resulted in a very small number of relevant references, which have been included where accessible.

The review of the literature had to be performed as a narrative review, since quantitative meta-analytic approaches were not appropriate due to substantial heterogeneity between studies and the quality of the available and accessible reported results. This results in part from different methodologies used, different operationalizations of the relevant concepts and a lack of quantitative data, which would allow for a recombination of the results. The approach taken thus was to start with available theoretical considerations about the mechanisms of the effects of long working hours, working at unusual hours, and in this case with a cross check to shift work, shift work, and the mechanisms of rest breaks, again with a cross check to selected results from shift work research, in this case the distinction between shift systems with different directions of rotation. These served as a basis for the inspection of the available (new) evidence on these topics and the narrative synthesis of the results.

For long working hours and for unusual working hours additional statistical analyses of the available data material (3rd and 4th EWCS, 2000 and 2005 on the European level; Gute Arbeit, 2004; BIBB-BAUA Erwerbstätigenbefragung, 2006, on the national German level) for cross check purposes have been performed. These analyses mainly served to check some special questions, especially those of controlling for possible confounding effects. This was necessary, e.g. in the area of the accident risk associated with work on Sundays, in order to cross validate results from one survey with a different sample, and to disentangle the effects of the confounders. Working on Sundays, e.g., is associated with different types of activities and jobs (and their different a priori risks) and with a number of other characteristics of the work schedules, like shift work, working on Saturdays, or in the evening. The approach generally taken for these analyses were (stepwise) multivariate logistic regressions, in order to determine the proportion of variance accounted for by the variable in question after controlling for the effects of other, confounding variables. This represents a rather conservative estimate of the effect

size, since all the common variance is attributed to those variables entering the equation before the core variable under consideration.

2 Long working hours

2.1 Long working hours and safety

Both early (Schneider, 1911; Vernon, 1921; Teissl, 1928) and more recent studies and reviews on the effects of long working hours on accident risk (Folkard, 1996; Hänecke et al., 1998; Lowery et al., 1998; Nachreiner, 2002; White & Beswick, 2003; Dong, 2005; Lombardi et al., 2010) show consistent results, indicating that the accident risk increases with an increase in hours worked per day and per week. The available results clearly demonstrate an exponential risk increase beyond the 7th, 8th, or 9th hour worked per day, resulting e.g. in a duplication of the risk for the 12th hour of a shift as compared to the average risk during an 8h shift, with the absolute level of the risk depending on the type of activity. Fig. 1 shows an example for such results from the study by Haenecke et al. (1998). This can be interpreted as a (fatigue based) loss of working capacity which may result in an increased risk for the whole work system, its environment or even the general public.

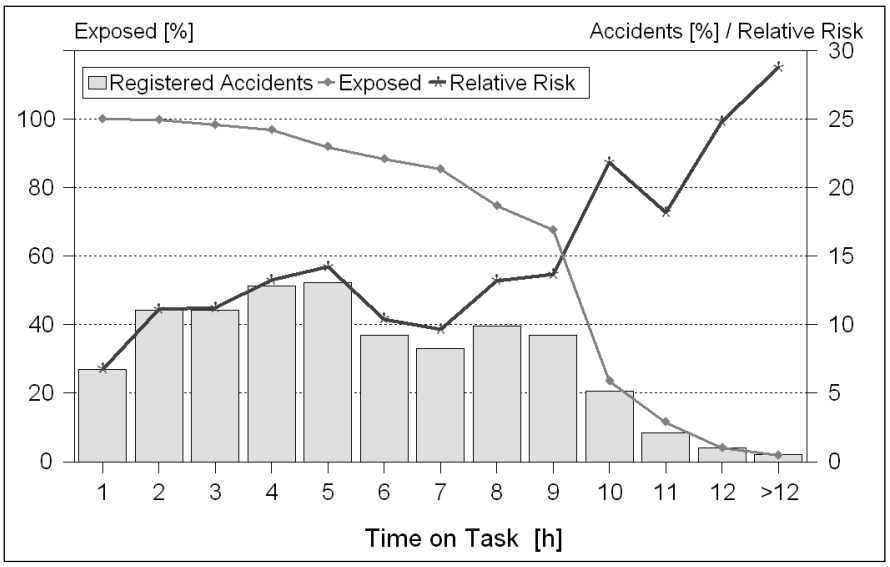

Figure 1: Relative risk of an accident with time lost as a function of hours on duty (adapted from Haenecke et al., 1998)

The number of hours worked / week also influences the risk of occupational accidents (Vegso et al., 2007) and the probability of accidents on the way home from work (Kirkcaldy et al., 1997). As compared to employees working ≤ 40 h/week, the accident risk for workers with 65 or more h/week shows an increase of 88 % (Vegso et al., 2007). These findings are supported by results of Dembe et al. (2005) who demonstrated consistent structural trends: In a sample of 10,000 persons, representative of the U.S. population, the authors showed a clear dose-response-effect of hours worked per day and per week on the incidence of accident-based injuries or illnesses. The incidence rate per 100 worker years increased by 100 % between < 40 and ≥ 65 h/week, and between < 8 and > 14 h/day, respectively. Thus, a substantial influence of hours worked per week and per day on the accident risk could be demonstrated, before and after controlling for demographic characteristics and workplace exposures.

Folkard & Lombardi (2004, 2006) developed a "Risk Index" in order to predict the accident risk from different work schedule characteristics, based on the studies noted above and others. They reported a cumulative trend in accident risk depending on both the number of h/day and h/week (see Figure 2 and Figure 3). According to these results the accident risk increases disproportionately with each hour worked/day beyond the 8th hour and with every consecutive shift worked. The authors used 12h shifts in Figure 3, which shows that there is a substantial risk increase even within the maximum of 48 h/week in the existing EU working time directive. The accident risk decreases during times of rest and recovery (both within and between shifts) which stresses the importance of sufficient recovery periods in order to avoid an accumulation of the accident risk (see also the section on rest periods).

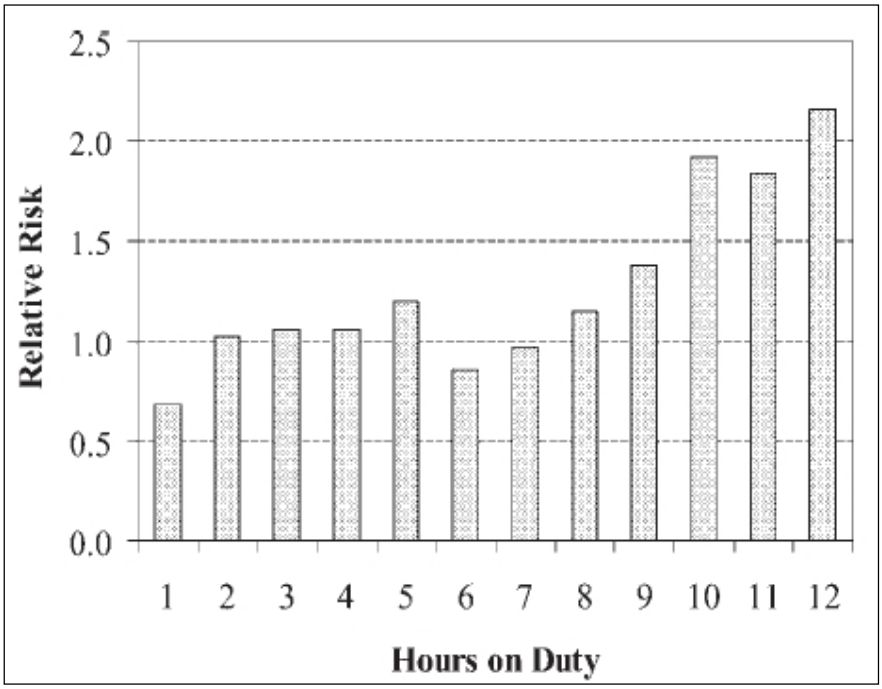

Figure 2: Mean relative accident risk over hours on duty
(Folkard & Lombardi, 2006)

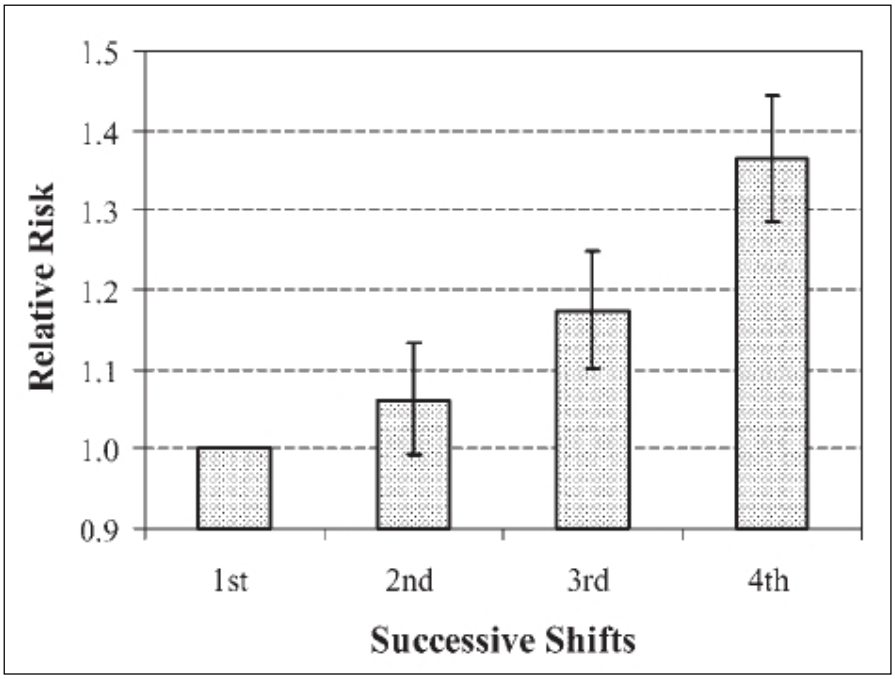

Figure 3: Mean relative accident risk over successive day shifts, 95 % CIs (Folkard & Lombardi, 2006)

However, Spencer et al. (2006) argue that predicting the accident risk from weekly working hours alone is not advisable, without taking into account other work schedule components, e.g., length of shift, type of shift, or rest breaks. Rest breaks should be considered on different dimensions, such as breaks within the shift, daily rest periods (e.g., time between two consecutive shifts), and weekly rest periods (e.g., on weekends). It is difficult to isolate the effects of such different work schedule attributes, because when the work week is extended beyond about 40 hours workers will probably also work in longer shifts, longer spans of shifts, at unusual times and therefore also at riskier times of the day or the week.

2.2 Long working hours and patient safety

There is evidence that not only the safety of the workers themselves can be impaired by working long hours, but that long working hours can impair product safety as well, e.g. long working hours of medical staff can negatively affect patient safety and health. In a study by Rogers et al. (2004) on nurses in the United States (n=393) it could be demonstrated that working > 12 h/day, overtime, and > 40 h/week increased the risk of errors in nurses. Logbooks over 2x2 weeks were used, measuring the scheduled and actual work hours, self reported errors and near errors, and sleep/wake patterns of nurses. The risk of errors was 1.85 times higher for nurses working 8.5-12.5h/day and even 3.29 times higher in nurses with > 12.5h/day compared to individuals working less than 8.5 h/day. Working times above 40h/week increased the risk of errors by 1.96 compared to < 40h/week.

In a review study, Weinger & Ancoli-Israel (2002) report that sleep deprivation, which can be caused by long working hours, night shift, and other work schedule factors, increases the risk of errors in medical staff and thus is another risk factor for patient safety related to long working hours.

Comparing traditional work schedules in British hospitals with intervention schedules, which were taking account of the EU working time directive, Cappuccio et al. (2009) showed an improvement regarding patient safety for the intervention schedule in comparison with the traditional schedule.

Reducing working time of junior doctors from 52.4 h/week to 43.2 h/week lead to increased time for sleep and resulted in 32.7 % fewer total medical errors. Landrigan et al. (2004) found similar effects in hospitals in the United States by changing extended (24h) shifts into shorter shifts and reducing weekly working hours from 77-81 h/week to ca. 63 h/week. Medical staff working in the intervention schedule made 36 % less medical errors than individuals on the traditional schedule. Both studies reduced not only working hours but also limited the number of night shifts and added other work schedule improvements. Therefore, it is not sufficiently clear, if the improvements in patient safety were caused by the working time reduction alone. However, it could be demonstrated, that careful work scheduling in conjunction with a work hour reduction can improve not only safety and health of employees but also of patients in hospitals and care facilities.

In a recent review Ehara (2008) analyzed the results of seven studies (5 intervention, 2 observational studies) dealing directly with work hours and patient safety (including the above mentioned Landrigan et al. study) and came to the conclusion that from these studies four suggest that a reduction in working hours had a favorable effect on patient safety indicators, three studies did not find a significant change and that no study found that reduced working hours were harmful to patient safety.

2.3 Long working hours and health

2.3.1 Overall health

Several reviews and empirical studies demonstrate various negative health effects of extended working hours: Long working hours are associated with poor perceived health, more illnesses, or even increased mortality (Sparks & Cooper, 1997; Spurgeon et al., 1997; Worrall & Cooper, 1999; Ettner & Grzywacz, 2001; van der Hulst, 2003; White & Beswick, 2003; Caruso et al., 2004a; Dembe et al., 2005; Kecklund, 2005; Caruso, 2006; Grosch et al., 2006; Rädiker et al., 2006; ILO, 2007; Rüters et al., 2008; Wirtz, 2010; Wirtz & Nachreiner, 2010).

In a study by Worrall & Cooper (1999) of managers in the UK (n=1,350), 21 % of managers with < 35 h/week reported a negative effect on their overall health by their work, as opposed to 40 % in the group of persons with 35-40 h/week and 75 % in persons with ≥ 60 h/week. These results are supported by findings from Wirtz (2010) who cross-validated the results of four different and independent samples, representative of the work force in Germany and the European Union. This study used the 3rd and 4th European Working Conditions Surveys (EWCS) from 2000 and 2005 as well as samples of two German surveys ("Was ist Gute Arbeit?", 2004, and "BiBB/BAuA Erwerbstaetigenbefragung", 2006); sample size ranged from $n \approx 4{,}000$ to $n \approx 20{,}000$ employed workers. In these studies, almost linear relationships between the amount of hours worked per week and several health impairments were observed: compared with part-time work (< 35 h/week), full-time work (35-47.9 h/week) increased the risk of reporting at least one health impairment on average by 20 % to 70 %, and long working hours (> 48 h/week) elevated the risk by 50 % to 100 % (see also Figure 4; differences in the level of complaints between samples result from a differing number of complaints covered in the various surveys and the questions asked). These findings were structurally consistent among all four samples and persisted even after controlling for several potential confounders, such as demographic variables, type and intensity of workload and additional work schedule attributes. The validity and the potential range for generalizing these results must therefore considered to be very high. Consistent results were also reported by Ettner & Grzywacz (2001) who found an increase in the risk of health problems by 25 % for employees working > 45 h/week, as compared to employees with less than 45 h/week.

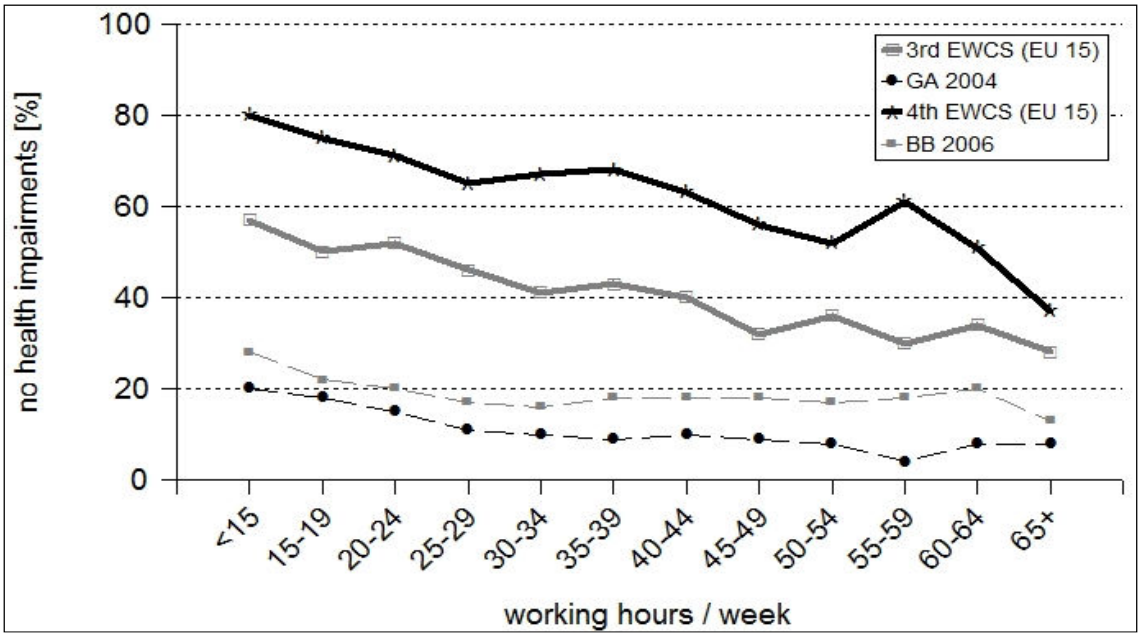

Figure 4: Frequency of reporting no health impairments over weekly working hours in four independent samples (3rd and 4th EWCS from 2000 and 2005, "Was ist gute Arbeit?" (GA 2004) and BIBB/BAuA Erwerbstaetigenbefragung (BB 2006);
see also Wirtz, 2010)

2.3.2 Psycho-vegetative impairments

Long working hours are associated not only with perceived overall health but also with several distinct health problems, such as psycho-vegetative impairments (e.g., mental health, different vegetative symptoms, gastrointestinal disorders, sleep problems, musculo-skeletal symptoms, or cardiovascular diseases).

Proctor et al. (1996), Baldwin et al. (1997), Rädiker et al. (2006), Rüters (2008), Artazcoz et al. (2009), Wirtz (2010), and Wirtz & Nachreiner (2010) demonstrated negative effects of long work hours on psycho-vegetative disorders and mental health. They found almost linear relationships between the number of hours worked / week and the frequency of reported psycho-vegetative impairments and depressive symptoms, which are shown in Figure 5. Furthermore, Lammers et al. (2007) showed that each additional hour worked / week increases the risk of psycho-vegetative health impairments by about 2 %, based on data of the 3rd EWCS. Remarkably, this increase in psycho-vegetative impairments, associated with an increasing number of working hours, can already be found in part-time workers (see Figure 5).

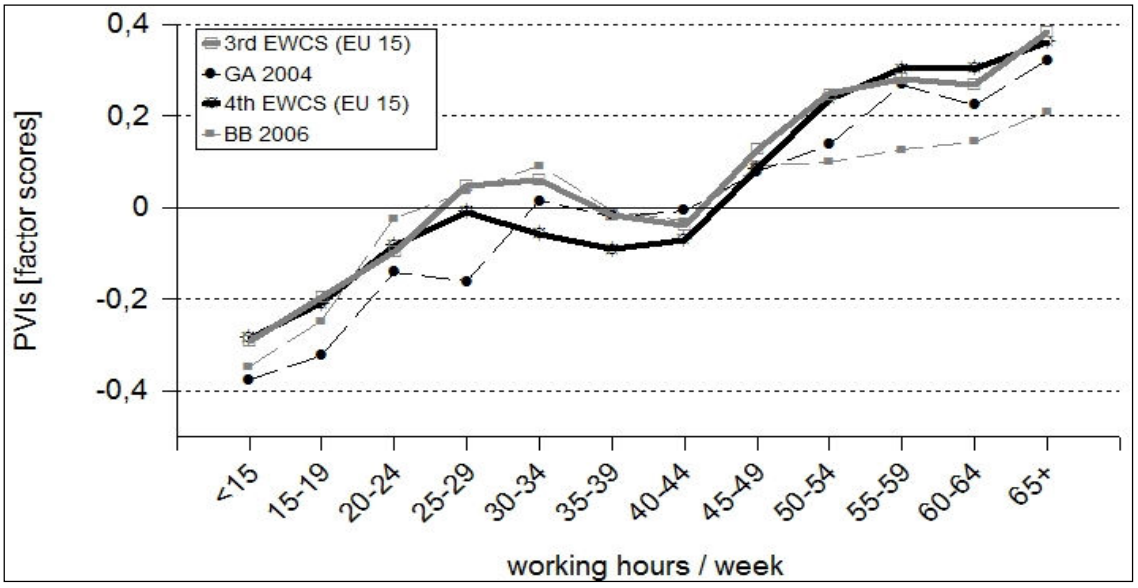

Figure 5: Psycho-vegetative impairments (PVIs) over weekly working hours in four independent samples (3rd and 4th EWCS from 2000 and 2005, "Was ist gute Arbeit?" (GA 2004) and BIBB/BAuA Erwerbstaetigenbefragung (BB 2006);
see also Wirtz, 2010)

An interesting observation in Figure 5 is the drop in reported impairments from those with 30-34 h to those with 35-39 hours. This might be the result of combining two different populations, those with part time and those with full time contracts. So the group with 35-39 hours might in fact be composed of two different subgroups, those working overtime in part time and those working full time with 35-39, without overtime. If this were so, the results for that group should better be separated for both subgroups, with a higher amount of complaints for those working overtime in part time contracts and a lower amount of complaints for those working 35-39h in full time most probably, yielding two separate distinctive regression functions. If this were so this could mean that working overtime – in relation to the contractual and thus the time expected to be devoted to work – is an essential factor besides the absolute amount of hours actually worked. This, however, remains to be analyzed in more detail.

2.3.3 Musculo-skeletal problems

There are only few consistent findings regarding the effects of long working hours on musculo-skeletal impairments, mostly due to lacking control of confounding factors, such as shift work, type and intensity of work load, job type, and demographic characteristics. However, several studies report a weak but consistent overall relationship between long working hours and musculo-skeletal problems (Lipscomb et al., 2002; Grosch et al., 2006; Trinkoff et al., 2006; Caruso & Waters, 2008; Wirtz, 2010).

Grosch et al. (2006) demonstrated that the risk of reporting poor overall physical health due to working hours above 70 h/week was five times higher than for persons working 35-40 h/week. The risk of reporting arm and back pain was elevated by 60 % for workers with > 70 h/week compared to full-time workers with 35-40 h/week. However, any increase in working hours between 40 and 70 h/week did not increase the risk of physical health impairments significantly. The authors used a representative sample of the U.S. population (n = 2,765) and adjusted their statistical analyses for individual characteristics, such as age, gender, and education, but did not control for work load

attributes, e.g. the amount of physical work. This lack of control may be one explanation of the rather weak relations between weekly working hours and physical health.

On the other hand, Trinkoff et al. (2006) found no statistically significant effect of long work hours after controlling for physical demands, which had the strongest effect on musculo-skeletal symptoms. However, results reported by Lipscomb et al. (2002) indicate that the number of h/week has an effect on the risk of physical health problems, when combined with other potentially harmful working time attributes, such as long daily and weekly working hours, work on weekends, or other than day shift. Working > 12 h/day and > 40 h/week increased the risk of reporting musculo-skeletal problems by 230 % to 260 %, compared to working < 12 h/day and < 40 h/week.

Wirtz (2010) reported that the risk of musculo-skeletal impairments was associated with the number of hours worked per week in a linear relationship. However, the amount of weekly working hours did not have a strong impact on the risk of musculo-skeletal problems. In contrast, the type and intensity of workload, and especially high physical demands, showed a considerably stronger impact on physical health problems. Thus, employees working under physically highly demanding working conditions showed the highest amount of physical health problems. However, these health impairments increased (moderately) with an increasing amount of hours worked per week, both for employees with and without high physical work load, whereas one would have expected a steeper increase in complaints with increasing hours for those with high physical work load, i.e. an interactive effect of work load and working hours.

2.3.4 Other symptoms

Long working hours are associated with several other health symptoms. For example, cardiovascular diseases can be promoted by extended working hours, leading to an increase in hypertension, myocardial infarction, and other heart symptoms (Uehata, 1991; Hayashi et al., 1996; Liu & Tanaka, 2002; Virtanen et al., 2010). Spurgeon (2003) and Beermann (2004) conclude in their reviews that the negative effects of long work hours on cardiovascular symptoms can be regarded as substantial and reliable.

Furthermore, results of Caruso et al. (2004b) and Wirtz et al. (2009) indicate that with an increasing number of working hours, the risk of gastrointestinal problems increases. However, there is still a lack of studies examining the impact of daily and weekly working hours on these types of health impairments (van der Hulst, 2003).

Some studies report an association between long working hours and mortality (Nylen et al., 2001), diabetes (Kawakami et al., 1999; Kroenke et al., 2006), reduced sleep duration (van der Hulst, 2003; Artazcoz et al., 2009; Krueger & Friedman, 2009; Tucker et al., 2010), and maladaptive health behaviors, such as increased consumption of alcohol, cigarette smoking, or lack of physical exercise and unhealthy weight gain (Nakamura et al., 1998; Trinkoff & Storr, 1998; Shields, 1999; Artazcoz et al., 2009). Reduced sleep duration can in turn increase the risk of several other health impairments, such as cardiovascular diseases, overweight, or weakening of the immune system (Dawson & Reid, 1997; Dinges et al., 1997; van der Hulst, 2003; Caruso, 2006; Härmä, 2006; Lombardi et al., 2010). Furthermore, Nachreiner et al. (2005), Rüters (2008), and Wirtz et al. (2009) report an increasing amount of sleep problems due to an increase in hours worked / week, which may add to the negative consequences of a reduced sleep duration.

2.4 Long term exposure, safety and health

There are almost no studies on the effects on safety and health of working extended hours over a long period. This is due to the fact that most studies examine the impact of the current usual weekly working hours on safety and health. Thus, they do not take into account for how long these (extended) daily/weekly working hours are worked, and if they are preceded / followed / interrupted by a period of shorter working time (e.g. in order to achieve an average max. 48 h/week, as provided in the

existing EU working time directive). Therefore it is not known if or how impairments to employees' health and safety (a) accumulate over an extended period of working long hours or overtime, and (b) if these impairments decrease again during a subsequent period of shorter working hours; i.e. we know nothing about the long term dynamics of working long hours. We do not know anything even for periods like one year, which can be agreed as a possible reference period between employers and unions in some countries, not to mention longer periods, e.g. extended periods during a working life or a complete working life.

This problem is very close to or connected with the problem of not allowing for or postponing adequate rest breaks, which will be dealt with below. It would, however, therefore be most important to have (or acquire) some evidence how shorter and longer periods of extended working hours affect employees' health and safety before determining certain reference periods for any maximum average number of weekly working hours. As will be shown further down, a conservative strategy would seem to restrict such reference periods for averaging peaks and troughs in order to avoid any long term accumulation of negative effects.

A prospective follow-up study in Finland investigated the impact of different working conditions on the risk of leaving work due to disability retirement (Krause et al., 1997; n = 1,038 Finnish men). The results indicate that employees working > 60 h/week have a 2.75 times higher risk of disability retirement in the following four years than employees working < 40 h/week (at the baseline assessment, but without control of the hours worked in the preceding or following years). The authors controlled for age but not for other potential confounding variables, although exposure to heavy physical work lead to a substantial risk increase and therefore probably should have been controlled for as well. The methodological problems of such an approach become quickly obvious: It is completely unknown how many hours these people worked in the following four years or until early retirement. Long term exposure and long term effects can only reasonably be addressed by longitudinal studies, preferable in a time series approach, with the number of hours worked and health problems recorded over a longer period of time.

Hoyer (2009, see also Hoyer & Nachreiner, 2010 for a condensed version) used such a time series approach with data on staffing, overtime, and time lost due to sickness and occupational accidents, collected over a period of five years (n = 1,100 German workers in an automobile production site). He demonstrated that an increase in actual and accumulated overtime lead to an increase in lost time due to sickness and occupational accidents within the next two months. In contrast, adapting staffing to production requirements reduced the amount of overtime worked and thus led to a decrease in time lost due to accidents and illnesses.

In conclusion, studies examining the concurrent and/or long term impact of long term exposure to long working hours on health and safety are urgently needed to achieve a better understanding and estimation of such dose-response effects over longer periods of time. When discussing about the extension of daily and/or weekly working hours, or the reduction of daily/weekly rest periods, it should be considered, that long daily and weekly working hours immediately increase the risk of accidents and injuries. Therefore, extending work hours over longer periods and without adequate rest will inevitably accumulate the accident risk and thus can be regarded as an important risk factor for both employee and product or patient safety and health.

2.5 Long working hours and work-life balance / social participation

Time for work, sleep, and leisure activities can be regarded as a zero-sum game: an increase in working hours inevitably leads to a reduction in time for sleep and / or leisure activities. Thus, the results of several studies show that family life and / or work-life balance (WLB) are being influenced by the number of working hours per week (e.g., Worrall & Cooper, 1999; Geurts & Demerouti, 2003; White & Beswick, 2003; Jansen et al., 2004; Grosch et al., 2006; Klenner & Schmidt, 2007; Geurts et al., 2009; Wirtz, 2010; Wirtz & Nachreiner, 2010). An increase in the actual number of working hours / week leads to a decrease in the reported quality of WLB (see also
Figure 11 and Figure 12 below).

26 out of 30 studies support this finding in a review by Albertsen et al. (2008). Furthermore, time spent with social and leisure activities decreases with longer working hours, before and after controlling for demographic variables and other working time attributes, such as working on weekends and / or shifts (Wirtz, 2010). The relations between working hours / week and reported WLB and leisure activities are almost linear, at least until about 40 h/week, demonstrating the negative impact of increasing work hours on work-life balance – beginning already in the domain of part time. Of course, however, the negative effects of increasing working times beyond 40 h/week on social participation are stronger than for part time work with < 35 h/week (Wirtz, 2010). A closer look at Figure 12 shows that the decline in WLB increases beyond 40 h, especially for those not working Sundays, so that 40 h/ week might indicate a limit up to which (on average) an unimpaired WLB can be retained, and thus, from a perspective of avoiding social impairments, arguing for a lower limit of weekly working hours than in the existing WTD.

Results reported by Klenner & Schmidt (2007) show a structurally consistent trend with correlations of $r = -0.3$ between weekly working hours and WLB, for both men and women. In the above mentioned study by Grosch et al. (2006), an increase in working hours elevated the risk of reporting impairments to family life by 1.55 for subjects reporting 41-48 h/week, 2.28 for 49-69 h/week, and 3.75 for > 70 h/week, compared to subjects working part-time (1-34 h/week). A negative impact of long working hours on family life could also be demonstrated by Worrall & Cooper (1999). They showed that 85 % to 90 % of managers with > 60 h/week reported negative effects of their work schedule on their social life, as opposed to 54 % of the managers with 35-40 h/week and 37 % working part-time (< 35 h/week). Thus, a decrease in WLB and quality of family life with increasing working hours per week could be found in several studies in the EU and the U.S., although in general there are not many studies providing empirical evidence for this relation and at the same time controlling for important confounders.

To our knowledge, there are almost no empirical studies in the available literature examining the amount of time spent with leisure and social activities reported (see also Caruso, 2006). However, time spent with social activities is an important indicator for social participation, which is very important for developing and maintaining social values and norms within a society. Therefore, reported subjective WLB should not be considered as an adequate and sufficient operationalization of social well-being or an unimpaired social life, but also more specific indicators, e.g. time spent with families and friends should be used. It must further be kept in mind that reported work-life balance is based on a subjective evaluation of the perceived available time for non-work activities, compared to a subjective standard on what should be available, as in satisfaction with (other) working conditions. Such subjective standards, however, depend on subjective experiences and normative standards and are thus adaptable to what can be “reasonably” achieved or expected.

Results of analyses of the 3rd and 4th EWCS indicate that time for household activities, childcare, sports, cultural activities, and individual training / learning activities is reduced with an increasing amount of working hours/week (Wirtz, 2010). These findings were again structurally similar in both EWCS samples from 2000 and 2005, before and after controlling for demographic and other working time attributes, indicating again a high validity and a wide range of generalization. Furthermore, Artazcoz et al. (2007, 2009) and Popham & Mitchell (2006) demonstrated negative effects of long working hours on time for physical exercise during leisure time. However, more studies measuring work schedule attributes and assessing social / leisure activities more precisely are urgently needed. This could best be achieved by conducting diary or time budget studies, for example, or asking for actual times spent within a reference period for such activities.

3 Working unusual hours

In the last decades, the number of employees working in flexible and / or unsocial hours (e.g., on evenings and weekends) has substantially increased (Golden & Figart, 2000; Demetriades & Pedersini, 2008). While work on Saturdays seems to be quite common again, discussions about allowing more work on Sundays are recurring in the European Union. However, working on weekends can reduce both recovery time and the amount of socially valuable hours. Despite all the attempts towards a 7x24 hours society the social rhythm in our societies remained as a stable pattern over the last 30 years, describing it as an evening and weekend society (e.g., Neuloh, 1964; Wedderburn, 1981; Baer et al., 1981, 1984; Hinnenberg et al., 2007).

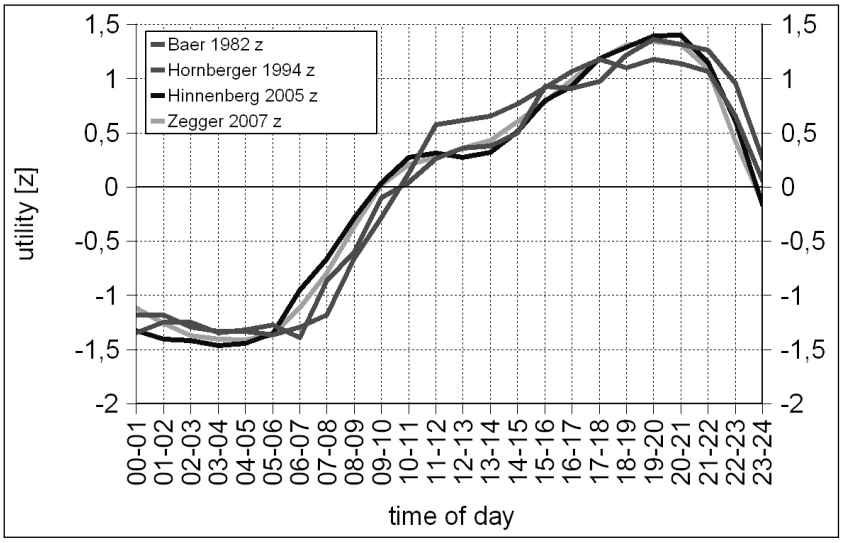

Figure 6: Utility of time across 25 years, Mondays – Thursdays
z-standardized, from Hinnenberg et al., 2007b

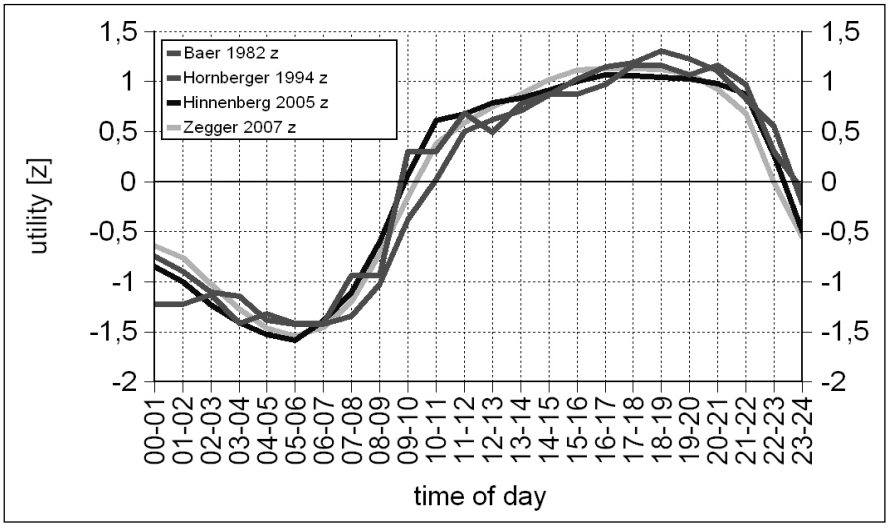

Figure 7: Utility of time across 25 years, Sundays,
z-standardized, from Hinnenberg et al., 2007b

Figure 6 (for Mondays through Thursdays) and 7 (for Sundays) show this rhythm, based on subjective utility ratings for each hour of a week from four studies conducted over the time span from 1982 until 2007 in four German samples, with scores z-standardized to achieve a common scaling. Within this rhythm, the utility of time for social and leisure activities is in general rated higher in the evenings and on weekends, with the highest values on Saturdays and Sundays. This is due to the fact that, for the majority of all society members, weekends (and especially Sundays) are in general free from work.

Thus, opportunities for social interaction are considerably increased on Saturdays and Sundays as compared to a normal work day, because nearly all the social environment, including partners for social interaction, is available for social activities / interaction on weekends. Especially family activities are most often scheduled on Sundays. This normative structure of the time enables members of a society to interact with each other and/or to take part in social activities. It is thus an important factor for active and passive socialisation activities and for developing and maintaining social norms and values.

Therefore, working at hours which are normatively devoted to social interaction, such as on evenings and weekends, and especially working on Sundays does interfere with the social rhythm, and should thus lead to severe impairments to social well-being as well as to a reduction of time for social commitments. Furthermore, quantity and quality of recovery time on weekends is most probably higher than on the other weekdays, due to this normative structure and the higher utility values of free time on weekends. Therefore, working on weekends should lead to poorer recovery and thus to a (fatigue based) loss of working capacity, which in turn could cause a higher accident risk on the following work days.

Only very few studies have addressed possible health and social effects of work on Saturdays and Sundays yet. However, there seems to be a quite common trend in the few preliminary results, indicating negative effects of work on evenings and weekends on social well-being and health and on the incidence of occupational accidents, which will be described in the following sections.

3.1 Safety

Using disabling and fatal accident rates in the state of Oregon, Horwitz and McCall (2003) estimated the odds ratio of a Sunday injury compared to a Tuesday injury at 3.129 and a Saturday injury compared to a Tuesday injury at 1.376. This study analysed 20,680 accepted workers' compensation claims filed by Oregon construction workers over the period of 1990-1997.

The results of our own studies (Rolfes, 2009; Nachreiner, 2009, 2010; Wirtz et al., 2010; Wirtz et al. (submitted)) on several large European (EWCS) and German samples indicate that, in accordance with the studies noted above, working on Sundays has a clear and substantial negative impact on safety, health, and the quality of work-life balance. Figure 8 shows this increased risk for occupational accidents, based on the EWCS survey of 2005 for the 31 countries included.

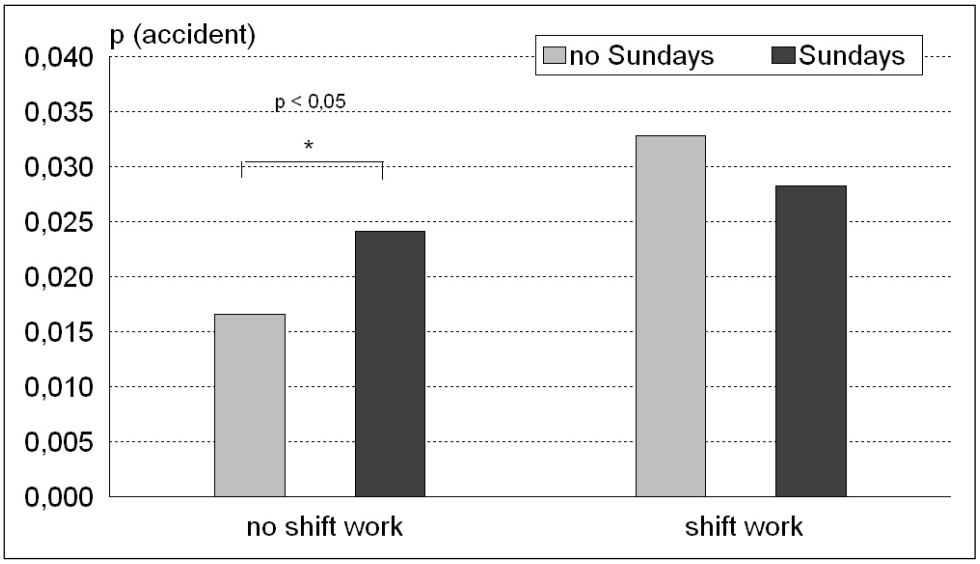

Figure 8: Accident risk for working on Sundays, controlled for working shifts (from Wirtz et al, submitted)

The probability of experiencing an occupational accident (with time lost) within the last year is clearly elevated for employees without shift work, who usually work on one or more Sundays per month, compared to workers working no Sundays. Shift work further increases the accident risk substantially. After controlling for gender, physical and mental workload, and autonomy, but not for any other working time attribute, a significant increase in the accident risk due to work on Sundays could be shown (OR: 1.238). However, controlling for workload and work schedule characteristics, work on Saturdays increased the accident risk by 1.389, whereas work on Sundays (OR: 1.087) did not have a significant influence on the occurrence of occupational accidents any more. This might be due to a methodological artefact. Since working on Saturdays is more common than working on Sundays, and working on Sundays usually includes also working on Saturdays, while the reverse is not true (i.e. those who work on Saturdays do not necessarily also work on Sundays), the variance in the accident risk that is attributable to Sundays is at least in part statistically attributed to work on Saturdays, the dominant variable. Since, in order to control for the effects of the other components, work on Saturdays had to be entered into the statistical regression equation before work on Sundays, this resulted in a substantial reduction of the variance attributable to work on Sundays. This problem has to be addressed further by testing some different and hopefully more suitable statistical control techniques.

A further and with regard to substance explanatory hypothesis is that, due to the social rhythm in European societies, time on weekends in general is most valuable for recovery, compared with all other weekdays. This might be due to the normative structure mentioned before, according to which rest and recuperation (together with social activities) are normatively associated with the weekend – and thus socially acceptable times for recuperation, whereas the same is not true for work days, which may lead to a less efficient recuperation process on such days. Rest on weekdays could thus be less recuperative that rest on Sundays.

Therefore, sufficient time for recovery on weekends seems to be an important factor for safety and health. Furthermore, results presented by Brogmus (2007) indicate a higher accident rate on Sundays than on any other weekday in a representative sample of the U.S. population. However, the relations between working on weekends and the incidence of occupational accidents need to be examined further, especially under the inclusion of more suitable data sets (most reported results are from EWCS data sets) and appropriate statistical control over confounding variables, e.g. the a priori risk of an accident for different jobs, since the distribution of working on Sundays is quite different for different sectors of the economy. In principle the accident rates across the 168 h of the week are available (at

least in Germany) from the workers compensations boards (Berufsgenossenschaften), what is missing, is the exposure data for working on Saturdays and Sundays, which would have to be constructed by rather complex statistical analyses (as in Haenecke et al., 1998)

3.2 Health

Available results clearly indicate a negative effect on health of working unsocial hours, e.g., on Saturdays, Sundays, and evenings (Lipscomb et al., 2002; Boisard et al., 2003; Jamal, 2004; Lyonette & Clark, 2009; Nachreiner, 2009, 2010; Wirtz, 2010; Wirtz & Nachreiner, 2010). Especially the risk of psycho-vegetative and psychosomatic impairments, such as gastrointestinal impairments, sleep problems, fatigue, or irritability, is increased in individuals working unusual or unsocial hours. These working time patterns interfere with biological circadian rhythms, e.g. body temperature, thereby increasing the risk of health impairments (Giebel et al., 2008).

Accordingly, Boisard et al. (2003) used the 3rd EWCS data to demonstrate that 57 % of individuals without Sunday work reported that work affected their health, as opposed to 66.9 % of individuals working at least 1 Sunday per month. 55.8 % of individuals never working on Saturdays reported health impairments due to their work, compared to 63.4 % of individuals with regular work on Saturdays. These findings – though not controlling for any potential confounders or using any inferential statistics procedures – generally match the results of Wirtz (2010) who showed with the 3rd and 4th EWCS data that working on Sundays increases the risk of reporting at least 1 health problem by 1.2 - 1.37 times – after controlling for demographic variables, type and intensity of work load, autonomy, and other work schedule attributes. F

igure 9 shows an example of such results from the 2005 EWCS (Wirtz & Nachreiner, submitted), where it can clearly be seen that the proportion of those with a least one (work attributed) health complaint is significantly higher for those working on Sundays as opposed to those working no Sundays, adjusted for age, sex, and children as covariates; and this holds for shift and non shift workers. Furthermore, there is also evidence for negative effects of work on evenings and Saturdays on employees' health (Boisard et al., 2003; Rüters, 2008; Wirtz, 2010).

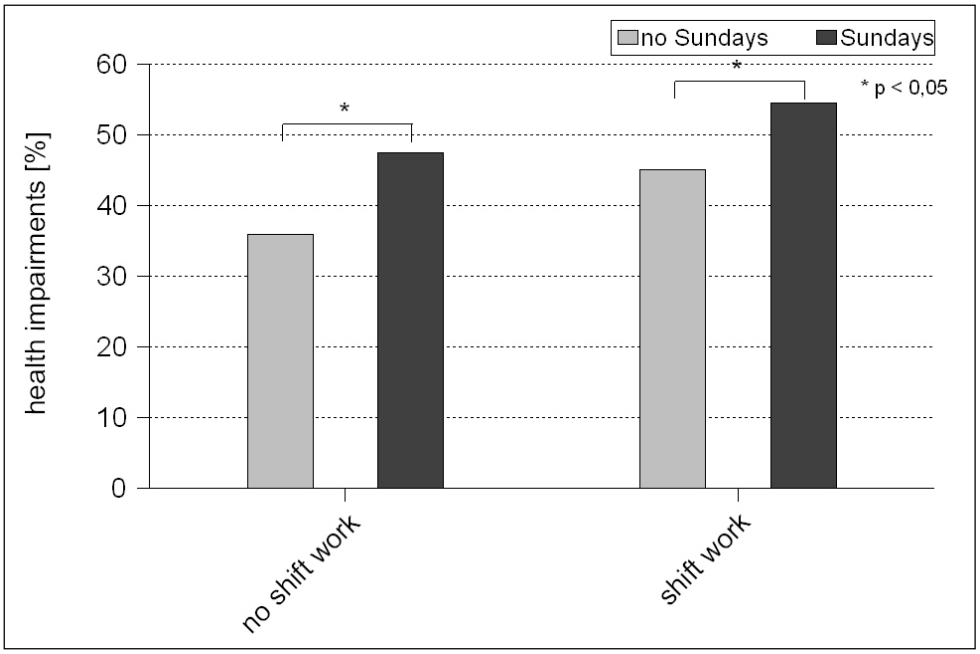

Figure 9: Proportions reporting at least one work related health complaint for working on Sundays, controlled for working shifts, EWCS 2005, 31 countries (Wirtz et al, submitted)

Kivimäki et al. (2006) in a Finnish prospective cohort study over 27 years (n = 788) showed that incomplete recovery from work during free weekends increased the mortality risk due to cardiovascular problems in initially healthy individuals. These findings were robust before and after controlling for several other risk factors and psychosocial working conditions. Although these results were based only on subjective reports on how much recovered the persons felt after a weekend without work, they indicate that insufficient recovery on weekends is an important risk factor for health and well-being.

3.3 Work-Life Balance

Any interference of working unusual hours with the social rhythm (by irregular working hours and work on evenings and weekends) should be associated with different social impairments, such as an impairment of family life and times for social activities (Wirtz et al., 2008). Several studies thus in fact do report a decrease in WLB due to unsocial working hours (Fagan & Burchell, 2002; Albertsen et al., 2008; Lyonette & Clark, 2009; Tucker et al., 2010; Wirtz, 2010), based mostly on data of the 3rd and 4th EWCS. The risk of reporting a poor WLB is increased by work on Sundays by 23.8 %, after controlling for demographic factors, workload, and working time attributes. As expected, working on evenings (OR: 1.84) and on Saturdays (OR: 1.49) also increases the risk of a poor WLB substantially (Wirtz & Nachreiner, 2010). Figure 10 shows an example of this impaired work-life balance due to work on Sundays (from Wirtz & Nachreiner, submitted). As can be clearly seen there is a substantial difference in work-life balance between those working on Sundays and those who do not work Sundays, even after controlling for age, sex, children and other work related variables.

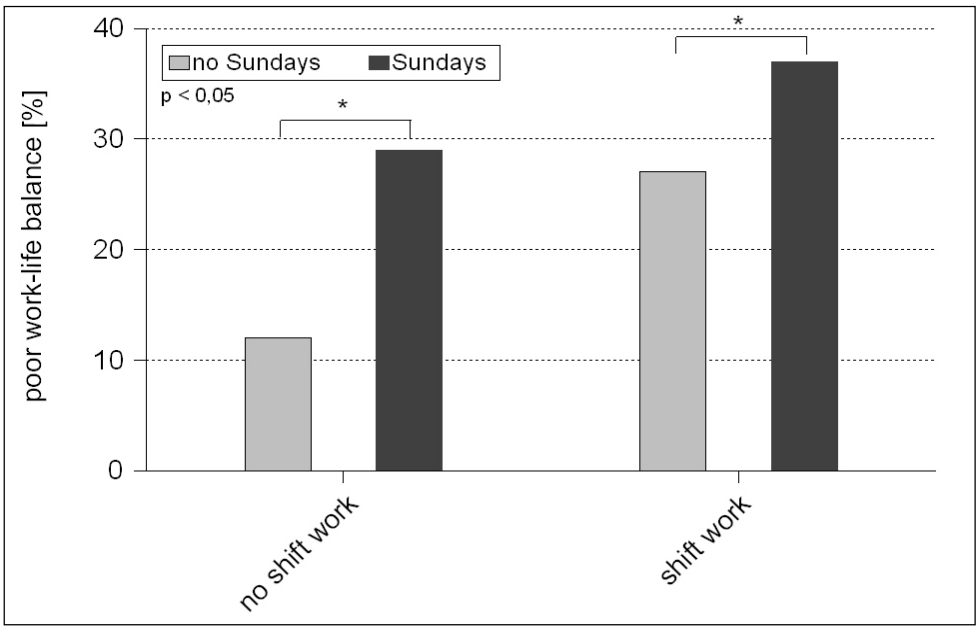

Figure 10: Proportions reporting a poor work-life balance for working on Sundays, controlled for working shifts and other confounders, EWCS 2005, 31 countries (Wirtz et al., submitted)

Fagan & Burchell (2002) reported results of the 3rd EWCS, in which 17 % of daytime only workers had a poor WLB, compared to 33 % in regular evening workers; 31 % working regular Saturdays, and

39 % with regular Sunday work reported poor WLB. However, the authors did not control for confounding factors and included no estimate of the predictive power.

Based on manager reports in a European company based survey, Kümmerling & Lehndorff (2007) demonstrated that the likelihood of sickness and absenteeism problems in European companies with work on weekends is 1.3 times higher than in establishments that do not require their staff to work on the weekend. Employee fluctuation is also reported to be increased in companies requiring weekend work.

4 Interactions of working long hours and unusual hours with other working time characteristics

4.1 Long working hours and unusual working times

As indicated by previous results (Wirtz et al., 2008), work at unsocial hours, e.g. evenings and weekends, interferes with the social rhythm of the society and thus shows detrimental effects on the reported WLB. A decrease in WLB can in turn increase the risk of psycho-vegetative health impairments (Frone, 2000; Grant-Vallone, 2001; Hammer et al., 2004; Lyonette & Clark, 2009; Wirtz & Nachreiner, 2010) and sickness absence (Jansen et al., 2006). Work on evenings and weekends may therefore have an indirect effect on health impairments in addition to its direct effects.

Additive effects of long working hours and work on evenings, Saturdays, and Sundays, variable working hours, shift and night work on health impairments, work-life balance, and time for leisure activities were reported by Wirtz (2010, see
Figure 11 and Figure 12). In general, the effects on health and social well-being of working long or extended hours is increased when combined with unsocial working hours. Thus, working unusual or unsocial hours alone negatively affects health and social well-being, and these negative effects are significantly enforced when combined with long working hours. As shown in
Figure 11 and Figure 12, scores for psycho-vegetative health impairments and WLB show an increase for individuals working regular Sundays that is comparable to working 15 to 20 hrs more per week without work on Sundays. It should be remembered, that those working on Sundays had to get a compensation for working on Sundays by a day off on a workday during the week (thereby postponing the weekly rest period), in order to comply with the provisions of the existing WTD.

Thus, the negative effects of work on Sundays obviously cannot be compensated for by allowing the same amount of time off on any other weekday (see also Bittman, 2005). These preliminary results, as shown in
Figure 11 and Figure 12, thus seem to indicate that in order to achieve a comparably low impairment to people not working on Sundays, those employees working on Sundays might need additional 14-15 h of free time, and thus less working time, per week – besides the usual compensatory free weekday. Such analyses should therefore be continued to test whether this holds also for other indicators of safety, health and work-life balance.

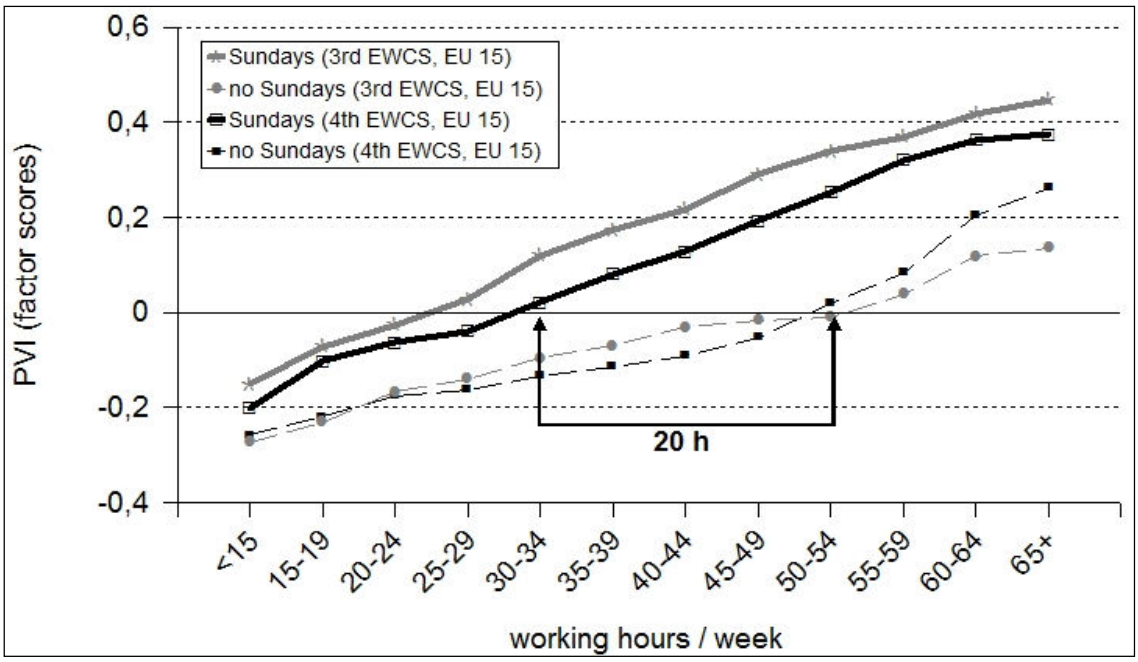

Figure 11: Psycho-vegetative impairments (PVI) for individuals with and without Sunday work over weekly working hours (based on Wirtz, 2010)

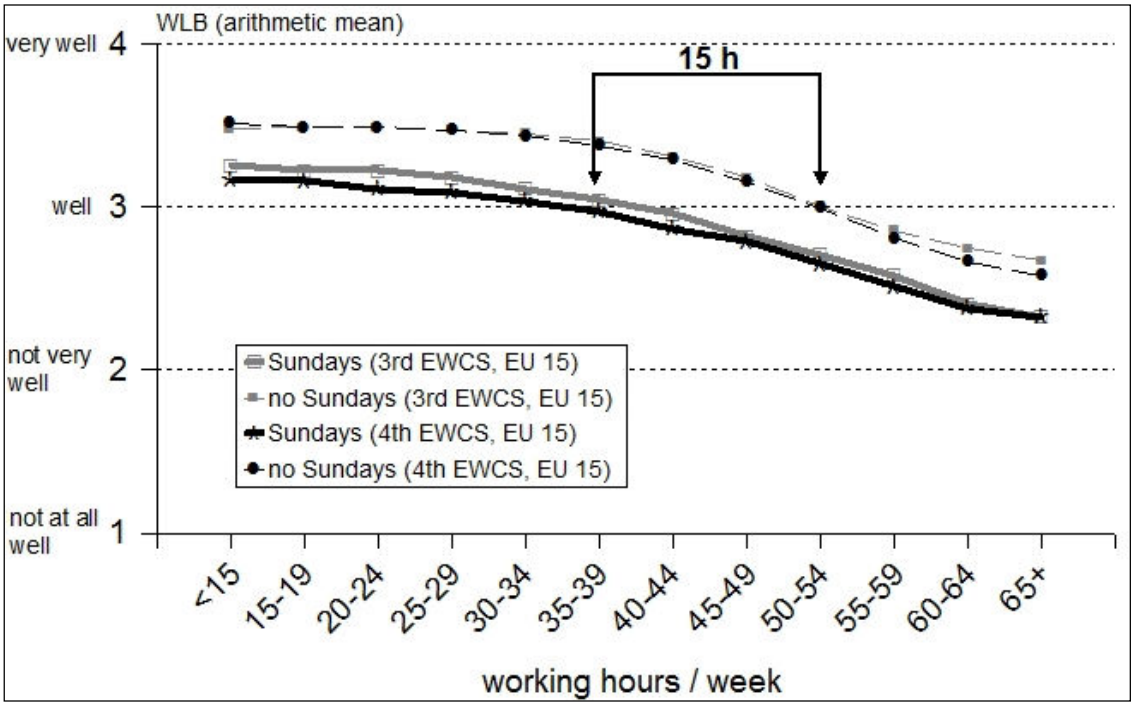

Figure 12: Subjective work-life balance (WLB) for individuals with and without Sunday work over weekly working hours (based on Wirtz, 2010)

A closer inspection of the graphs presented in Figure 12 shows that there is a clear cut difference between those working on Sundays and those working no Sundays, and that this difference and the trend over increasing working hours is remarkably stable from 2000 to 2005, which indicates that there is a quite stable difference for those working Sundays and those who do not. Besides the numerical differences per category of working hours, there is also a difference in the trends between both groups: those working no Sundays show a rather stable trend until 35-39 hours, where the beginning of a decrease in WLB can be observed, which from then on decreases substantially. For those working Sundays this decline starts definitely earlier, e.g. between 25 and 29 hours. Both trends then would suggest that there are some critical points in the number of working hours, beyond which the decline in WLB begins (and which, if combined, would suggest the above mentioned linear decrease in WLB for the total population. Taking the deviation from the stable state as an indication for beginning and to be avoided social impairments this could argue for fixing the number of hours/week at these inflection points, e.g. about 35 to 40 hours for those not working Sundays and 25 to 29 hours for those working unusual hours – at least from a perspective of avoiding social impairment.

4.2 Long working hours and control / autonomy over working hours

Several studies (e.g. Joyce et al., 2010a,b) demonstrate that control over and/or choice in arranging working hours by employees has a positive impact on their health and work-life balance. For example, Wirtz (2010) showed that control over different working conditions, including working time, had a positive effect on health and social well-being. However, the variable "control" showed no interactive effects with the weekly working time. Therefore, autonomy seems to have a positive impact independent of the length of the working week, (and most probably independent of other work schedule characteristics, which are – partially – controlled by the employee). However, negative effects of long working hours on health and social participation could be observed both for employees with and without control over their working hours (Janßen & Nachreiner, 2004; Burchell et al., 2007; Hughes & Parks, 2007; Valcour, 2007; Wirtz, 2010). Thus, the positive effects of having control over ones work scheduling will moderate the (reported) impairing effects to health and WLB, but do not protect against or completely compensate for the much stronger negative effects of working unusual and long hours (see Janßen & Nachreiner, 2004). The question, however, is whether there really are less negative effects, depending on a self-controlled more favorable arrangement of working hours, or whether this is a cognitive reinterpretation, since those in control of their working conditions would have, at least in part, to attribute the blame for any negative effects to themselves (because they had their choice in arranging their working hours) und thus tend to report less impairments. This, however, could only be analyzed with factual data on the working times and the impairments, which are not available at the moment.

4.3 Long working hours and type and intensity of workload

Exposure to high physical and mental workload increases the risk of health impairments. These effects are elevated by working long hours mostly in an additive manner (Wirtz, 2010). Thus, individuals with high (mental and/or physical) workload show a higher proportion of health impairments than individuals with lower workload, independent of the number of hours worked per week. This is true for the whole range of working hours from part-time to extended work hours. However, these results of analyses of the 3rd and 4th EWCS, and two large German samples may be due to a selection bias, where only healthy and fit individuals are able to cope with high workload for long working hours (known as healthy-worker-effect). Therefore, the negative effects of combining long working hours with high workload may have been underestimated. Support for this hypothesis can – at least in Germany – be found by a comparison of the proportion of those still working across different age groups, showing that there is such a (self-)selection process. So the results presented in the literature and in this report may be rather conservative estimates of the effects of coping with high workload for long hours.

In accordance with this hypothesis White & Beswick (2003) conclude in their review that job type and job demands can moderate the relationship between long working hours and health, although this topic was no central point in their study.

Mostly, the effects of physical and mental demands are being controlled for in the analyses of the effects of working hours by statistical analyses, and they have a demonstrable substantial impact on health. But there is a clear lack of studies examining the effects on safety, health, and WLB of combining long working hours with demanding working conditions, and controlling for a potential (self-)selection bias.

4.4 Shift work and long working hours

The effects of combining shift work with extended working hours are similar to the combined effects of unusual and long working hours. Wirtz (2010) reported additive effects on health and social well-being of combining shift and night work with long working hours. Thus, shift work increases the risk of impairments to health and WLB, and this negative effect is further increased by working extended hours (see also Rädiker et al., 2006; Rüters, 2008). In a literature review on the impact of extended work shifts, Knauth (2007) reported that it is difficult to draw firm conclusions from the available evidence due to methodological issues. Several studies comparing 8-h shifts with longer shifts report negative effects of extended work shifts on health and safety. However, there are a couple of methodological problems in the reviewed studies, such as a lack of control for confounding factors, e.g. shift start, type, and rotation, the distribution of rest periods, and the absence of comparable control groups, which prevent drawing firm generalizable conclusions.

5 Night and shift work

Shift work, and especially in combination with night work, constitutes a considerable risk to safety and health (Knauth & Hornberger, 1997; Wedderburn, 2000; Shields, 2002; Spurgeon, 2003; Costa, 2003; Folkard & Tucker, 2003; Knutson, 2003, Nachreiner et al., 2006). In particular impairments and disorders based on the desynchronization of periodically, i.e. circadian, controlled body functions, e.g. the sleep/wake rhythm and digestion, can be found. A full adaptation of biological rhythms to night work has not been observed – even after a number of consecutive night shifts (Knauth & Rutenfranz, 1976). This is quite plausible as there are other Zeitgebers than just work or daylight under real life conditions, i.e. social contacts, and consciousness about time. Besides older studies and reviews also the more recent ones clearly demonstrate the negative effects of work at unusual times, including shift work, on health and safety (Wirtz, 2010; Wirtz & Nachreiner, 2010).

In addition to being subjected to biological desynchronisation (or chronodisruption or circadian disruption, as it has been called in the more recent literature on shift work and cancer, Erren et al., 2009; Straif et al., 2007; see also Costa et al., 2010) shift workers are also subjected to a social desynchronisation, a desynchronization from the social rhythm of a society (Nachreiner et al., 1985, see also above, section 3). This means that shift workers – and in this case also already those without night work, e.g. those working in fixed or rotating morning/afternoon shifts – have to work during valuable times for social interaction and participation and thus are restricted from social participation and interaction (Baer et al., 1985; Hornberger & Knauth, 1993) leading to substantial social impairments.

Shift work, and especially shift work including night work, is therefore considered a substantial risk factor for safety, health and well being, which is legally or by supreme court decisions already acknowledged in some member states of the EU (e.g. Germany; see also the current WTD).

5.1 Effects on safety

Generally speaking there is a consistent tendency for the risk of incidents, accidents or injuries to be higher on the afternoon shift than on the morning shift, with the highest risk on the night shift (for a detailed review see Folkard & Tucker, 2003), under otherwise comparable conditions. As this condition is often not met, e.g. through maintenance operations during the day shift, or a reduced traffic frequency during the night, leading to a change in the a priori risk probability, there are studies that report a higher risk on day than on night shifts. With a comparable or statistically controlled a priori risk, however, the evidence is clear: working at night bears a higher risk of an accident than during day work. Folkard and Lombardi (2004, 2006) have thus been able to show, that there is a circadian variation in the relative accident risk, with the maxima during the hours of the night shift and the minima in the beginning of the afternoon shift.

It must be mentioned that the increased risk is not only true for night shifts but also for late or afternoon shifts (especially in the late hours of that shift) in comparison with morning shifts, resulting in a generally higher accident risk for shift workers than for non shift workers (see results presented by Wirtz (2010) on the basis of the EWCSs; and sections 2 and 3 above, and especially Figure 8). Working at unusual times, and shift work clearly is a very special case of working at unusual times, is consistently associated with a higher risk to safety. It is thus not astonishing that the disastrous events mentioned in the Introduction were all associated with shift work, from the Seveso to the Deep Water Horizon explosion.

Furthermore, there is some reliable evidence that the relative risk of an accident increases over successive shifts (see Folkard & Tucker, 2003), and that this increase is substantially higher for successive night shifts than that for successive day shifts (Folkard & Lombardi, 2004, 2006). Whereas for both the increase follows an exponential function), pointing to a lack of (complete) recovery between shifts, this increase is definitely sharper for night shifts, resulting in a much greater difference for the fourth shift than for the first one.

Investigations have shown that with an increasing number of consecutive night shifts, but also for consecutive early shifts (Folkard & Barton, 1993; Kecklund & Akerstedt, 1995), there is an increased risk of an accumulated sleep deficit and thus increased sleepiness or decreased alertness during work hours (Knauth et al., 1983; Chan et al., 1987; Alfredsson et al., 1991; Escriba et al., 1992; Barak et al., 1995). In combination with the fatigue resulting from the actually ongoing work, especially when working long hours, this should result in an increase in the accident risk.

5.2 Effects on health

In general, shift work, especially that including night work, as a consequence of the circadian desynchronization increases the risk of sleep disorders (Sallinen & Kecklund, 2010), disorders of the digestive system (Costa, 1996; Knutsson & Bøggild, 2010), loss of appetite, cardiovascular diseases (Knutsson et al., 1986; Bøggild & Knutsson, 1999; Frost et al., 2009; Puttonen et al., 2010) and psycho-vegetative problems (Costa, 1995), i.e. impairments in functions that follow a circadian rhythm. In particular permanent night work thus increases the risk of health impairments to a substantial degree (Wedderburn, 2000; Knauth & Hornberger, 1997, see also Figure 9). Working shifts, whether they include night work or not, but in particular if they do, must therefore be considered as a special risk factor for health and well being.

5.2.1 Shift work and cancer

In October 2007, the International Agency for Research on Cancer (IARC) categorized shift work that involves circadian or chronodisruption as probably carcinogenic in humans (Straif et al., 2007; Erren et al., 2009; Kolstad, 2008; Costa et al., 2010). While the evidence from experiments with chronodisruption in animals is clear (leading to a classification of carcinogenic in animals), this is

definitely less the case with the epidemiological evidence for humans. A few epidemiological studies show a significant but rather weak association of cancer and night work, while others do not. This is why the IARC has classified shift work including a disruption of the circadian rhythm as probably carcinogenic to humans.

Six out of eight underlying epidemiological studies show a statistically significant, albeit always only very small risk enhancement through shift work including night work, especially for breast cancer in women and prostate cancer in men (both are the most prevalent types of cancer in women and men respectively).

The problem with the available evidence in humans, however, is that it has not been clearly defined what such a "circadian disruption" really is, how it could be (quantitatively) assessed, and how this disruption is associated with working shifts – e.g. what kind of shift systems lead to which degree of disruption, and from which degree of disruption over which span of time a triggering of cancer can be expected. This is one of the reasons why the exposure to "night work" including a "circadian disruption" as the causal agent has not been adequately classified yet, so that no dose (circadian disruption? or shift work including night work leading to circadian disruption?) – response (cancer) assessments can be performed. Shift work, even that including night work, encompasses a whole lot of different shift systems with demonstrably different effects (besides cancer). So the definition of the risk factor (if it were shift work including night work) is unclear until now. If it were the circadian disruption it will be necessary to specify how this can be quantified, a yet unresolved problem. As an aside it should be mentioned that the experimental manipulations conducted with animals are in no way comparable to the effects experienced by shift workers, although they support a possible causal mechanism for the observed carcinogenity in animals and a possible causal pathway for humans.

Another methodological criticism is the lack of information concerning the exposure time in humans, e.g. duration of the exposure and breaks in the exposure, i.e. especially the dynamics of the exposure.

A further problem with the available evidence is the confounding of night work with other working conditions (e.g. work in hospitals or as cabin attendants in the air traffic sector) in the available studies, which makes it difficult to clearly attribute the effects to the night work (since circadian or chronodisruption has not been measured).

A last problem with the available evidence is that it is restricted to special professional groups, e.g. flight attendants and nurses, who probably are also exposed to other cancer promoting agents, while a broad and representative survey is still missing.

The available evidence for the association of night work and cancer must thus until today be regarded as insufficient; more valid research results, with the above mentioned methodological problems adequately addressed, are therefore urgently required to assess and to reduce any possible risk of cancer associated with night and shift work.

5.2.2 Shift work and (psycho-) social impairments

Besides the desynchronization with the circadian physiological rhythms shift work (even where it does not include night work, e.g. alternating morning and afternoon shifts) also leads to a desynchronization from the social rhythm of a society (Ernst, 1984; see also section on unusal hours). As mentioned above, social activities are concentrated in the evenings and weekends, since this normally is the time free of work– except for those working unusual hours or shifts – which makes it easier to coordinate social or family activities.

Working shifts, like working other forms of unusual hours, must therefore interfere with such activities (Ernst, 1984, Nachreiner et al., 1984) and thus result in social impairments, as can be seen from the earliest to the most recent reviews (e.g. Mott et al., 1965; Bunnage, 1981; Knauth et al., 1983; Nachreiner et al., 1984; Nachreiner et al., 1985; Walker, 1985; Colligan & Rosa, 1990; Wedderburn, 1993: Shields, 2002; Albertsen et al., 2008).

Social impairments are mostly reported in those domains which require a coordination of activities and where the social partners for the interaction are bound to the general social rhythm and cannot adapt to that of the shift worker. As families try to partially adapt to their shift working member(s) (e.g. Neuloh, 1964, Nachreiner et al., 1975) impairments, although quite considerable, are less pronounced than in those areas which do not adapt to the deviating rhythm of shift workers (e.g. organizations, public life).

Social impairments thus range from effects on the shift worker, her/his personality structure and interests (e.g. Nachreiner, 1975), the relations with primary (family) and secondary groups (friends, clubs, organizations) (e.g. Jansen et al., 2004; van Amelsvoort et al., 2004)) to the engagement in public organizations (community councils, Nachreiner et al., 1985). All reviews consistently show these social impairments, more recently dealt with under the topic of work-life balance or work-nonwork conflict. Work-life balance thus is decreased in shift workers, and due to the desynchronization more work-nonwork conflicts can be observed (Albertsen et al., 2008; see also Figure 10).

Shift work, however, does not only affect shift workers only. It also affects their partners and their children. Shift work of the partner requires some form of adaptation, connected with special efforts to manage a partnership or family life (Neuloh, 1964). Shift workers thus show a higher proportion of broken partnerships and divorces and difficulties in finding a partner/establishing a partnership (e.g. Nachreiner, 1985; White et al., 1990; Presser 2000).

It has further been shown that children of shift workers achieve lower performance at school and have a lower chance of attending higher education compared to children of day working fathers – as well as showing impairments in their social lives (Diekmann et al., 1981; Maasen, 1981; Volger et al., 1988; Lenzing & Nachreiner, 2001; Heymann & Earle, 2001; Strazdins et al., 2004).

It can thus be firmly concluded that shift work is a risk factor for the social well being of those working shifts as well as for those living together with them. It should also be observed that shift workers regularly show some kind of withdrawal from social activities, combined with a loss of interests in such activities (e.g. shift workers prefer solitary hobbies that can be performed without necessary coordination with others). The problem with this is that shift workers also withdraw form public live and the pursuit of their interest (e.g. in community councils, unions, etc.) which should also have an effect on society as a whole.

It should further be mentioned that different shift systems lead to different kinds/amounts of social impairment. For social impairment night work is not a prerequisite, these effects can also be observed with shift work not including night work, and in some instances even more than in shift work including night work, e.g. when there is a high proportion of afternoon shifts. As with health problems, some kinds of shift work tend to increase the impairments, while others show only moderate degrees of impairment (see e.g. Bonitz et al., 1987; Albertsen et al. 2008). Irrespective of such differential effects, however, shift work remains a risk factor for social participation and well being.

6 Rest periods and the postponement of rest periods

6.1 Introduction

There are a number of different reasons for introducing rest periods into the work process, e.g. avoiding negative consequences of work stress and work strain (e.g. physical and mental fatigue as well as other impairing effects, i.e. monotony, satiation, and reduced vigilance; see ISO 10075), recuperation and recovery from such effects, increasing performance and productivity, taking a meal, social interaction with colleagues at the work place, opportunities for sleep, leisure activities or social participation. It is obvious that these different functions require different kinds (and lengths) of rest periods, i.e. rest breaks during a shift, daily rest periods, weekly rest periods as well as longer periods of rest/absence from work. The following section will, however, cover only those kinds and aspects of

rest periods that are related to avoiding and recovering from fatigue and/or other impairing effects resulting from preceding work periods.

The effects of rest breaks are a standard and traditional topic in ergonomics, dating back until the beginning of the last century (e.g. Rivers & Kraepelin, 1896; Vernon, 1921; Graf, 1922). Graf (1922, 1927) was able to show that the optimal position and length of a rest break – with a view to the "most profitable rest break", both with regard to production and fatigue – depends on the type and intensity of the work to be performed and that work including breaks, i.e. with a smaller net amount of working time, is more productive than working the same span of time, and thus more working time in absolute terms, without breaks. His results clearly showed that taking a break of the right length at the right time in order to avoid fatigue (or at least to achieve recuperation from the effects of the preceding work period) was superior to working long blocks and postponing the rest break.

This is due to the fact that – beyond a certain limit – the relation between work stress, work strain (for the terminology see ISO 10075), and its effects (e.g. fatigue) is not linear but follows an exponential function. This in turn is due to the feedback function, where the same amount of work load or work stress meets a reduced capacity for work within the individual due to its preceding coping with the preceding work load and an insufficient recovery, i.e. a lack of return of the functions under strain to their baseline or a tolerable steady state. This has been demonstrated both for physical (e.g. Rohmert, 1960a,b) as well as for mental work (Schmidtke, 1965), with exponential relations for both, the intensity of the work load and the duration of the exposure to that workload, which interact in a multiplicative way. Furthermore the function of recovery from fatigue also follows such an exponential, non-linear function, with the greatest amount of recovery occurring during the first part of a rest break, i.e. a decreasing recovery function over time. This is the reason why recovery from accumulated effects of workload, e.g. accumulated fatigue, requires disproportionately longer times for recovery than recovery from less extended deviations from the baseline (e.g. less fatigue).

This evidence has in ergonomics (but not necessarily in practice) lead to a strategy of avoiding (especially an accumulation of) fatigue by an early scheduling of short rest breaks after short periods of work (see e.g. Graf, 1922, 1927), as opposed to a strategy of recovery from (accumulated) fatigue after longer or extended periods of work. The timing of such breaks or rest periods depends, of course, on the nature and the intensity of the work load or work stress associated with the performance of the task, which means that for higher intensities of work load shorter work periods are required, whereas these can be extended for lower intensities of work load.

As a corollary from this evidence any postponement of rest periods, and thus an accumulation of impairing effects, carries the risk of decreased performance and productivity, safety and health.

Reviewing the available recent – rather scarce – evidence on the effects of rest periods and their postponement has not lead to any conflicting evidence with these well established principles – but rather to their confirmation, as shown in the following sections. For reasons of clarity we will use the terms rest breaks or rest pauses with reference to rest periods during a work shift, whereas we will use the term rest periods for longer periods, e.g. daily or weekly rest.

6.2 Rest periods and safety

6.2.1 Rest breaks and safety

There are a number of studies which have examined the relations between rest breaks and driving. For example Stave (1977) reported that having a 4-minutes break within a 3 hours journey, in which the first errors begin to occur, is a very successful strategy in reducing / avoiding mistakes and errors. Feyer & Williamson (1995) found that tiredness / fatigue in driving, as one of the causes of an increased accident risk, can best be dealt with if the time of the break can be chosen autonomously by the drivers. However, the study does not address a postponement of rest breaks in this context which might be of great importance to safety. On the other hand there is conflicting evidence, showing that autonomously controlled breaks often lead to a postponement of rest breaks, which can result in an

accumulation of fatigue (Rutenfranz & Stoll, 1966). The results by Feyer & Williamson (1995) might thus be due to the special conditions encountered (long distance driving in Australia).

However, there is also some rather confusing evidence. A study by Drory (1985) showed that a 30-minutes break after a 7 hours journey did not reduce the level of fatigue and the performance on a simulated truck driving task remained constant over time. In addition, Lisper & Eriksson (1980) found that as far as driving was concerned there was no difference whether the break lasted for 15 or for 60 minutes in an 8h driving task. Whereas the Drory (1985) results are peculiar (as is the delayed onset of the break after seven hours) the findings of Lisper & Eriksson (1980) might be due to the fact that the 15 minutes break was already long enough for a complete recovery, and the additional 45 minutes in the 60 minutes condition met a recuperated driver.

The relations between rest breaks and accidents in the industrial sector are somewhat different and more consistent with existing theory. A study by Tucker et al. (2003) showed that the accident risk during an uninterrupted 2 hours work period increased continually. The study examined 8.55 hour shifts which were interrupted by a break every 2 hours. Tucker et al. (2003) were able to show that towards the end of the uninterrupted 2 hours work period the accident risk was approximately twice as high as in the beginning of that work period and that the break reduced the risk, comparable to the initial level. It was thus concluded that fixed rest breaks at regular intervals are well suited for reducing the accident risk – especially where repetitive and machine paced work is concerned (Folkard et al., 2003, 2006). On the other hand Mitra et al. (2008) were able to show that when rest breaks were scheduled but workers were not able to take them this lead to an increase in impairments and the risk of an error.

Consistent with the results by Graf (1927) Bhatia & Murrell (1969) in their study were able to show that introducing a 10 minutes rest break after every 60 minutes of work is less tiring than a break of 15 minutes every 90 minutes, confirming that postponement of (the same relative amount of) rest breaks is not a preferable solution.

There have been numerous studies examining the effects of different rest break schedules during work with computers. Kopardekar &/ Mital (1994) for example found that working with interspersed short rest breaks every half hour or hour reduced the error frequencies as compared to continuous work. Consistent results have been found by Galinsky et al. (2000). In the same line and again in agreement with older findings Dababneh et al. (2001) found that short rest pauses are able to increase productivity. However, it was also found that too many short breaks (in this case more frequent than one break per hour) were considered unpleasant as they restricted the work flow.

Concerning the position of rest breaks within the work process Murrell (1962, 1979) was able to show that a rest break at a point in time when work performance is already decreasing does not achieve the same recuperative effect as a break taken before this point in time, supporting the preventive functions of early breaks. This has also been supported by findings from Horne & Reyner (1999) with automobile accidents in which drivers fell asleep. In this review accidents caused by drivers falling asleep were analysed as well as results from experiments on breaks, including phases of sleep, which were introduced into the driving. It has been found that not taking a break can lead to devastating consequences and that a break including sleep is a suitable means for minimizing this risk.

However, as argued before, obviously not everyone is able to determine the optimal point in time for a break, as has again been shown in the study by McLean et al. (2001) in which scheduled short breaks achieved greater effects then autonomously taken short breaks by the workers. As shown by Rutenfranz & Stoll (1966) already one of the reasons for this is that workers tend to postpone and accumulate rest breaks in order to finish earlier (or to have an accumulated longer rest period before the end of the shift). This, however, is associated with an increased risk for errors and accidents, as has been shown before.

6.2.2 Daily rest and safety

Relevant studies which directly examined the aspects of work safety in connection with the duration of daily rest periods have not been found. However, when examining the aspect of long working hours and overtime, which at the same time means a postponement (and/or reduction) of daily rest periods, an increase in accident risk has been demonstrated (Folkard, 1996; Hänecke et al., 1998; Lowery et al., 1998; Nachreiner, 2002; White & Beswick, 2003; Dong, 2005), as has been shown above.

General evidence concerning critical safety effects of too short (daily) rest periods, however, can be gained from laboratory and field studies on the consequences of sleep deprivation. Results from a laboratory study by Williamson and Feyer (2000) clearly showed that sleep deprivation negatively affected the performance in the co-ordination tasks of their experiment.

A number of field studies also demonstrate safety critical effects of sleep deprivation – and this not only for the employees themselves, e.g. in the form of accidents (Marcus & Loughlin, 1996; Coplen & Sussman, 2000; Stutts et al., 2003), but also in the field of patient safety (Weinger & Ancoli-Israel, 2002; Lockley, 2007). Insufficient rest periods due to long working hours in combination with sleep loss often lead to an increased error rate, which in the field of medical care can have a strong influence on patient safety (see section on long working hours).

As shown by Folkard and Lombardi (2006), the accident risk increases with successive shifts, both for day and for night shifts, which is a clear indication that daily rest periods were not sufficient to accomplish a complete recovery from (daily) work. The increased risk on night shifts may reflect, at least in part and besides the effects of the special work load imposed by working nights, the effects of a typically reduced day sleep length (and quality) between successive night shifts. This is why Tepas & Carvalhais (1990) point to the fact that chronic sleep deprivation increases the accident risk in shift workers working night shifts.

6.2.3 Weekly rest and safety

Relevant studies which directly examined work safety in relation to weekly rest periods have not been found. Current investigations into the effects of working at unusual hours (see section above) indicate that working at weekends resp. on Sundays leads to an increased safety risk. Besides working at unusual hours this may also imply a postponement of rest periods, e.g. when working on Sundays the rest periods might well be postponed to a subsequent day of the week.

6.2.4 Longer rest periods and safety

A few relevant studies which directly examined safety aspects in connection with longer rest periods have been found. For offshore operations, Mikkelsen et al. (2004) were able to show that the number of injuries of Norwegian offshore workers is associated with the duration of their onshore rest periods. This study compared the effects of a 3 vs. 4 weeks rest period onshore following a 3 weeks work period on the oil rig. In this case the extended rest period, representing at the same time a reduction in average working hours, lead to a reduction in injuries. So the question remains whether the effects are due to the extended rest period or the reduced average working time.

On the other hand, until only a few years ago symmetric work/leave schedules (e.g. 1-1 / 2-2) were applied. Meanwhile 2-3 work/leave schedules are used even though there is no empirical evidence to show that longer rest periods improve fatigue, wakefulness, performance and quality of sleep (Parkes, 2010). This could be due to the fact that after 2 weeks sufficient recuperation has taken place and a longer rest period could not lead to any further recuperation. In general, however, the relationship between work/leave and safety or health effects in such situations has up to now been only inadequately investigated so that no firm conclusions can be drawn. It is assumed, however, that longer rest periods in relation to working times should reduce the accident risk, but for the time being this remains an assumption. Furthermore, Parkes (2010) reports that it is easier to recruit qualified personnel using a 2-3 work/leave schedule than using a 2-2 schedule, which may result, however, from the reduced working time and the relation of work / non-work periods.

6.3 Rest periods and health

6.3.1 Rest breaks and health

A number of studies suggest that having several short breaks during work reduces the increase in experienced impairments and physical complaints over the working day (Hüttges et al., 2005; Galinsky et al., 2000; Henning et al., 1997). Short breaks are thus suitable for reducing the consequences of strain (e.g. sensations of monotony), especially in monotonous and repetitive job activities (Faucett et al., 2007). Where (scheduled) breaks are not or cannot be taken this leads to increased reported impairments (Mitra et al., 2008). These investigations thus show that adequate rest breaks play an important role in safeguarding the workers health and ability to work. If rest breaks are postponed, this leads to impairments to health and well being.
Scheduling rest breaks (time, duration) is – as with safety aspects – dependent on the type and intensity of the job activities (investigated e.g. for activities requiring a standing position by van Dieen et al., 1998).

It has been shown in some studies that individual choice on breaks has a positive influence on reported health and well being (Hahn, 1989) whereas fixed breaks can lead to interruptions of the work flow (Henning et al., 1997) and furthermore to emotional impairments (Boucsein & Thum, 1997). However, self scheduled rest breaks are not always superior to scheduled ones, as shown by the study of McLean et al. (2001), reported above, most probably caused by the fact that self determined breaks are often postponed, and thus taken too late, e.g. when fatigue, monotony or satiation become sensible by the worker, or in order to finish work earlier (Rutenfranz & Stoll, 1966), with usually negative consequences for health and well being (e.g. feeling exhausted at the end of a shift).

6.3.2 Daily rest and health

Several investigations demonstrate a clear link between inadequate daily rest periods between shifts and sleep duration. Short rest periods of 8, 9 or 10 hours sometimes reduce sleep duration drastically to 3 – 5 hours (Saito & Kogi, 1978; Knauth et al., 1983; Totterdell & Folkard, 1990; Tucker et al., 2010), which must lead to insufficient recuperation and increased fatigue at the start of the next shift, providing unfavourable conditions for that shift. Such reduced rest periods also appear in, especially short, backward rotating shift systems (Tucker et al., 2010), which are usually associated with increased health complaints, as compared to forward rotating systems with the same number of work hours (e.g. Barton & Folkard, 1993; Beermann et al., 1990; Sallinen & Kecklund, 2010; van Amelsvoort et al., 2004; Viitasalo et al. 2008; Horn & Nachreiner, in preparation). Comparing backward (i.e. a sequence from night to afternoon to morning shifts, as opposed to forward rotating systems, with a reverse sequence of shifts but the same number of hours) with forward rotating shifts allows for testing the effects of the distribution of work and rest, i.e. their dynamics. This thus is an indirect test of the effects of a postponement of rest, as is the case in backward rotating systems, where rest periods are usually postponed into greater blocks of time off work. Since both for health and work-life balance backward rotation in general is inferior to forward rotation, this is also an argument against delaying rest periods.

Kurumatani et al. (1994) conclude from their investigations that more than 16 hours between work shifts are necessary to enable a sleep duration of 7 hours. However, it should be mentioned that the persons who participated in this study had considerable commuting times to and from work, which reduced their effective sleeping times. On the other hand this would argue against any backward rotation and a reduction or postponement of rest periods.

Roach et al. (2003) studied the sleeping behaviour of locomotive engineers and found that the total duration of sleep is not only dependent on the duration of the rest period between shifts but in particular also on the characteristics of the specific situation. Rest periods during the night lead, as a rule, to an increased sleep duration as compared to rest periods during the day. The study by Feyer & Williamson (1995) of long distance truck drivers also showed the importance of the timing of rest periods. For all drivers, the influence of circadian rhythms was evident in the occurrence of fatigue, with a better management of the problem being evident among drivers who were able to arrange the

timing of rest to more closely coincide with periods of fatigue. In a further study, Tucker et al. (1998) also investigated the effects of rest periods between shifts. They showed that the duration of night sleep is reduced between successive shifts beginning at 06:00 as compared to those begin at 07:00. Minimum rest periods between shifts should therefore also take these time of day components into consideration, in order to ensure the possibility of sufficient sleep time.

Jansen et al. (2003) conclude from their study that higher daily and weekly work hours and especially overtime are in general accompanied by higher requirements for rest. This is not surprising since the working time is prolonged and the rest period reduced and at least partially postponed, resulting in an accumulation of negative effects.

6.3.3 Weekly rest and health

A number of studies agree in their conclusions that one free day after a block of successive working days is often not enough to provide for sufficient rest and recuperation (Folkard & Lombardi, 2006), which may also apply for normal daily work, e.g. that of office workers (Akerstedt et al., 2000). As a general rule for shift work, scheduling two days of rest after a block of night shifts is preferable to one day off for achieving full recuperation (e.g. Totterdell et al., 1995). The validity of this principle has also been demonstrated in the medical sector by recent results from Tucker et al. (2010), who found substantially increased fatigue in medical doctors if before the next work assignment only one free day had been scheduled after a phase of night work.

In the context of 12 hour shifts in the production sector a study by Tucker et al. (1999) found that workers in such a 12 hour shift systems who had a rest period of more than 24 hours between day and night shift blocks showed slightly increased alertness during the shift, a slightly reduced rate of chronic fatigue as well as longer periods of sleep during the night shift blocks and on days off. In a study by Kandelaars et al. (2005), positive effects of longer rest periods (> 48 hours) have also been demonstrated, showing that the sleep length and thus recuperation effectiveness can be improved through longer rest periods.

Akerstedt et al. (2000) investigated rest requirements caused by different systems of non-standard working hours for selected populations using subjective alertness ratings (assessed via the Karolinska Sleepiness Scale). Comparing the data from several individual studies (train drivers with two days off after 4-5 days with irregular working hours, workers in the chemical industry with traditional three-shift work, construction workers with consecutive 7 x 12 hour day shifts, flight cabin crews with irregular working hours in connection with travelling across nine time zones) the authors conclude from the results that one day of rest after a sequence of shifts is not sufficient for adequate recuperation, two days usually are, but that for those working long shifts in long sequences three days are required for recuperation and 3-4 days are necessary after periods of severely disturbed circadian rhythms.

6.3.4 Longer rest periods and health

Relevant investigations which examined the effects of longer rest periods on health are rather scarce.
A study of offshore operations (Alekperov et al., 1988) demonstrated that shorter changes in work/leave schedules (1 -1 vs. 2-2) lead to less detrimental effects on physiological functions in the operators. The postponing of the rest period thus obviously increased the biological impairments. This however does not correspond to the 2-3 work/leave schedules currently in use, which are favoured by offshore workers because of the longer off period (Parkes, 2010). It must be kept in mind, however, that for these jobs a considerable amount of time is spent in commuting between work and home locations, reducing the amount of free time substantially. It is thus comprehensible that these workers opt for a less frequent change between on and off work periods, because it leaves them more time off work. Commuting times, however, are generally not taken into consideration in such studies. Systematic investigations into accident or incident rates or reported health problems for these on/off schedules, however, have not been undertaken yet.

With regard to sabbaticals Knauth et al. (2009) argue that those which serve purposes of recovery from the effects of work during one's working life make more sense than models in which a great deal of overtime is accumulated in order to allow for an early retirement from work – when health impairments may already exist –, the latter representing another example for the postponement of rest and its effects. Gazie (1995) in an empirical study with teachers found that a sabbatical in connection with professional training activities considerably reduced experienced burnout and intentions of leaving the profession.

There will most probably be a difference in the effects of such sabbaticals if the free period is taken either as "unpaid vacation" (without previous accumulation of overtime) or as a compensation for accumulated overtime. More serious and more frequent impairments would of course be expected where overtime hours were worked in advance and time withdrawn from the time account at a later point in time, as this would lead to a concentration of work and an accumulation of its effects during the work period and a postponement of rest periods to a later point in time.

Using bivariate time series analyses between overtime, actual and that banked on a working time account over a period of 60 months, and sick leave and accident rates (in conjunction with staffing operations) of two production units from the automotive industry Hoyer & Nachreiner (2010) were able to show that both, actual and accumulated overtime were related to lost times due to illnesses and accidents, in a complex temporal structure, with overtime preceding lost times, indicating thus that overtime (which was also related to staffing) is a causal agent for lost times due to illnesses and accidents. This study represents one of the rare examples where working long hours and the postponement of rest periods have been observed over a longer period of time (60 months), yielding insight into the complex temporal and causal structure of the effects.

6.4 Rest periods and work-life balance

6.4.1 Rest breaks and work-life balance

Relevant studies which directly investigated any relations of rest breaks with reported work-life balance have not been found.

6.4.2 Daily rest and work-life balance

With regard to daily rest attention must be paid to the chronological position of the rest periods because of the social rhythms in our societies (see section on unusual hours) and the differential utility of time for social interaction (Wedderburn, 1981; Baer et al., 1981, 1985; Hornberger & Knauth, 1993, Hinnenberg et al., 2007) If rest periods are postponed (and shortened) due to working long hours per day or per week into regions where social interaction becomes difficult or impossible due to either duration or chronological position this must result in a reduced work life balance, as has been shown in the section on working unusual hours.

6.4.3 Weekly rest and work-life balance

The same reasoning as for daily rest periods applies to weekly rest periods and work life balance. A special case is postponing rest from the weekend on a weekday, which has already been dealt with under working unusual hours. Furthermore recent results from the Tucker et al. (2010) study show that young doctors working on call duties on the weekend between to consecutive working weeks experience considerably increased work–life interference.

6.4.4 Longer rest periods and work-life balance

Relevant empirical studies which investigated the relations of longer rest periods with work-life balance have not been found. Differences would, however, be expected for such longer periods as a compensation for preceding overtime (i.e. postponed and accumulated rest periods) and those more closely resembling times out without any compensatory function.

7 Flexible working hours

7.1 Introduction

During the last years there is an increasing demand for more flexibility in the arrangement of working hours. Employers want to adapt production/service times to the demands of the market in order to reduce their entrepreneurial and economic risk, and employees want to adapt their working times to their non-work, private demands in order to achieve a better work life balance. In principle this can result in a win-win situation where both parties take advantages from a more flexible arrangement of working hours. On the other hand production/service requirements and private demands/preferences are not always in accordance, so workers have to accept working times which do not coincide with their expectations or preferences. As can be clearly seen from the available literature (for a review see Costa et al., 2003; Janßen & Nachreiner, 2004a,b;) production or company interests are usually dominant in arranging flexible working hours – this is why employers opt for flexibility, and especially this kind of company controlled flexibility – and employee discretion in deciding about working times is rather restricted, as a rule within the limits of production/service requirements (although exemptions from this rule can be found).

A first problem in reviewing and reporting the effects of flexible working hours is the lack of a general accepted definition. Some consider any deviation from standard working hours as flexible working times, but that would include rigid shift systems as well and thus blur any distinction, especially also with regard to the effects. Since adaptation to changing requirements (either production or individual demands) is at the core of flexible working hours, the SALTSA group (Costa et al., 2003 has proposed the following definition: Flexible working hours involve a continuous choice on behalf of employers, employees or both, regarding the amount (chronometry) and the temporal distribution (chronology) of working hours. This is what will be considered flexible working hours in the following sections.

Flexibility in working time arrangements in the above mentioned sense can be found in a number of different forms (e.g. flexitime, several part time arrangements or working time accounts), each again with a number of different specific implementations, resulting in a number of different manifestations that cannot be reviewed in detail, because the effects will depend on the characteristics of the specific implementation, and not on the classification into a certain category (e.g. flexitime). A more promising approach is thus to extract the basic dimensions of flexible working hours arrangements (see definition) and to assess their impact on safety, health, and work-life balance. Basic dimensions for describing flexible working times arrangements are thus the variability (or irregularity) of working hours, both with regard to the chronometry and the chronology of the resulting working times, the control over the working times by employees and / or the company, and the reliability of the resulting working time arrangements.

7.2 Effects on safety

The effects of flexible hours on safety are not well understood. Studies dealing with this specific topic have not been found. However, if flexible hours imply working for extended times, postponing rest periods and working at unusual times, even if they are self determined, they should also be associated with higher risks to safety.

7.3 Effects on health

The available evidence clearly shows that a high degree of variability or irregularity of working hours has detrimental effects on health and well being, comparable in nature to that of shift workers (e.g. sleep and digestive problems, reduced social participation, see Costa et al., 2003; Janßen & Nachreiner, 2004a,b), which most probably are also due to a (partial) desynchronization of physiological and social rhythms.

Giebel et al. (2004, 2008) were able to show that the degree of irregularity or the suppression of rhythmic components in the actual working times (as analyzed by spectral analyses) was clearly associated with the amount of reported health complaints, and this applied both to full time as well as to part time workers.

Janßen & Nachreiner (2004a,b), using the data from the 3rd EWCS and a separate study of their own demonstrated that high degrees of variability of working hours (apart from that introduced by shift work) consistently lead to stronger impairments than in schedules with less variability. Figure 13 shows an example of these results, in this case the proportion of those reporting sleep problems.

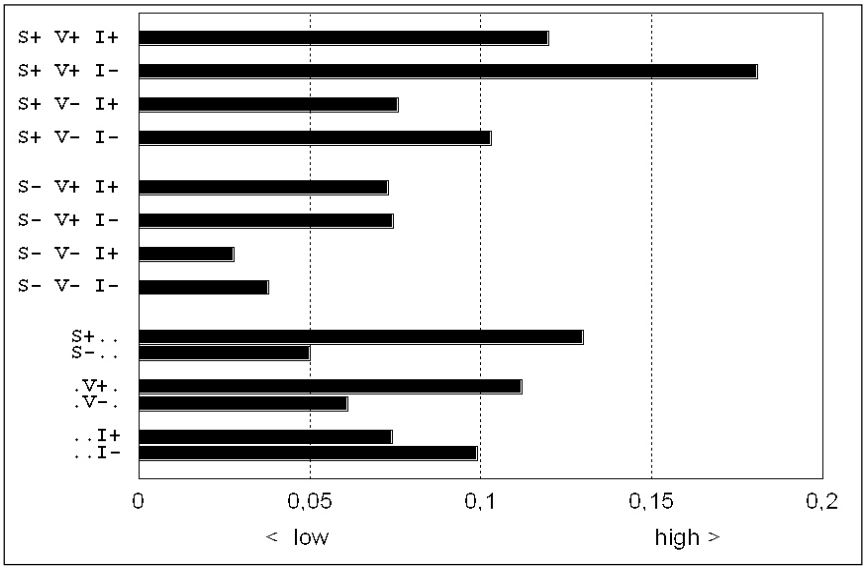

Figure 13: Proportion with sleep problems under different forms of flexible working hours

S = shift work, V = variability, I = Influence

(based on results from Janßen & Nachreiner, 2004; 3rd EWCS 2000)

As can be seen from Figure 13 there are main effects for all three dimensions: variability (V), shift work (S), and influence or autonomy (I), shown in the lower part of the graph. Variability of the working hours increased the proportion of those reporting sleep problems (and other health impairments), as is the case for shift work (both for more regular and for irregular working times). The third dimension that these authors used was the discretion of the workers in influencing the chronometry and chronology of their working hours. As would be expected, those with less autonomy had more complaints than those with more reported autonomy. The combination of the effects was mostly additive, so that the best condition emerged as a rather regular working time arrangement, without shifts, and a high degree of autonomy, whereas the worst condition was the one where shift work was combined with irregular working hours (beyond that resulting from working shifts), and with a low (or no) degree of autonomy (i.e. company controlled, flexible, irregular shift work). The latter clearly was the most disadvantageous condition with regard to health (and social participation as well).

The available evidence in general and consistently shows that company controlled variability has stronger negative effects than employee controlled variability or flexibilty, but this evidence also demonstrates that employee control over variability cannot fully compensate the negative effects of working time variability, and especially in the case of high irregularity. The results would thus indicate that variability of working times, whether self determined or company controlled, carries the risk of higher impairments to health.

This already points to the fact that autonomy on the side of the workers in controlling their working hours usually has a positive moderating effect on the reported outcomes of working flexible hours with regard to health (see also the recent review of intervention studies by Joyce et al., 2010; as well as Albertsen et al., 2008). Whether this is due to a cognitive reinterpretation (self attribution of blame for working such hours) or due to a factual different (i.e. superior) organization of working hours, however, remains to be analyzed, since most data, e.g. the EWCS, do not contain the necessary information for such analyses (e.g. the concrete schedules worked).

Besides variability the reliability of the flexibly arranged working time schedules plays an important role in the effects of flexible working hours, again both with regard to physical and to psychosocial well being. If flexibly arranged working times are unreliable, e.g. because of frequent rescheduling, emergencies or work on call, the risk of health and psychosocial complaints is increased (Janßen & Nachreiner, 2005). The causes for the detrimental effect on work-life balance (see below) are rather trivial (e.g. uncontrollable private activities), whereas the health effects will most probably be due to a temporary desynchronization with circadian and social rhythms.

This is most probably the case where flexible hours are combined with shift work so that no stable form of (an at least relative) adaptation is possible. Shift work with highly variable and predominantly company controlled working hours (besides the variability resulting from shift or night work itself) thus leads to the highest amount of physical and psychosocial impairments, as compared to other types of flexible working hours.

It has been reported already in the section on extended working hours that the combination of long and flexible working hours shows interactive effects. Whereas flexible working times can better be dealt with in the part time domain, working long flexible hours will aggravate coping with one's working hours, and exacerbate the negative effects on health.

7.4 Effects to work-life balance / social participation

Although flexible working hours are held and said to improve the conditions for a better work-life balance or social participation, the available empirical results in general do not coincide with these claims.

As has been shown by Janßen & Nachreiner (2004a,b) variability (in chronometry and chronology) reduces the work-life balance and social activities of the workers. Contrary to expectation workers with temporal flexibility complain more about the incompatibility of their working hours with their private life and social activities. This may be a result of the fact that most employees have only a limited amount of discretion in adapting their working times to their personal demands, whereas most of the variability and irregularity results from company control over working hours.

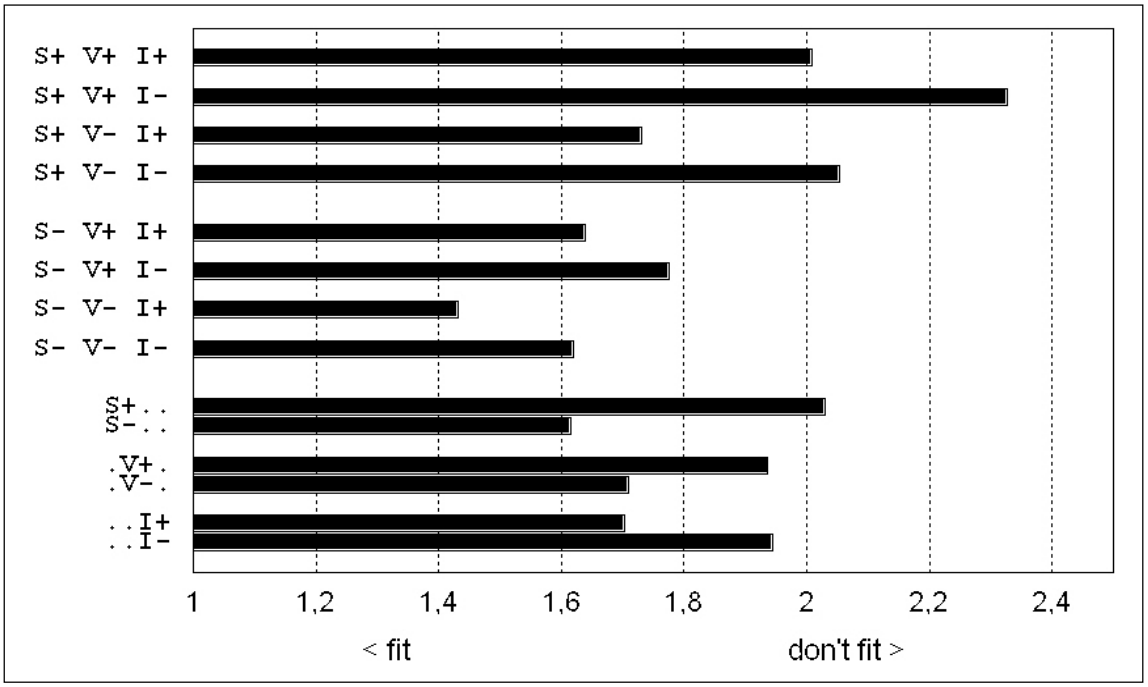

Figure 14: Work-life balance (work hours fit in with family and social life) under different forms of flexible working hours

S = shift work, V = variability, I = Influence

(based on results from Janßen & Nachreiner, 2004a; 3rd EWCS 2000)

Figure 14, as an example, shows results from Janßen & Nachreiner (2004a) on the effects of flexible hours on work-life balance (work hours fit in with family and social life). There are again the main effects for shift work, variability and autonomy, as well as the combined effects for the different combinations, completely compatible with the effects on health.

As has been shown with health effects autonomy and variability usually show additive effects, and again, as with health, working company controlled variable hours in shifts without much choice shows the most detrimental effects to work-life balance, whereas again low variability in day work with some autonomy yields the most favorable results. The same pattern of effects can be shown for a lot of different social activities, so that in general this seems to be a generalizable pattern of the effects of working flexible hours on work-life balance and social participation. It should again be noted that also in this case autonomy (partially) compensates for variability, but that full compensation cannot be achieved – with arguments similar to those on health effects to be kept in mind.

8 Conclusions

8.1 Long working hours

The available evidence clearly shows that long working hours have a detrimental impact on the safety, health, and work-life balance of the worker. Besides any direct impact on the worker there is also a negative impact of working long hours on the general public, e.g. with regard to environmental or patient safety, or the social integration of these workers.

The available data do not allow for a distinction of long term vs. short term effects of long term vs. short term exposure to long working hours. This is a gap in the available evidence that should urgently be closed by the collection of suitable data and appropriate research approaches.

Based on safety considerations a maximum number of 8 hours of working time per day can be recommended, since beyond this number of working hours the accident risk increases disproportionately. Longer hours of work per day can only be accepted if work is interrupted by adequate rest periods which avoid any accumulation of fatigue.

Based on health (as well as on safety) considerations no appropriate maximum limits for weekly working times can be specified. Since a linear increase of health impairments with increasing numbers of working hours can be observed the question of setting a limit is a question of how much impairment one is prepared to accept.

Based on the effects of long working hours on WLB, the evidence concerning the accumulation of and recovery from fatigue accumulated over subsequent work days or shifts and weekly rest periods, a reduction in the maximum number of weekly working hours would be indicated. WLB begins to decline substantially beyond 40 h/week. Weekly rest periods of one day often are not sufficient to avoid an accumulation of adverse effects and to achieve full recuperation from work – especially when there is a high work load to be dealt with. This would argue for an increased weekly rest period and thus a reduction in the number of work days to five per week. Combining this with the results from daily working time and safety yields a recommendation of 5 x 8 = 40 h per week.

The increase of the accident risk is, of course, depending on the nature and intensity of the work activities, the resulting work load and the effort and strain required. However, the reported increase in the risk with increasing hours of work has consistently been found across different jobs with different kinds and amounts of work load. Both, additive as well as interactive effects have been observed, but the effects were mostly additive. Thus for more demanding jobs shorter working hours must be considered – or a reduction in work load.

8.2 Rest periods

Rest periods should be taken / scheduled with the aim of avoiding impairing effects as for example fatigue, monotony, satiation, or reduced vigilance. Rest periods should thus be provided prior to the manifestation of any of these effects. This would argue against any postponement of rest periods (e.g. until to a point in time where these effects become manifest either in performance or in the perception of the worker) and any accumulation of such effects, e.g. fatigue. This would also argue for rather short reference periods for calculating averages of the exposure to work, in order to avoid any undue accumulation of impairing effects during times with high workload or extended hours within the reference period. The important thing to achieve is an appropriate dynamics in the relation of work and rest which avoids the accumulation of impairing effects, both with regard to health and WLB..

If fatigue (or other impairing effects) cannot be avoided rest periods should be scheduled so as to achieve complete recovery from fatigue (or other impairing effects). This, of course, depends on the

nature and intensity of work activities. The minimum of 11 hours daily rest seems in fact to be the minimum required. Longer daily rest periods, however, would be beneficial for the maintenance of unimpaired health and safety.

8.3 Unusual hours

Working at unusual hours, i.e. work on Saturdays, Sundays, in the evenings and working nights or shifts, increases the risk to safety, health and work-life balance, especially in combination with long working hours. This should therefore be avoided as far as possible. Since work at unusual hours restricts the utility of the remaining hours off work, working at unusual hours would best be compensated by additional time off or a reduction in the amount of working hours. Monetary compensation cannot compensate for the adverse effects on safety, health and work-life balance.

Variability of working hours that leads to a (partial) desynchronization with the circadian as well as with the social rhythm of a society should be avoided as far as possible.

Autonomy of the workers in deciding on the arrangement of their working hours in general has a beneficiary effect in that it reduces negative outcomes. Autonomy, however, cannot compensate for violations of ergonomics principles of the design of working hours.

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