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Reviewing the effort–reward imbalance model: drawing up the balance of 45 empirical studies

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Abstract

The present paper provides a review of 45 studies on the Effort–Reward Imbalance (ERI) Model published from 1986 to 2003 (inclusive). In 1986, the ERI Model was introduced by Siegrist et al. (Biological and Psychological Factors in Cardiovascular Disease, Springer, Berlin, 1986, pp. 104–126; Social Science & Medicine 22 (1986) 247). The central tenet of the ERI Model is that an imbalance between (high) efforts and (low) rewards leads to (sustained) strain reactions. Besides efforts and rewards, overcommitment (i.e., a personality characteristic) is a crucial aspect of the model. Essentially, the ERI Model contains three main assumptions, which could be labeled as (1) the extrinsic ERI hypothesis: high efforts in combination with low rewards increase the risk of poor health, (2) the intrinsic overcommitment hypothesis: a high level of overcommitment may increase the risk of poor health, and (3) the interaction hypothesis: employees reporting an extrinsic ERI *and* a high level of overcommitment have an *even higher* risk of poor health. The review showed that the extrinsic ERI hypothesis has gained considerable empirical support. Results for overcommitment remain inconsistent and the moderating effect of overcommitment on the relation between ERI and employee health has been scarcely examined. Based on these review results suggestions for future research are proposed.

Keywords: Effort–reward imbalance; ERI model; Work overcommitment; Employee health

Introduction

Occupational health researchers have tried to gain more insight into the relationship between work characteristics and employee health. With the help of work stress models they attempt to reduce the complex reality into comprehensive and parsimonious models, highlighting some core elements in order to explain job-related health. One of the most important models that has recently guided occupational health research is the Effort–Reward Imbalance (ERI) Model (Siegrist, 1996; Siegrist, Siegrist, & Weber, 1986). The ERI Model has its origin in medical sociology and emphasizes both the effort and the reward structure of work (Marmot, Siegrist, Theorell, & Feeney, 1999). The model is based upon the premise that work-related benefits depend upon a reciprocal relationship between efforts and rewards at work. Efforts represent job demands and/or obligations that are imposed on the employee. Occupational rewards distributed by the employer (and by society at large) consist of money, esteem, and job security/career opportunities. More specifically, the ERI Model claims that work characterized by both high efforts and low rewards represents a reciprocity deficit

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between “costs” and “gains”. This imbalance may cause sustained strain reactions. So, working hard without receiving appreciation is an example of a stressful imbalance. In addition, it is assumed that this process will be intensified by overcommitment (a personality characteristic), such that highly overcommitted employees will respond with more strain reactions to an ERI, in comparison with less overcommitted employees.

Over the past years, the ERI Model has gained popularity (especially in European research), and numerous studies have applied the model to various health outcomes. Although the number of ERI studies rose steadily, a detailed review evaluating those studies is to our knowledge still lacking. The present study tries to fill this gap by presenting a review of empirical studies testing the ERI Model. Since the ERI Model has considerably evolved over time and some studies might have been designed from a previous/different perspective of the model, it is necessary to get more familiar with the background of the model. Hence, we will give a short historical overview of the most relevant developments that preceded the model in its current form.

Development of the ERI model

In 1986, a sociological framework being the ERI Model was introduced by Siegrist et al. (1986) to predict and explain (the onset of) cardiovascular-related outcomes. The ERI Model claims that the work role is crucial in order to fulfill individual self-regulatory needs. That is, work offers opportunities to acquire self-efficacy (e.g., successful performance), self-esteem (e.g., recognition) and self-integration (e.g., belonging to a significant group). Based on the principle of social exchange (i.e., reciprocity), the employee invests efforts and expects rewards in return. However, in case an imbalance is present between high effort and low reward, this taken-for-granted routine is disrupted and the fulfillment of the self-regulatory needs is threatened. According to Siegrist et al. (1986) this imbalance may lead to a state of “active distress” by evoking strong negative emotions, which in turn activate two stress axes, i.e., the sympathetic-adrenomedullary and the pituitary–adrenal–cortical system (Henry & Stephens, 1977). In the long run, sustained activation of the autonomic nervous system may contribute to the development of physical (e.g., cardiovascular) and mental (e.g., depression) diseases (see also Weiner, 1992).

In its premature years, the ERI Model was primarily used to investigate cardiovascular outcomes. It was not until 1998 that the model was applied to other psychological and behavioral outcomes as well. Appels can be considered as a pioneer in linking ERI (i.e., high effort and low reward) to psychological outcomes such as vital exhaustion (Appels, Siegrist, & Vos, 1997). Appels’ work (Appels & Schouten, 1991) showed that vital exhaustion may lead to acute myocardial infarction (AMI). In addition, he found strong independent effects of ERI and vital exhaustion on AMI (Appels, Siegrist, & Vos, 1997). Those results suggest that ERI could lead to cardiac events, but also that this relation might be mediated by vital exhaustion. Implicitly, the ERI Model can also be considered as predictive for psychological well-being, as ERI evokes strong negative emotions, which are related to impaired well-being (cf. Gaillard & Wientjes, 1994). Furthermore, it has been argued that the model can be applied to addictive behavior as well. According to Blum, Cull, Braverman, and Comings (1996), prolonged stress leads to dysfunction or disruption of the mesolimbic dopamine system, which in turn stimulates addictive behavior. To summarize, an ERI seems to evoke adverse health by stimulating neurobiological, psychological and behavioral pathways.

In general, the idea prevails that people will not passively stay in a high-effort–low-reward imbalance situation, but that they will try to cognitively and behaviorally reduce their efforts and/or maximize their rewards (e.g., cognitive theory of emotion (Lazarus, 1991) and expectancy theory of motivation (Schönpflug & Batman, 1989)). Hence, an ERI might not influence health over a longer period. But according to Siegrist (1996), negative effect associated with ERI may not be consciously appraised, as it is a chronically recurrent everyday experience (cf. Gaillard & Wientjes, 1994). Furthermore, Siegrist (1996) identified some specific circumstances under which a high cost/low gain condition is maintained: (1) when there is no alternative choice on the labor market, (2) for strategic reasons (e.g., expecting future gains), and (3) when the employee is characterized by a motivational pattern of excessive work-related overcommitment. Overcommitment is seen as a personality characteristic based on the cognitive, emotional and motivational elements of Type A behavior that reflect an exorbitant ambition in combination with the need to be approved and esteemed (Hanson, Schaufeli, Vrijkotte, Plomp, & Godaert, 2000; Siegrist, 1998). Overcommitment can be defined as the person-specific component, whereas efforts and rewards compromise the situation-specific component.

To measure the key concepts of the ERI Model, information was gathered from different sources, i.e., contextual information (such as administrative data and objective measures), descriptive and evaluative information (through interviews and questionnaires). A combination of those sources was mainly used to measure effort and reward. Overcommitment was solely assessed by a questionnaire (cf. Matschinger, Siegrist, Siegrist, & Dittmann, 1986). Subsequently, a questionnaire was developed to measure all components of the ERI Model, i.e., effort, reward and overcommitment. The introduction of this so-called ERI Questionnaire (ERI-Q; (Siegrist & Peter, 1996a) led to a predominant use of questionnaires to test the ERI Model.

The effort scale in the ERI-Q contains six items of which the content varies from physical load, time pressure, interruptions, responsibility, working overtime to increasing demands. Siegrist et al. (2004) have recommended to include the item on physical load only in those occupational groups where prevalence of physical workload is part of the typical task profile. Reward in the ERI-Q has been operationalized by means of 11 items, and is usually measured as a composite measure. Theoretically, a three-factor structure underlies the concept of reward (i.e., money, esteem and security/career opportunities). Recent studies confirm the presence of the three-factorial structure (Siegrist et al., 2004), and the importance of splitting three types of rewards (Dragano, Knesebeck, Rödel, & Siegrist, 2003; van Vegchel, de Jonge, Bakker, & Schaufeli, 2002). The operationalization of overcommitment has considerably changed over time. Originally, overcommitment was operationalized by the scale "need for control", as a more work-related reformulation of the Type A concept (cf. Matschinger et al., 1986). The need for control scale contains two latent factors: vigor and immersion. Vigor refers to successful coping (by perfectionism and hard work). Immersion defines a critical state of coping with demands reflecting frustrated, but continued efforts and associated negative feelings. Immersion consists of four subscales: (a) need for approval, (b) competitiveness, (c) disproportionate irritability, and (d) inability to withdraw from work (Siegrist, 1996). Although some empirical studies were able to replicate the factorial structure of immersion (e.g., Peter et al., 1998), other studies could not replicate the respective factorial structure, and showed that especially the factor "inability to withdraw from work" was essential for the ERI Model (see Hanson et al., 2000; Niedhammer, Siegrist, Landre, Goldberg, & Leclerc, 2000). Therefore, a shorter version was developed to represent overcommitment, mainly consisting of inability to withdraw from work (five items) and one item of disproportionate irritability (Siegrist et al., 2004).

Despite developments in their operationalization over time, the concepts effort, reward and overcommitment remained the core components of the ERI Model. Graphical representations of the original version and the current version of the ERI Model are shown in Figs. 1 and 2, respectively. As can be seen, two concepts have been relabeled: "intrinsic effort/need for control" into "overcommitment", and "status control" into "security/career opportunities". Reasons for this are not reported in the literature.

The most profound change in Figs. 1 and 2 comprises the role of overcommitment. According to Fig. 1, overcommitment is part of effort. Because highly overcommitted employees underestimate challenging situations and overestimate their own capability, they tend to invest (too) many efforts. Therefore, the amount

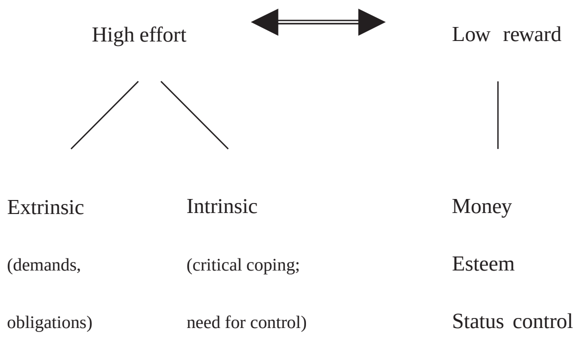

Fig. 1. Original ERI Model (Siegrist, 1996, p. 30).

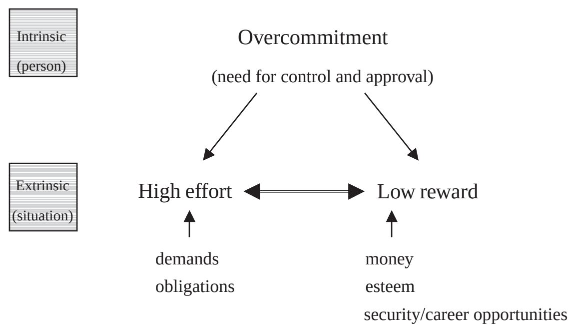

Fig. 2. Current ERI Model (Siegrist, 1999, p. 40).

of effort invested is dependent upon both extrinsic (i.e., demands and obligations from work) and intrinsic (i.e., overcommitment) efforts. So, the main assumption of the ERI Model was that a mismatch between high extrinsic or *intrinsic* efforts and low reward may lead to an adverse health. Later, as shown in Fig. 2, overcommitment is seen as an independent concept. Overcommitment influences the perception of both high efforts and low reward, and therefore influences employee health indirectly. In addition, overcommitment is thought to have a direct effect on employee health as well, as being highly overcommitted (i.e., involved with work all the time) might be exhaustive in the long run.

Based upon this line of reasoning, Siegrist (2002) has formulated three predictions that can be postulated for the ERI Model. Firstly, the *extrinsic ERI hypothesis*: an imbalance between (high) extrinsic effort and (low) reward increases the risk of poor health, over and above the risks associated with each one of the components (i.e., high efforts and low rewards). Secondly, the *intrinsic overcommitment (OVC) hypothesis*: a high level of overcommitment, possibly resulting in continued exaggerated efforts combined with disappointing rewards, may also increase the risk of poor health (even in the absence of an extrinsic ERI, i.e., a main effect of overcommitment). And finally, the *interaction hypothesis* (i.e., ERI $\times$ OVC): an extrinsic ERI in combination with a high level of overcommitment leads to the highest risk of poor health. Therefore, a complete test of the ERI Model covers all three conditions mentioned (i.e., effort, reward and overcommitment).

Due to changes in the concepts and their operationalizations, studies may differ in their design of the study. For instance, some studies might have included overcommitment into the effort concept, and studies might differ in the labels they used for several concepts. The three hypotheses (i.e., ERI, OVC, and ERI $\times$ OVC) mentioned above will guide the current review of the ERI Model, as they are consistent with the most recent view of the model. However, we are aware that the development of the ERI Model has its influence on the study. Therefore, we will systematically consider the amount of support that is found for each hypothesis, taking into account the development through time.

Studies included in the review

Since the current review might be the first review for the ERI Model, the present review tries to encompass as much empirical studies as possible. Inspection of the ERI studies showed that most studies used (logistic) regression analyses in which variables are examined in a particular composition (for instance including socio-demographic variables), which complicates revealing the unique contribution of the ERI variables (as would be necessary for a meta-analysis). As many studies would have to be excluded for a meta-analysis, a review of a narrative nature was preferred, which also allows to take methodological strengths and weaknesses into account (see also van der Doef & Maes, 1999).

With the help of several databases, such as PsycINFO, Sociological abstracts, MEDLINE, and ERIC, studies testing the ERI Model were identified. Sequentially, the reference lists of relevant publications were screened for additional empirical studies. In addition, several researchers known for their involvement with the ERI Model were contacted and asked whether they knew some additional ERI studies, which resulted in a few other papers.

Inclusion criteria for this review were: (1) publication in the period from 1986 to 2003 (inclusive), as the model was firstly introduced in 1986, (2) inclusion of *at least* two core dimensions of the model, either extrinsic effort and reward, or overcommitment and reward, and (3) inclusion of an effect measure *to test* the predictions of the ERI Model. Hence, descriptive/theoretical papers as well as psychometric papers on the ERI Model were not included in the review. In addition, (4) studies should be peer-reviewed scientific published papers (therefore paper presentations, personal communication, unpublished papers, dissertations, etc. were excluded).

Based on the criteria mentioned above, 45 studies were included in the review. A notable study that has been excluded on basis of those criteria is a study by Aust, Peter, and Siegrist (1997). Since it is the only intervention study based on the ERI Model, we felt this study needed to be briefly mentioned. Unfortunately this study only tested overcommitment, and no effect measures to test the model as such were included; therefore, the study was excluded from the review. Otherwise, studies that were included were categorized according to their outcome variables, such that a distinction had been made between physical health outcomes, behavioral outcomes and psychological well-being. Physical health outcomes encompass cardiovascular outcomes and other non-CVD-related physical outcomes. Behavioral outcomes are represented by behavioral reactions to strain (such as alcohol consumption). Psychological well-being includes general (psycho)somatic health symptoms and job-related psychological well-being.

Review results

Table 1 summarizes the ERI studies for each hypothesis per outcome category. Note that the ERI hypothesis has been divided into three different columns (i.e., all efforts included into an ERI index regardless of the type of effort used, an ERI index containing *only* extrinsic efforts, an ERI index including at least *intrinsic* effort—combined with or without extrinsic efforts) to give a more accurate reflection of the specific ERI hypothesis under study. Due to previous definitions of the ERI Model an ERI index might encompass both extrinsic and/or *intrinsic* efforts especially in earlier studies, whereas the current hypotheses state that only extrinsic efforts should be included into the ERI index. A detailed overview of the studies and their findings with respect to the sample that has been used, the design of the study, the specific outcome measures under study, method used, operationalization of ERI (and overcommitment), and whether or not support for each hypothesis of the ERI Model was found (results) is presented as an Appendix in the online version of this paper.

Physical health outcomes

Physical health outcomes were subdivided into cardiovascular disease (CVD) outcomes and other outcomes. A total of 25 studies could be identified that studied the ERI Model in relation to physical health outcomes. More specifically, 24 studies were aimed at

Table 1
Number of studies included in the review sorted by hypothesis (i.e., ERI, OVC, and interaction) and outcome category

Outcome category	Total ($n=45$)	ERI hypothesis (effort × reward)			OVC hypothesis	Interaction hypothesis (effort × reward × OVC)
		All[a]	Extrinsic effort[b]	Remaining[c]		
Physical health outcomes	25*					
CVD incidence	8	8	5	3	5	1
CVD symptoms and risk factors	17	15	13	2	11	3
Other outcomes	1	1	1	0	1	1
Behavioral outcomes	3					
Behavioral outcomes	3	3	3	0	1	0
Psychological well-being	19*					
(Psycho)somatic health symptoms	16	15	13	3	7	3
Job-related well-being	7	6	6	0	2	4

*Note that some studies include several types of outcomes and therefore are counted twice, i.e., the sum of studies in the sub-categories exceeds the number of studies in the main outcome categories (and in a similar way this means that counting the total amount of studies exceeds 45).

[a]All studies that tested the ERI hypothesis (i.e., effort × reward).

[b]Only studies that explicitly tested the ERI hypothesis with *extrinsic* effort and rewards (i.e., extrinsic effort × reward).

[c]Remaining studies that tested ERI hypothesis at least with *intrinsic* (and possibly extrinsic) efforts and rewards (i.e., intrinsic/extrinsic effort × reward).

CVD outcomes, whereas one study related to other outcomes (i.e., cortisol) (see Table 1).

CVD outcomes

Since the ERI Model was originally developed to study the relation between work stress and CVD, it is not astonishing that most studies include a CVD outcome measure. In more detail, Table 1 shows that eight studies examined CVD incidence (i.e., mortality and morbidity) and 17 studies verified CVD symptoms/risk factors (such as hypertension and cholesterol). Studies that used self-reported heart disease outcomes were also included in the 'CVD symptoms and risk factors' section.

CVD incidence: Several similarities appeared between studies including CVD incidence (all numbers refer to the studies as listed in the Appendix)). Foremost, all studies indicated that an ERI at work (i.e., ERI, a high-effort–low-reward situation) was positively associated with the occurrence of coronary events [1, 6–8, 14, 18, 21, 22]. Moreover, the method used was either logistic regression analyses [1, 8, 14, 18, 21, 22] or a Cox proportional hazard model [6, 7]. The odds ratios ranged from 1.22 to 8.98, meaning that employees in a high-effort–low-reward situation had an elevated risk of CVD incidence over 1 to almost 9 times as high as employees in a reversed working situation (i.e., low effort and high reward). In addition, even though two studies used a retrospective design [1, 14], most studies used a prospective design, supporting the predictive value of the ERI Model [6–8, 18, 21, 22]. Another feature of the CVD incidence studies was that they mainly tested the model within a male population [1, 8, 18, 21, 22], which restricts generalizability. Especially, a study by Peter et al. [14] which reported different results for women (increased CVD risk by overcommitment) and men (increased CVD risk by ERI) casts doubt on the possibility of generalizing male studies to women. Another point of consideration is the operationalization of ERI itself. Firstly, some studies used the original questionnaire (i.e., the ERI-Q), whereas other studies used proxy measures (e.g., [6–8, 14]). Secondly, different calculations of an ERI index have been used, e.g., a ratio [6, 7, 14, 18, 21] or a median split [8]. Thirdly, in three (earlier) studies the concept of "effort" within those ERI indices represented both extrinsic and *intrinsic* efforts (which is actually overcommitment) [18, 21, 22]. Despite variation in the operationalization of the ERI concept, results were consistent, supporting the robustness of the relation between ERI and CVD. Actually, a recent study showed a reasonable agreement between original and proxy measures within the same population, with correlations between both kinds of measures ranging from .37 to .62 (Fahlen, Peter, & Knutsson, 2004). With the exception of two studies [6, 8], all studies included a measurement of overcommitment into their study (whether or not into an ERI index). Four studies found that high overcommitment was associated with an increased risk for CVD events [7, 14, 21, 22]. In other words, the risk of getting a CVD or even of dying due to a CVD was 1.18–4.53 times as high for highly overcommitted employees in comparison with low overcommitted employees. Appels et al. (1997) also found an effect of overcommitment on AMI status, but this effect diminished when ERI was added to the analyses. The combination of ERI and overcommitment was only studied by Kuper et al. [7], but they found no evidence that highly overcommitted people showed a particularly high risk on cardiovascular heart disease due to ERI (i.e., a moderating effect).

In summary, ERI studies including CVD incidence as an outcome were quite similar with regard to design (prospective), method (relative risk models), and population (male). Operationalization of concepts and ERI indicators differed, but did not seem to affect the results substantially. The ERI hypothesis was supported by all studies with respect to CVD incidence. In other words, employees who reported to work under high efforts without receiving proper rewards actually turned out to be more prone to get a CVD, and even died of a CVD, a few years later. Most studies that examined the intrinsic OVC hypothesis found support, showing that highly overcommitted employees are more likely to get a CVD and/or die of a CVD. A combined effect of ERI and overcommitment was examined in only one study, but did not support the interaction (ERI $\times$ OVC) hypothesis. That is, working in an ERI situation as well as being highly overcommitted at the same time did not seem to elevate the risk over and above the separate effects of ERI and OVC.

CVD symptoms and risk factors: A high-effort–low-reward imbalance (ERI) was positively associated with CVD symptoms and/or risk factors in 13 out of 17 studies [2, 6, 9, 11–13, 15–17, 19, 20, 23, 25]. Two studies did not test a combination of high effort and low reward simultaneously [5, 10]. Therefore results of ERI are unknown. The other two studies did contain a measure of ERI, but did not find an effect of ERI on CVD risk [4, 24]. Those studies solely deviated in the method used to examine the relation between ERI and CVD risk, i.e., multilevel analyses and general linear models, whereas most other studies used logistic regression analyses. To put it differently, the statistical method used might have influenced the outcomes. Nevertheless, on balance spending high efforts at work without receiving a proper (high) reward was related to more CVD symptoms and risk factors (such as hypertension and high cholesterol). More specifically, employees had an elevated risk for CVD symptoms ranging from 1.23 to 6.71 in an ERI situation. Remarkably, those two studies, which could not demonstrate an effect of ERI, did show an effect of overcommitment (on high-frequency heart rate and the fibrinolytic system, respectively). In addition, four other studies found a positive association between overcommitment (i.e., "immersion" and "vigor" which are dimensions of "need for control") and CVD risk factors. More specifically, in highly overcommitted employees a higher blood pressure [10, 17], higher LDL cholesterol (but only for women) [12], and more restenosis [5] was found, indirectly increasing the risk of getting a CVD. Overall, highly overcommitted employees had an elevated risk ranging from 1.37 to 1.86 for CVD risk factors. Further, three studies examined the interaction between ERI and overcommitment, but none of the studies found a significant effect [4, 24, 25]. ERI was mainly assessed by ratios (cf. [6, 12, 13, 24, 25]) and a direct division into categories (cf. [2, 9, 11, 15, 16, 19, 23]). Again, precaution should be taken in interpreting the ERI indices, as effort may represent intrinsic effort (i.e., overcommitment) [2] or a mingling of extrinsic and intrinsic efforts [23]. In addition, 13 out of 17 studies included only male respondents in their samples [5, 9–11, 13, 15–17, 19, 20, 23–25]. As with CVD incidence, another study by Peter et al. [12] showed an elevated risk for CVD risk for men in case of ERI, whereas women had an elevated risk due to high overcommitment. Various study designs were used in assessing CVD symptoms: a prospective design [2, 5, 6, 9, 10, 17, 20], an experimental design [15, 16], a 1 day subject-within design [4, 24, 25], and a cross-sectional design [11–13, 19, 23, 26]. Results with respect to cross-sectional studies showed a similar pattern. That is, all cross-sectional studies found an association between ERI and CVD risk factors, and none of those studies found an overall effect of overcommitment. Otherwise, no considerable pattern in finding (non-)support for the ERI Model seemed to be present due to study design.

To recapitulate, most studies investigated and supported the ERI hypothesis, meaning that a high-effort–low-reward situation at work was associated with reporting more CVD symptoms and/or risk factors. The intrinsic overcommitment hypothesis was evaluated in the majority of studies, and about half of those studies found that highly overcommitted employees reported more CVD symptoms. The interaction between ERI and overcommitment with regard to CVD symptoms was investigated in just three studies, and none of those three studies found support for this interaction hypothesis. Furthermore, most studies, as with CVD incidence, included a male population, which is also inherent to the CVD outcomes (often being male is one of the selection criteria). With the exception of the cross-sectional studies that found consistently support for ERI but not for overcommitment, results did not show a particular pattern due to the use of different methods and study designs.

Other outcomes

One study included a physical health outcome that could not be classified as a CVD-related outcome. Hanson et al. [3] studied effort, reward, ERI, overcommitment as well as the interaction between ERI and overcommitment in relation to *cortisol* by means of physical measurements during 1 day (1 day within-subject design). The variables were assessed with a Dutch version of the original ERI questionnaire, and ERI was operationalized with the help of a ratio. Multilevel analyses were used to calculate the relations between the variables from 77 health care and office employees, but no significant effects were found. So, in this study cortisol did not seem to be influenced by a high-effort–low-reward situation, by high overcommitment, or the combination of ERI and overcommitment.

Behavioral outcomes

Three ERI studies including behavioral outcomes were identified (see Table 1 and Appendix). Firstly, in addition to hypertension (see "CVD symptoms and risk factors" section), Peter and Siegrist [11] studied the cross-sectional relation between ERI and (registered) *sickness absence* in male middle managers. Single components (frequent interruptions as a high-effort indicator, forced job change as a low-reward indicator, and overcommitment) as well as an ERI index composed of three categories were studied. Results showed that forced job change (which indicates low reward in their paper) was significantly and positively related to sickness absence, whereas working in a high-effort–low-reward situation was not significantly related to a higher sickness absence.

Secondly, in another–cross-sectional—study by Peter et al. among male middle managers [26] *smoking* was studied in relation to ERI, but not in relation to overcommitment. Effort and reward, as well as an ERI index with three categories (i.e., neither high effort nor low reward, either high effort or low reward, both high effort and low reward) were studied with logistic regression analysis and revealed that ERI was associated with an elevated risk of 4.34 for smoking.

Finally, in a cross-sectional study among employees of metal-working companies Puls et al. [27] found that ERI was related to an increased *alcohol consumption*. ERI was measured by its original questionnaire and operationalized as a ratio. Statistical analyses were conducted by means of path analyses. Overcommitment however was not examined in this study.

In summary, the ERI hypothesis was supported in two out of three studies [26, 27]. More specifically, working in a high-effort–low-reward job was related to more smoking and an increased alcohol assumption, but not to a higher (registered) sickness absence rate. The overcommitment hypothesis was only examined with regard to sickness absence, but no relation was found between overcommitment and sickness absence [11]. The ERI $\times$ OVC interaction hypothesis to test the simultaneous influence of ERI and OVC on the behavioral outcomes was not examined.

Psychological well-being

In this section ERI studies which measure psychological well-being as an outcome category are discussed. A distinction has been made between (1) (psycho)somatic health symptoms and (2) job-related well-being, including burnout (or emotional exhaustion), job satisfaction, and work motivation (cf. the classification of affective well-being by for instance (Warr (1987) or Ryff and Keyes (1995)). As can be seen from Table 1, 16 studies could be identified measuring (psycho)somatic health symptoms, and seven studies examined job-related well-being.

(Psycho)somatic health symptoms

In this review, (psycho)somatic health symptoms are generally defined as physical symptoms of which the deeper cause is assumed to be psychological of nature. Therefore, the (psycho)somatic health symptoms vary from mental symptoms (e.g., general mental health and depression) to physical symptoms (such as self-reported general physical health status and musculoskeletal symptoms).

Studies with regard to (psycho)somatic health symptoms were quite similar with respect to statistical analyses (logistic regression analyses), measurement instrument (proxy questionnaires) and design (cross-sectional). In terms of design, the studies guided by Kuper [7], Stansfeld [41, 42], and Ostry [37] were notable exceptions, since they used longitudinal prospective designs. Most studies found that work characterized by ERI was positively associated with impaired employee well-being. More specifically, employees working in a high-effort–low-reward situation had an elevated risk of 1.44–18.55 for (psycho)somatic symptoms. Two studies that were unable to demonstrate this association between ERI and (psycho)somatic symptoms were the studies in charge of Rothenbacher [40] and Joksimovic [33] which included the dyspepsia symptom and specific musculoskeletal disorders, respectively. Possibly, ERI might be stronger related to more general health outcomes, whereas it is more difficult to find a relation between ERI and a specific health outcome, such as dyspepsia and specific musculoskeletal disorders. Remarkable in this respect is that Dragano et al. [30] did find an association between ERI and specific muskuloskeletal outcomes, although it should be noted that the different types of rewards (i.e., esteem, security and promotion) had been measured separately. As such a similar level of specificity might have been achieved between rewards and outcomes. ERI was either calculated by ratios (cf. [7, 30, 33, 35, 38–40, 43]) or by categories [32, 37, 41, 42, 44, 45]. The study by Stansfeld et al. [41, 42] slightly deviated as they used intrinsic effort (i.e., overcommitment) instead of extrinsic effort to calculate ERI. As main effects of intrinsic effort were not studied by them, the effects of OVC itself remain unknown. Some studies did not include a measure of overcommitment [38, 39, 45], whereas studies that did measure overcommitment reported different findings. Six studies found a positive relation between overcommitment and impaired well-being [7, 30, 33, 35, 40, 43]. In other words, employees characterized by high overcommitment were 1.92–5.92 times as likely to suffer from various (psycho)somatic symptoms (ranging from musculoskeletal disorders to depression), as compared to their less overcommitted employees. However, Calnan et al. [29] found no effect of high OVC on general health. Since their study was the only study using linear (instead of logistic) regression analyses, this might be an effect of the statistical method that was used. Furthermore, three studies examined the interaction between ERI and OVC. De Jonge et al. [32] found that risks of ERI were aggravated for highly OVC employees (i.e., ORs ranged from 3.57 to 6.50), whereas Kuper et al. [7] and Van Vegchel et al. [44] found no evidence for a moderating effect of OVC on the relation between ERI and (psycho)somatic symptoms.

In short, with regard to the hypotheses of the ERI Model, most studies consistently reported a positive relation between ERI at work and (psycho)somatic health symptoms. However, it should be mentioned that it seemed to be difficult to find effects of ERI on (very) specific health outcomes, unless the specific rewards have analyzed separately. This was however not the case for overcommitment: general as well as specific health outcomes often showed an elevated risk due to high overcommitment. Finally, results with respect to the interaction hypothesis (ERI $\times$ OVC) were inconsistent. Out of three studies that examined the moderating effect of overcommitment on (psycho)somatic health, only one study found an increased risk for psychosomatic health symptoms and physical health for highly overcommitted employees in a high-effort–low-reward situation, as opposed to low overcommitted employees in a similar situation.

Job-related well-being

Burnout, viz. (emotional) exhaustion which is the main component of burnout [28, 31, 32, 36, 44, 45], as well as job satisfaction [29, 31, 32, 36, 44] were most extensively studied among the ERI studies including job-related well-being (see Appendix). Another well-being outcome, i.e., work motivation, was included in one study [31]. Typically, all studies examining job-related well-being were cross-sectional, included employees from human service organizations (e.g., employees from medical practices and health care employees), and used proxy ERI measures. Although it should be noted that Bakker et al. [28] used the original questionnaire for effort and overcommitment (but a proxy measure for reward), while for Lewig and Dollard [36] the opposite was the case (i.e., reward measured by the original questionnaire). Results showed that five studies found an association between ERI and poor job-related well-being [28, 31, 32, 44, 45]. Moreover, all those studies showed that employees with high effort and low reward had an elevated risk for (emotional) exhaustion, whereas some studies also found that ERI was associated with more depersonalization [28] and less job satisfaction [32, 44] (in general ORs ranged from 5.49 to 37.37). It should be mentioned that the study by De Jonge and Hamers [31] was partially supportive, lending support for ERI in relation to (more) emotional exhaustion, but not for (less) job satisfaction and work motivation. Furthermore, except for one study [45] all studies examined overcommitment. Firstly, main effects of overcommitment were reported by Calnan et al. [29] for job satisfaction, and by Bakker et al. [28] for emotional exhaustion and depersonalization. Secondly, the remaining studies calculated an interaction between ERI and (high) overcommitment resulting in elevated risks ranging from 5.44 to 20.81 for job-related well-being [28, 31, 32, 44]. Results varied across studies. Bakker et al. [28] found an interaction between ERI and high overcommitment for emotional exhaustion and personal accomplishment. De Jonge et al. [32] found that risks of more emotional exhaustion and less job satisfaction due to ERI were higher in overcommitted employees, whereas De Jonge and Hamers [31] found no effect of overcommitment on the ERI–outcome association, and Van Vegchel et al. [44] found no or even reversed effects of overcommitment regarding that association.

To recapitulate, all well-being studies seemed to fit a certain profile such that most studies were cross-sectional, included a human service population, used proxy ERI measures, and examined (the moderating effect of) overcommitment. Most studies showed that working during ERI was related to poor job-related well-being, especially to higher (emotional) exhaustion. Two studies examined the intrinsic OVC hypothesis and found that high overcommitment was related to less job satisfaction, and more emotional exhaustion and depersonalization. Four out of five studies investigated the moderating effect of overcommitment on the relation between ERI and job-related well-being, but results were not consistent. Half of the studies were supportive, while the other half were not.

Discussion

The present review balanced the results of 45 empirical studies published from 1986 up to and including 2003 with respect to the ERI Model. Taking the development of the ERI Model into account, the model was evaluated on the basis of evidence for three hypotheses (cf. Siegrist, 2002). Firstly, the (extrinsic) ERI hypothesis which assumes that employees with high efforts and low rewards at work will have a higher risk of poor health. Secondly, the OVC hypothesis which maintains that employees with a high level of overcommitment will also have a higher risk of poor health (independently of an ERI situation). And, a combination of both hypotheses, the interaction (ERI × OVC) hypothesis maintains that employees with both ERI *and* a high level of overcommitment will have an *even higher* risk of poor health. A distinction was made between physical health outcomes (mainly CVD-related outcomes), behavioral outcomes (i.e., sickness absence, smoking and alcohol consumption) and psychological well-being (i.e., (psycho)somatic health symptoms and job-related well-being). Table 2 shows the confirmative rate of the ERI studies for each hypothesis per outcome category. The confirmative rate contains a percentage that consists of the number of supportive studies divided by the total number of studies that examined the concerning hypothesis.

As can be seen from Table 2, the ERI hypothesis was most intensively studied (i.e., 48 out of 52 studies; note that some studies include several types of outcomes and therefore are counted twice, i.e., total amount of studies exceeds 45) and in general the majority of those studies supported the respective hypothesis, even after extensive confounder adjustment. In other words, in most studies a combination of high effort and low reward was associated with poor employee health. To do justice to the development of the ERI Model, in addition to a "total" confirmative rate of studies supporting the ERI hypothesis, the ERI hypothesis was split up into "extrinsic effort" representing the current version of the model (i.e., high extrinsic effort–low reward) and "remaining" to reflect a previous version of the model (i.e., high intrinsic and/or extrinsic effort–low reward) (see also Figs. 2 and 1, respectively). Eight studies included intrinsic effort (with or without extrinsic effort) into their ERI index, and also supported the ERI hypothesis. More specifically, based on outcome category, the review revealed the following findings. For physical health outcomes (mainly cardiovascular), the combination of high effort and low reward not only proved to have explanatory power for the manifestation of CVD (i.e., CVD incidence, 100% support), but also to be able to identify employees at risk at an earlier stage of CVD development (i.e., CVD symptoms/risk factors, 87% support). The only physiological outcome not (directly) related to CVD, being cortisol, did not support the ERI hypothesis. With regard to behavioral outcomes, ERI was associated with increased smoking and alcohol consumption but not to an increased sickness absence (i.e., 2 out of 3 studies showed support). Psychological well-being seemed to be related to ERI as well, supporting the use of the ERI Model beyond cardiovascular outcomes. Negative effects of a high-effort–low-reward situation were found for both

Table 2
Confirmative rate of studies with regard to the ERI hypothesis, the OVC hypothesis and the interaction (ERI × OVC) hypothesis per outcome category (a study is regarded as confirmative if at least half of the outcome measures in a certain study show support for the concerning hypothesis based on the "+" in the Appendix)

Outcome category	Total ($n=45$)	ERI hypothesis (effort × reward)			OVC hypothesis	Interaction hypothesis (effort × reward × OVC)
		All[a]	Extrinsic effort[b]	Remaining[c]		
Physical health outcomes	25*					
CVD incidence	8	100% (8/8)	100% (5/5)	100% (3/3)	80% (4/5)	0% (0/1)
CVD symptoms and risk factors	17	87% (13/15)	85% (11/13)	100% (2/2)	45% (5/11)	0% (0/3)
Other outcomes	1	0% (0/1)	0% (0/1)	0% (0/0)	0% (0/1)	0% (0/1)
Behavioral outcomes	3					
Behavioral outcomes	3	67% (2/3)	67% (2/3)	0% (0/0)	0% (0/1)	0% (0/0)
Psychological well-being	19*					
(Psycho)somatic health symptoms	16	87% (13/15)	85% (11/13)	100% (3/3)	86% (6/7)	33% (1/3)
Job-related well-being	7	83% (5/6)	83% (5/6)	0% (0/0)	100% (2/2)	50% (2/4)

*Note that some studies include several types of outcomes and therefore are counted twice, i.e., the sum of studies in the sub-categories exceeds the number of studies in the main outcome categories (and in a similar way this means that counting the total amount of studies exceeds 45).

[a] All studies that tested the ERI hypothesis (i.e., effort × reward).

[b] Only studies that explicitly tested the ERI hypothesis with *extrinsic* effort and rewards (i.e., extrinsic effort × reward).

[c] Remaining studies that tested ERI hypothesis at least with *intrinsic* (and possibly extrinsic) efforts and rewards (i.e., intrinsic/extrinsic effort × reward).

psychosomatic health symptoms (i.e., 13 out of 15 studies) and job-related well-being (5 out of 6). Remarkably, ERI seemed less predictive for more specific (psycho)somatic health outcomes and especially the job-related outcome exhaustion seemed to be of importance. This latter finding might lend support for Appel's notion (1997) that ERI is mediated by vital exhaustion in explaining CVD.

The OVC hypothesis, stating that high overcommitment leads to impaired health and well-being, was examined in about half of the studies (i.e., 27 out of 52, see Table 2). Review results varied depending on outcome category. For physical/cardiovascular health outcomes, most studies found that high overcommitment was predictive of a future CVD incident (i.e., 4 out of 5), and roughly one-half of the studies identified CVD symptoms/risk factors based on high overcommitment (i.e., 5 out of 11). Notable is the study by Joksimovic et al. (1999), which showed that overcommitment was also useful in predicting the further course of disease in those who already suffered from a manifest CVD. The sole study examining overcommitment in relation to a behavioral outcome (i.e., sickness absence) was not supportive. With respect to psychological well-being, most studies (i.e., 6 out of 7) showed a relation between high overcommitment and (psycho)somatic health symptoms (varying from particular musculoskeletal pains to depression), and two studies that investigated overcommitment in relation to job-related well-being both supported the OVC hypothesis as well.

Finally, Table 2 shows the confirmative rate of studies investigating the interaction (ERI × OVC) hypothesis. Compared to the other hypotheses, the interaction hypothesis was scarcely examined (i.e., 12 out of 52 studies). Therefore, strong conclusions with regard to the moderating role of overcommitment on the relation between ERI and employee health cannot be made. A difference did exist between studies with regard to the outcome category. Whereas studies including physical/cardiovascular and behavioral outcomes did hardly or not at all include a test of the moderating effect, studies with regard to psychological well-being (especially with regard to job-related well-being) studied the moderating role of overcommitment more intensively. None of the studies including physical health outcomes supported the interaction hypothesis (i.e., 1 study for CVD incidence, 3 studies for CVD risk, and 1 study for cortisol). One out of three studies including (psycho)somatic health symptoms showed that risks of an ERI work situation were aggravated for employees characterized by high overcommitment. And exactly half of the job-related well-being studies (i.e., 2 out of 4) supported the hypothesis that risks of poor well-being (i.e., exhaustion, less personal accomplishment and job dissatisfaction) due to ERI were higher in highly overcommitted employees.

To recapitulate, the ERI Model seems to be a fruitful model in order to crystallize the relation between work characteristics and employee health. In general, the ERI hypothesis has been intensively examined and most studies support the notion that a combination of high effort and low reward induces an impaired employee health. The OVC hypothesis was studied in about half of the studies, of which most studies found evidence that high-overcommitted employees had an impaired health compared to their less overcommitted counterparts. Even though it should be noted that results varied considerably among outcome categories. The interaction hypothesis between ERI and OVC had been hardly incorporated into empirical research, which precludes strong conclusions with respect to the overall support of this hypothesis.

In a way, it is not surprising that the ERI hypothesis was studied most often. After all, a high-effort–low-reward imbalance lies at the heart of the ERI Model. Furthermore, from the beginning an ERI was assumed to affect employee well-being (i.e., the ERI hypothesis), whereas the role of overcommitment (and its hypotheses) evolved over time. Originally, overcommitment was considered to be part of the effort concept (i.e., intrinsic effort), while in later versions overcommitment was assumed to be an independent concept. The erratic role of overcommitment shines through the (empirical) literature as many different roles have been dedicated to overcommitment. For instance, overcommitment could be seen as a moderator influencing the relation between ERI and employee health (e.g., de Jonge, Bosma, Peter, & Siegrist, 2000). Overcommitment could also have a direct effect on employee health (with or without reward). Other possible roles of overcommitment are that overcommitment directly influences ERI (without influencing employee health as such). And, as Appels et al. (1997) assume in their study, overcommitment could be a result of ERI, i.e., overcommitment as an outcome. All in all, the development of the ERI Model may have contributed to the fact that more attention has been devoted to the ERI hypothesis, as compared to the overcommitment part. However, in order to evaluate the full ERI Model, future research should contain a test of effort, reward *as well as* overcommitment. A good starting point might be to test the specific hypotheses as suggested by Siegrist (2002), being the ERI, the OVC, and the ERI × OVC hypothesis.

Although the ERI hypothesis was most extensively studied, there are still many ways to operationalize the co-occurrence of high effort and low reward. Firstly, depending on the theoretical interpretation of the ERI Model alternative formulations can be postulated. For instance, do high effort and low reward separately have an effect on employee health, or should they occur together to have a possible influence on employee health, and if so, should there be an interaction effect (i.e., effect over and above the sum of the separate effects of effort and reward)? In line with the most recent hypotheses an interaction effect has been mentioned by Siegrist (2002), between effort and reward.

Secondly, looking in detail at the calculation of the ERI index showed that studies differed considerably. Even though most studies used ratios or categories for high/low effort and high/low reward, several ways are possible to calculate a ratio (continuous or dichotomized, with or without logarithmic transformation) and to handle the resulting quotient. For instance, the quotient has been used to make a division between two groups (i.e., ratio >1 as risk group vs. ratio $\leqslant 1$ as non-risk group), three groups (i.e., low, intermediate, high), or four groups. In a similar vein, internal differences exist for the categories. For example, results (continuous or dichotomized) have been divided into two (e.g., cut off point and median split), three (e.g., neither high efforts nor low rewards, either high efforts or low rewards, both high efforts and low rewards) or four (e.g., low efforts–high rewards, low effort–low rewards, high efforts–high rewards, high efforts–low rewards) categories. In earlier publications it was common to use three categories, but lately the use of four categories has been intensified since research has shown the importance of distinguishing the conditions high effort–high reward from low effort–low reward (cf. de Jonge et al., 2000). Another definition for ERI, primarily used in the earlier version of the ERI studies, is the co-manifestation of at least one high effort and one reward indicator. Although this definition might have been formulated for explorational reasons, difficulties resulting from this are the many possible compositions of different efforts and rewards enlarging possible chance capitalization. In general, it should be mentioned that the use of cut off points for variables is rather arbitrary to create an ERI (or stressful work) situation, as neither natural nor clinically based thresholds are available thus far (de Jonge et al., 2000). Moreover, it is no doubt that the use of different ERI indices complicates the comparison between studies.

Thirdly, on a more general level of measurement the review showed that approximately one-half of the ERI studies used the original questionnaire, whereas the other half used proxy measures. On the one hand, the use of the original questionnaire simplifies comparison across studies and relates as closely as possible to the original concepts as meant by the model (cf. Beehr, Glaser, Canali, & Wallwey, 2001; Schnall, Landsbergis, & Baker, 1994). On the other hand, studies using original as well as proxy measures found support for the ERI Model, indicating an effect of ERI regardless of the measure being used, strengthening the robustness of the model. In addition, the concept of effort in the original questionnaire is composed of a variety of items of which the content differs (such as physical load, time pressure and working overtime). Several dimensions might be captured by effort, for instance physical and psychological demands. Possibly, in case of some specific occupations it might be desirable to split up specific demands. In a similar vein, the concept of reward has been operationalized in various ways, mostly as one global reward construct including several specific rewards. A disadvantage of one global reward indicator (and using different specific rewards to construct this indicator) might be that it is not clear whether specific rewards can have different effects. Hence, a clear definition of which specific rewards should be included and analyzing those specific rewards separately might be a fruitful extension of the ERI Model (Dragano et al., 2003; van Vegchel et al., 2002). Moreover, the present review showed that support was found for musculoskeletal disorders when specific rewards were included in the analyses (Dragano et al., 2003), whereas no effect was found when a global reward construct was used (Rothenbacher, Peter, Bode, Adler, & Brenner, 1998) (note that both studies used the original questionnaire).

The statistical method often involved logistic regression analyses for both naturally dichotomous and (dichotomized) continuous variables. Although analyzing a dichotomous outcome variable (such as CVD-incidence) requires the use of logistic regression analyses, there is a risk in dichotomizing continuous variables. First of all, by dichotomizing continuous variables information is lost and variance might be thrown away. Secondly, the cut off point determines the division among categories, making the division dependent on the value of the cut off point, which could give a wrong estimation. The same could be argued for the calculation of the ERI index. Most studies use categories or ratios of which the quotient is divided into categories. Therefore, in case of continuous variables the use of continuous analyses (e.g., hierarchical regression analyses) as well as a continuous ERI index (e.g., a multiplicative interaction term) might be advisable in future research.

ERI studies including behavioral and job-related outcomes were rather scarce. In addition, to our knowledge only one intervention study with respect to the ERI Model exists (Aust et al., 1997). Intervention studies are important to gain more insight into the practical value of the ERI Model, and are therefore highly recommended (cf. Kompier, Geurts, Gründemann, Vink, & Smulders, 1998).

In general, study designs were either prospective (i.e., longitudinal) or cross-sectional, and the proportion of longitudinal vs. cross-sectional studies differed by outcome measures. Studies examining CVD incidence were mainly prospective, strengthening the predictive value of the ERI Model. On the other hand, studies including CVD symptoms/risk factors also used cross-sectional designs. Remarkably, all those cross-sectional studies supported the ERI assumption, but none of them supported the OVC assumption. Possibly, ERI and overcommitment could have different time lagged effects such that working during an ERI has short term effects at least in terms of CVD symptoms, whereas overcommitment is a long term determinant of CVD symptoms. With regard to behavioral outcomes and psychological well-being mainly cross-sectional designs were used. However, to examine causal patterns preferably with different time lags between effort, reward, overcommitment and health more longitudinal studies are needed (e.g., see Taris & Kompier, 2003). In addition, with the help of longitudinal studies the causal direction of the relation between ERI variables (i.e., effort, reward and overcommitment) and employee health could be further examined. For instance, does an ERI cause poor employee health, or do employees with a poor health report more efforts and less rewards (i.e., reversed causation), or do they mutually influence each other (i.e., reciprocal relation: cf. de Jonge et al., 2001). In a similar vein, the role of overcommitment (being a personal characteristic) could be further examined in relation to ERI and employee health.

And finally, to establish the generalizability of the ERI Model, research should be expanded to an even more diverse array of respondents. The present review showed that research including CVD-related outcomes predominantly used male populations, which hampers generalizing results to a female population. This is particularly important, given two studies by Peter et al. (1998, 2002) that report different results for men (i.e., CVD risk due to ERI) and women (i.e., CVD risk due to OVC). This possibly reflects the multi-faceted nature of the ERI Model for men and women. Furthermore, studies with regard to job-related well-being all included a population from the human service sector. Although different occupations have been studied within those human service professions, studying different populations would be recommendable in order to generalize results to non-human service occupations. In addition, the vast majority of ERI studies have been conducted in West-European countries. Three notable exceptions are a study by Pikhart et al. (2001) in five post-communistic countries, a Japanese study by Tsutsumi, Kayaba, Theorell, and Siegrist (2001), and an Australian study by Lewig and Dollard (2003). In order to establish generalizability and cross-cultural differences, the ERI Model should be examined in different (non-West-European) countries as well.

At the end, it should be noted that a review will always be limited to papers that have been published. The present review tried to encompass as much studies as possible, being unaware of results of unpublished papers. To draw the balance, in 18 years of empirical research the ERI Model has proven to be a valuable contribution to occupational health research. While the ERI Model is on the right track to help explain the work stress phenomenon, the road is never ending. There is still much to be done as we continuously have to learn about the particular relationship between job characteristics and employee health and well-being.

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Appendix A. Supplementary analysis tools

A collection of macros that can be applied to sequence batches of up to 5000 sequences can be obtained from our web site (http://igm.ccc.uab.edu/˜schroeder/publications/).

Appendix B. Supplementary data

The online version of this article contains additional supplementary data. Please visit doi:10.1016/j.socscimed.2004.06.043.

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