

Effort-reward imbalance at work - theory, measurement and evidence

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1 Theoretical background

Research on effort-reward imbalance and health is part of a larger scientific program that aims at understanding the contribution of social and psychological factors to human health and disease. More specifically, protective and damaging effects on health produced by peoples' behaviours, cognitions and emotions through core social roles in adult life (work role, civic roles, family roles etc.) are analysed using a specific theoretical and methodological approach.

This theoretical approach is focused on the notion of social reciprocity, a fundamental principle of interpersonal behavior and an 'evolutionary old' grammar of social exchange. Social reciprocity is characterized by mutual cooperative investments based on the norm of return expectancy where efforts are equalized by respective rewards. Failed reciprocity resulting from a violation of this norm elicits strong negative emotions and sustained stress responses because it threatens this fundamental principle.

The model of effort-reward imbalance (ERI) claims that failed reciprocity in terms of high efforts spent and low rewards received in turn is likely to elicit recurrent negative emotions and sustained stress responses in exposed people. Conversely, positive emotions evoked by appropriate social rewards promote well-being, health and survival.

A major specification of this theoretical perspective concerns the work role, and in particular its contractual basis. So far, a majority of research evidence concerns ERI at work. More recently, this perspective has been applied to additional social roles in adult life (for further information please [click here](#)).

According to the model, effort at work is spent as part of a social contract that reciprocates effort by adequate reward. Rewards are distributed by three transmitter systems: money, esteem, and career opportunities including job security. Each one of these components of work-related rewards was shown to matter for health.

The model of ERI at work claims that an imbalance between (high) effort and (low) reward is maintained under the following conditions:

1. Work contracts are poorly defined or employees have little choice of alternative workplaces (e.g. due to low level of skill, lack of mobility, precarious labor market);
2. employees may accept this imbalance for strategic reasons (this strategy is mainly chosen to improve future work prospects by anticipatory investments);
3. the experience of 'high cost / low gain' at work is frequent in people who exhibit a specific cognitive and motivational pattern of coping with demands characterized by excessive work-related commitment ('overcommitment'). Overcommitted men and women suffer from inappropriate perceptions of demands and of their own coping resources more often than their less involved colleagues, because perceptual distortion prevents them from accurately assessing cost-gain relations.

A graphic representation of the model is given in figure 1.

The following three hypotheses are derived from the ERI model:

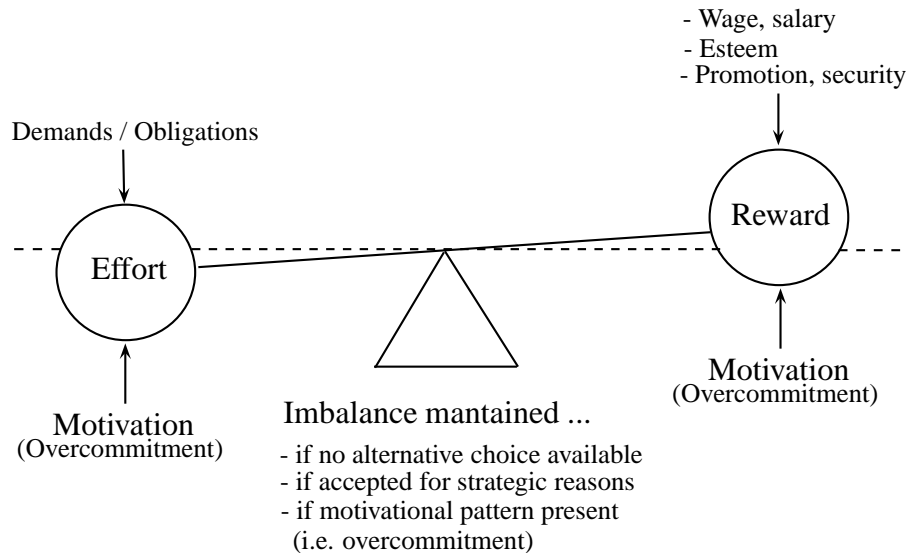


Figure 1: Schematic representation of the ERI-model

1. An imbalance between high effort and low reward (non-reciprocity) increases the risk of reduced health over and above the risk associated with each one of the components.
2. Overcommitted people are at increased risk of reduced health (whether or not this pattern of coping is reinforced by work characteristics).
3. Relatively highest risks of reduced health are expected in people who are characterized by conditions (1) and (2).

1.1 Key publications

- Siegrist, J. (1996). Adverse health effects of high effort - low reward conditions at work. *Journal of Occupational Health Psychology*, **1**, 27–43.
- Siegrist, J. (2000). Place, social exchange and health: proposed sociological framework. *Social Science & Medicine*, **51**, 1283–1293.
- Siegrist, J. (2002). Effort-reward Imbalance at Work and Health. In Perrewe, P. and Ganster, D. (Eds.), *Research in Occupational Stress and Well Being, Vol. 2: Historical and Current Perspectives on Stress and Health*, New York: JAI Elsevier, pp. 261–291.
- Siegrist, J. and Marmot, M. (2004). Health inequalities and the psychosocial environment - two scientific challenges. *Social Science & Medicine*, **58** (8), 1463–1473.
- Siegrist, J. and Theorell, T. (2006). Socioeconomic position and health: the role of work and employment. In Siegrist, J. and Marmot, M. (Eds.), *Social inequalities in health. New evidence and policy implications*, Oxford: Oxford University Press.

2 Measurement

In principle, different measurement approaches towards assessing ERI are feasible. To some extent, contextual information (e.g. job descriptions, level of salary, career mobility, job loss) can be used. However, core aspects of the model concern experiences and perceptions of working people. Therefore, self-report data are of core importance. These data can be acquired through qualitative interviews, ecological momentary assessments, standardized questionnaires or structured interviews.

In large scale social epidemiological research an economic measure in terms of a psychometrically well justified standardized questionnaire has proven to be particularly useful. In this tradition, the ERI model has been operationalized as a standardized self-report measure containing 23 Likert-scaled items in its established short version. These items define three unidimensional scales: 'effort' (6 items), 'reward' (11 items), and 'overcommitment' (6 items) with each item rated on a 5 point (effort, reward) or 4 point (overcommitment) Likert scale respectively. Examples of items are 'I have constant time pressure due to a heavy work load' (effort); 'My job promotion prospects are poor' (reward); 'Work rarely lets me go, it is still on my mind when I go to bed' (overcommitment). For access to information on full wording of the scales (in several languages), on psychometric properties of the scales and on analysis of ERI data please [click here](#).

2.1 Key publications

de Jonge, J., van der Linden, S., Schaufeli, W., Peter, R. and Siegrist, J. (2008). Factorial invariance and stability of the effort-reward imbalance scales: A longitudinal analysis of two samples with different time lags. *International Journal of Behavioral Medicine*, **15**, 62–72.

Rantanen, J., Feldt, T., Hyvönen, K., Kinnunen, U. and Mäkikangas, A. (2012). Factorial validity of the effort-reward imbalance scale: evidence from multi-sample and three-wave follow-up studies. *International Archives of Occupational and Environmental Health*, 1–12, URL <http://dx.doi.org/10.1007/s00420-012-0798-9>, 10.1007/s00420-012-0798-9.

Siegrist, J., Starke, D., Chandola, T., Godin, I., Marmot, M., Niedhammer, I. and Peter, R. (2004). The measurement of Effort-Reward Imbalance at work: European comparisons. *Social Science & Medicine*, **58** (8), 1483–1499.

2.2 Other Publications

Aboa-Éboulé, C., Brisson, C., Blanchette, C., Maunsell, E., Bourbonnais, R., Abdous, B., Vézina, M., Milot, A. and Dagenais, G. R. (2011b). Effort-Reward Imbalance at Work and Psychological Distress: A Validation Study of Post-Myocardial Infarction Patients. *Psychosomatic Medicine*, **73** (6), 448–455, doi:10.1097/01.psy.0000399790.82499.d7, URL <http://www.psychosomaticmedicine.org/content/73/6/448.abstract>.

Buapetch, A., Lagampan, S., Faucett, J. and Kalampakorn, S. (2008). The Thai Version of Effort-Reward Imbalance Questionnaire (Thai ERIQ): A Study of Psychometric Properties in Garment Workers. *Journal of Occupational Health*, **50**, 480–491.

- Conway, P. (2009). The instruments for subjective assessment of work-related stress. *Giornale italiano di medicina del lavoro ed ergonomia*, **31**, 197–199.
- Eum, K., Li, J., Lee, H., Kim, S., Paek, D., Siegrist, J. and Cho, S. (2007). Psychometric properties of the Korean version of the effort-reward imbalance questionnaire: a study in a petrochemical company. *International Archives of Occupational and Environmental Health*, **80** (8), 653–661, doi: 10.1007/s00420-007-0174-3.
- Fernández-López, J., Fernández-Fidalgo, M., Martín-Payo, R. and Rödel, A. (2006). Análisis factorial confirmatorio de la versión española del cuestionario “effort-reward imbalance”, de medida del estrés laboral [Confirmatory factor analysis of the Spanish version of the effort-reward imbalance questionnaire]. *Atención Primaria*, **38**, 465–466.
- Fernández-López, J., Fernández-Fidalgo, M., Martín-Payo, R. and Rödel, A. (2007). Estrés laboral y calidad de vida en sanitarios de atención primaria: una prueba de la validez del cuestionario PECVEC. *Atención Primaria*, **39** (8), 425–431.
- Griep, R., Rotenberg, L., Vasconcellos, A., Landsbergis, P., Comaru, C. and Alves, M. (2009). The psychometric properties of demand-control and effort-reward imbalance scales among Brazilian nurses. *International archives of occupational and environmental health*, **82**, 1163–1172, doi: 10.1007/s00420-009-0460-3.
- Harter Griep, R., Rotenberg, L., Chor, D., Toivanen, S. and Landsbergis, P. (2010). Beyond simple approaches to studying the association between work characteristics and absenteeism: Combining the DCS and ERI models. *Work & Stress*, **24** (2), 179–195, doi:10.1080/02678373.2010.493083, URL <http://www.tandfonline.com/doi/abs/10.1080/02678373.2010.493083>.
- Johnston, J. (2006). Using computerized ambulatory diaries for the assessment of job characteristics and work-related stress in nurses. *Work & Stress*, **20**, 163–172.
- Lau, B. (2008). Effort-reward imbalance and overcommitment in employees in a Norwegian municipality: a cross sectional study. *Journal of Occupational Medicine and Toxicology*, **3**, 9.
- Lehr, D., Koch, S. and Hillert, A. (2010). Where is (im)balance? Necessity and construction of evaluated cut-off pointers for effort-reward imbalance and overcommitment. *Journal of Occupational and Organizational Psychology*, **83** (1), 251–261.
- Li, J., Yang, W., Cheng, Y., Siegrist, J. and Cho, S. (2005). Effort-reward imbalance at work and job dissatisfaction in Chinese health care workers: A validation study. *International Archives of Occupational and Environmental Health*, **78**, 198–204.
- Magnavita, N. (2007). Two tools for health surveillance of job stress: the Karasek Job Content Questionnaire and the Siegrist Effort Reward Imbalance Questionnaire. *Giornale italiano di medicina del lavoro ed ergonomia*, **29** (3 Suppl), 667–670.
- Niedhammer, I., Siegrist, J., Landre, M., Goldberg, M. and Leclerc, A. (2000). Etude des qualités psychométriques de la version française du modèle d'équilibre Efforts/Recompenses. *Revue d'Epidémiologie et de Santé Publique*, **48**, 419–437.
- Preckel, D., Meinel, M., Kudielka, B., Haug, H. and Fisher, J. (2007). Effort-reward-imbalance, overcommitment and self-reported health: Is it the interaction that matters? *Journal of Occupational and Organizational Psychology*, **80** (1), 91–107, doi:10.1348/096317905X80183.
- Rödel, A., Siegrist, J., Hessel, A. and Brähler, E. (2004). Fragebogen zur Messung beruflicher Gratifikationskrisen. Psychometrische Testung an einer repräsentativen deutschen Stichprobe. *Zeitschrift für Differentielle und Diagnostische Psychologie*, **25** (4), 227–238, doi:10.1024/0170-1789.25.4.227.

- Shimazu, A. and de Jonge, J. (2009). Reciprocal relations between effort-reward imbalance at work and adverse health: A three-wave panel survey. *Social Science & Medicine*, **68**, 60–68, doi:10.1016/j.socscimed.2008.09.05.
- Siegrist, J., Wege, N., Pühlhofer, F. and Wahrendorf, M. (2009). A short generic measure of work stress in the era of globalization: effort-reward imbalance. *Int Arch Occup Environ Health*, **82**, 1005–1013, doi:10.1007/s00420-008-0384-3.
- Silva, L. and Barreto, S. (2010). Transcultural adaptation into Brazilian Portuguese of the effort-reward imbalance scale: a study with bank workers. *Revista panamericana de salud publica*, **27**, 32–36.
- Sperlich, S., Arnhold-Kerri, S., Engelke, S., Noeres, D., Collatz, J. and Geyer, S. (2009). Development of a questionnaire for measuring effort-reward imbalance in household and family work. *Psychotherapie, Psychosomatik, medizinische Psychologie*, **59**, 177–185, doi:10.1055/s-2008-1067386.
- Tse, J., Flin, R. and Mearns, K. (2007). Facets of job effort in bus driver health: deconstructing “effort” in the effort-reward imbalance model. *Journal of Occupational Health Psychology*, **12** (1), 48–62, doi:10.1037/1076-8998.12.1.48.
- Tsutsumi, A., Ishitake, T., Peter, R., Siegrist, J. and Matoba, T. (2001). The Japanese version of the Effort-Reward-Imbalance Questionnaire: a study in dental technicians. *Work & Stress*, **15**, 86–96.
- Tsutsumi, A., Iwata, N., Wakita, T., Kumagai, R., Noguchi, H. and Kawakami, N. (2008). Improving the Measurement Accuracy of the Effort-Reward Imbalance Scales. *International Journal of Behavioural Medicine*, **15**, 109–119, doi:10.1080/10705500801929718.
- Tsutsumi, A., Iwata, N., Watabe, N., Pikhart, J., Fernández-López, J. et al. (2009). Application of item response theory to achieve cross-cultural comparability of occupational stress measurement. *International journal of methods in psychiatric research*, **18**, 58–67, doi:10.1002/mpr.277.
- Weyers, S., Peter, R., Boggild, H., Jeppesen, H. and Siegrist, J. (2006). Psychosocial work stress is associated with poor self-rated health in Danish nurses: a test of the effort-reward imbalance model. *Scandinavian Journal of Caring Sciences*, **20**, 26–34.
- Zurlo, M., Pes, D. and Siegrist, J. (2010). Validity and reliability of the effort-reward imbalance questionnaire in a sample of 673 Italian teachers. *International archives of occupational and environmental health*, **83** (6), 665–674, doi:10.1007/s00420-010-0512-8.

3 Selected publications on research evidence

3.1 Reviews

The following reviews provide a summary of research on associations between ERI at work and health:

- Backé, E.-M., Seidler, A., Latza, U., Rossnagel, K. and Schumann, B. (2012). The role of psychosocial stress at work for the development of cardiovascular diseases: a systematic review. *International Archives of Occupational and Environmental Health*, **85**, 67–79, URL <http://dx.doi.org/10.1007/s00420-011-0643-6>, 10.1007/s00420-011-0643-6.
- Chandola, T., Heraclides, A. and Kumari, M. (2010). Psychophysiological biomarkers of workplace stressors. *Neuroscience and Biobehavioral Reviews*, **35**, 51–57, doi:10.1016/j.neubiorev.2009.11.005, URL <http://www.sciencedirect.com/science/article/pii/S0149763409001717>.

- Eller, N., Netterstrøm, B. and Gyntelberg, F. (2009). Work-Related Psychosocial Factors and the Development of Ischemic Heart Disease: A Systematic Review. *Cardiology in Review*, **17** (2), 83–97, doi:10.1097/CRD.0b013e318198c8e9.
- Marmot, M., Siegrist, J. and Theorell, T. (2006). Health and the psychosocial environment at work. In Marmot, M. and Wilkinson, R. (Eds.), *Social Determinants of Health*, Oxford: Oxford University Press, pp. 97–130.
- Marmot, M., Theorell, T. and Siegrist, J. (2002). Work and coronary heart disease. In Stansfeld, S. and Marmot, M. (Eds.), *Stress and the heart*, London: BMJ Books, pp. 50–71.
- Nieuwenhuijsen, K., Bruinvels, D. and Frings-Dresen, M. (2010). Psychosocial work environment and stress-related disorders, a systematic review. *Occupational Medicine*, **60** (4), 277–286, doi:10.1093/occmed/kqq081, URL <http://occmed.oxfordjournals.org/content/60/4/277.abstract>.
- Siegrist, J. (2002). Effort-reward Imbalance at Work and Health. In Perrewe, P. and Ganster, D. (Eds.), *Research in Occupational Stress and Well Being, Vol. 2: Historical and Current Perspectives on Stress and Health*, New York: JAI Elsevier, pp. 261–291.
- Siegrist, J. (2005). Social reciprocity and health: New scientific evidence and policy implications. *Psychoneuroendocrinology*, **30** (10), 1033–1038, doi:10.1016/j.psyneuen.2005.03.017.
- Siegrist, J. (2008). Chronic psychosocial stress at work and risk of depression: evidence from prospective studies. *European Archives of Psychiatry and Clinical Neuroscience*, **258**, 115–119, 10.1007/s00406-008-5024-0.
- Siegrist, J. (2008b). Effort-reward imbalance and health in a globalized economy. *Scandinavian Journal of Work, Environment & Health*, **6** (Special issue), 163–168.
- Siegrist, J. and Dragano, N. (2008). Psychosoziale Belastungen und Erkrankungsrisiken im Erwerb-leben. *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz*, **51**, 305–312.
- Tsutsumi, A. and Kawakami, N. (2004). A review of empirical studies on the model of effort–reward imbalance at work: reducing occupational stress by implementing a new theory. *Social Science & Medicine*, **59** (11), 2335–2359, doi:10.1016/j.socscimed.2004.03.030.
- van Vegchel, N., de Jonge, J., Bosma, H. and Schaufeli, W. (2005). Reviewing the effort–reward imbalance model: drawing up the balance of 45 empirical studies. *Social Science & Medicine*, **60** (5), 1117–1131, doi:10.1016/j.socscimed.2004.06.043.

3.2 Cardiovascular risk and diseases (including Type-II-diabetes)

Most research on the association between ERI at work and health was done on cardiovascular diseases. Selected studies and reviews are:

- Aboa-Éboulé, C., Brisson, C., Maunsell, E., Bourbonnais, R., Vézina, M., Milot, A. and Dagenais, G. R. (2011). Effort-Reward Imbalance at Work and Recurrent Coronary Heart Disease Events: A 4-Year Prospective Study of Post-Myocardial Infarction Patients. *Psychosomatic Medicine*, **73** (6), 436–447, doi:10.1097/PSY.0b013e318222b2d8, URL <http://www.psychosomaticmedicine.org/content/73/6/436.abstract>.
- Bosma, H., Peter, R., Siegrist, J. and Marmot, M. (1998). Two alternative job stress models and the risk of coronary heart disease. *American Journal of Public Health*, **88**, 68–74.

- Chandola, T., Siegrist, J. and Marmot, M. (2005). Do changes in effort-reward imbalance at work contribute to an explanation of the social gradient in angina? *Occup Environ Med*, **62** (4), 223–230, doi:10.1136/oem.2004.016675.
- Hintsanen, M., Elovainio, M., Puttonen, S., Kivimäki, M., Koskinen, T., Raitakari, O. and Keltikangas-Järvinen, L. (2007). Effort-reward imbalance, heart rate, and heart rate variability: the cardiovascular risk in young finns study. *International Journal of Behavioral Medicine*, **14**, 202–212, doi:10.1007/BF03002994.
- Kivimäki, M., Leino, P., Luukkonen, R., Riihimäki, H., Vahtera, J. and Kirjonen, J. (2002). Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees. *BMJ*, **325**, 857–862, doi:10.1136/bmj.325.7369.857.
- Kivimäki, M., Virtanen, M., Elovainio, M., Kouvonen, A., Väänänen, A. and Vahtera, J. (2006). Work stress in the etiology of coronary heart disease - a meta-analysis. *Scandinavian Journal of Work Environment & Health*, **32** (6), 431–442, doi:10.5271/sjweh.1049.
- Kumari, M., Head, J. and Marmot, M. (2004). Prospective study of social and other risk factors for incidence of type 2 diabetes in the Whitehall II study. *Archives of Internal Medicine*, **164**, 1873–1880.
- Kuper, H., Singh-Manoux, A., Siegrist, J. and Marmot, M. (2002). When reciprocity fails: effort-reward imbalance in relation to coronary heart disease and health functioning within the Whitehall II study. *Occupational Environmental Medicine*, **59**, 777–784.
- Maina, G., Bovenzi, M., Palmas, A., Prodi, A. and Filon, F. (2011). Job strain, effort-reward imbalance and ambulatory blood pressure: results of a cross-sectional study in call handler operators. *International Archives of Occupational and Environmental Health*, **84**, 383–391, URL <http://dx.doi.org/10.1007/s00420-010-0576-5>, 10.1007/s00420-010-0576-5.
- Maina, G., Bovenzi, M., Palmas, A., Prodi, A. and Filon, F. (2011b). Job strain, effort-reward imbalance and ambulatory blood pressure: results of a cross-sectional study in call handler operators. *International Archives of Occupational and Environmental Health*, **84**, 383–391, URL <http://dx.doi.org/10.1007/s00420-010-0576-5>, 10.1007/s00420-010-0576-5.
- Peter, R., Hammarström, A., Hallqvist, J., Siegrist, J. and Theorell, T. (2006). Does occupational gender segregation influence the association of effort-reward imbalance with myocardial infarction in the SHEEP study? *International Journal of Behavioral Medicine*, **13** (1), 34–43, doi:10.1207/s15327558ijbm1301\5.
- Smith, L., Roman, A., Dollard, M., Winefield, A. and Siegrist, J. (2005). Effort-reward imbalance at work: The effects of work stress on anger and cardiovascular disease symptoms in a community sample. *Stress and Health*, **21** (2), 113–128, doi:10.1002/smi.1045.
- Utsugi, M., Saijo, Y., Yoshioka, E., Sato, T., Horikawa, N., Gong, Y. and Kishi, R. (2009). Relationship between two alternative occupational stress models and arterial stiffness: a cross-sectional study among Japanese workers. *International Archives of Occupational and Environmental Health*, **82**, 175–183, doi:10.1007/s00420-008-0319-z.
- Wege, N., Dragano, N., Moebus, S., Stang, A., Erbel, R., Jöckel, K. and Siegrist, J. (2008). When does work stress hurt? Testing the interaction with socioeconomic status in the Heinz Nixdorf Recall Study. *Journal of Epidemiology and Community Health*, **62**, 338–341.
- Xu, W., Hang, J., Cao, T., Shi, R., Zeng, W., Deng, Y., Gao, W., Zhao, Y. and Guo, L. (2010). Job Stress and Carotid Intima-media Thickness in Chinese Workers. *Journal of Occupational Health*, **52** (5), 257–262.

Xu, W., Hang, J., Guo, L., Zhao, Y., Li, Z. and Gao, W. (2012). Plasma fibrinogen: A possible link between job stress and cardiovascular disease among Chinese workers. *American Journal of Industrial Medicine*, **55** (2), 167–175, doi:10.1002/ajim.21017, URL <http://dx.doi.org/10.1002/ajim.21017>.

Xu, W., Zhao, Y., Guo, L., Guo, Y. and Gao, W. (2009). Job Stress and Coronary Heart Disease: A Case-control Study using a Chinese Population. *Journal of Occupational Health*, **51** (2), 107–113.

3.3 Psychiatric disorders

Concerning ERI at work and psychiatric disorders (mainly depression), there is evidence from prospective and cross-sectional investigations (selection):

Bourbonnais, R., Jauvin, N., Dussault, J. and Vézina, M. (2007). Psychosocial work environment, interpersonal violence at work and mental health among correctional officers. *International Journal of Law and Psychiatry*, **30**, 355–368.

Buddeberg-Fischer, B., Stamm, M., Buddeberg, C., Bauer, G., Hämming, O. and Klagofer, R. (2008b). Arbeitsstress, Gesundheit und Lebenszufriedenheit junger Ärztinnen und Ärzte. Ergebnisse einer Schweizer Longitudinalstudie. (Work stress, health and satisfaction of life in young doctors: results of a longitudinal study in Switzerland). *Deutsche Medizinische Wochenschrift*, **133**, 2441–2447, doi: 10.1055/s-0028-1100936.

Chen, S.-W., Wang, P.-C., Hsin, P.-L., Oates, A., Sun, I.-W. and Liu, S.-I. (2011). Job stress models, depressive disorders and work performance of engineers in microelectronics industry. *International Archives of Occupational and Environmental Health*, **84**, 91–103, URL <http://dx.doi.org/10.1007/s00420-010-0538-y>, 10.1007/s00420-010-0538-y.

Dragano, N., He, Y., Moebus, S., Jöckel, K., Erbel, R. and Siegrist, J. (2008). Two models of job stress and depressive symptoms: results from a population based study. *Social Psychiatry and Psychiatric Epidemiology*, **43**, 72–78.

Godin, I., Kittel, F., Coppieters, Y. and Siegrist, J. (2005). A prospective study of cumulative job stress in relation to mental health. *BMC Public Health*, **5**, 67.

Griffin, J., Greiner, B., Stansfeld, S. and Marmot, M. (2007). The effect of self-reported and observed job conditions on depression and anxiety symptoms: A comparison of theoretical models. *Journal of Occupational Health Psychology*, **12** (4), 334–349.

Head, J., Stansfeld, S. and Siegrist, J. (2004). Psychosocial work environment and alcohol dependence. *Occupational and Environmental Medicine*, **61**, 219–224.

Kikuchi, Y., Nakaya, M., Ikeda, M., Narita, K., Takeda, M. and Nishi, M. (2010). Effort-reward imbalance and depressive state in nurses. *Occupational Medicine*, **60** (3), 231–233, doi:10.1093/occmed/kqp167, URL <http://occmed.oxfordjournals.org/content/60/3/231.abstract>.

Kivimäki, M., Vahtera, J., Elovainio, M., Virtanen, M. and Siegrist, J. (2007). Effort-reward imbalance, procedural injustice and relational injustice as psychosocial predictors of health: Complementary or redundant models? *Occup Environ Med*, **64**, 659–665, doi:10.1136/oem.2006.031310.

Lehr, D., Hillert, A. and Keller, S. (2009). What can balance the effort? Associations between effort-reward imbalance, overcommitment, and affective disorders in German teachers. *International Journal of Occupational and Environmental Health*, **15**, 374–384.

- Park, S., Min, K., Chang, S., Kim, H. and Min, J. (2009). Job stress and depressive symptoms among Korean employees: the effect of culture on work. *International Archives of Occupational and Environmental Health*, **82**, 397–405, doi:10.1007/s00420-008-0347-8.
- Pikhart, H., Bobak, M., Pajak, A., Malyutina, S., Kubinova, R., Topor, R., Sebakova, H., Nikitin, Y. and Marmot, M. (2004). Psychosocial factors at work and depression in three countries of Central and Eastern Europe. *Social Science & Medicine*, **58** (8), 1475–1482.
- Rugulies, R., Norborg, M., Sørensen, T., Knudsen, L. and Burr, H. (2009b). Effort-reward imbalance at work and risk of sleep disturbances. Cross-sectional and prospective results from the Danish Work Environment Cohort Study. *Journal of Psychosomatic Research*, **66**, 75–83, doi:10.1016/j.jpsychores.2008.05.005.
- Rystedt, L., Devereaux, K. and Sverke, M. (2007). Comparing and combining the demand-control-support model and the effort-reward imbalance model to predict long-term mental strain. *European Journal of Work and Organizational Psychology*, **16**, 261–278, doi:10.1080/13594320601182311.
- Stansfeld, S., Fuhrer, R., Shipley, M. and Marmot, M. (1999). Work characteristics predict psychiatric disorder: prospective results from the Whitehall II study. *Occupational and Environmental Medicine*, **56**, 302–307.
- Tang, J., Leka, S. and MacLennan, S. (2012). The psychosocial work environment and mental health of teachers: a comparative study between the United Kingdom and Hong Kong. *International Archives of Occupational and Environmental Health*, 1–10, URL <http://dx.doi.org/10.1007/s00420-012-0799-8>, 10.1007/s00420-012-0799-8.
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- Wang, J. L., Patten, S. B., Currie, S., Sareen, J. and Schmitz, N. (2012). Predictors of 1-year outcomes of major depressive disorder among individuals with a lifetime diagnosis: a population-based study. *Psychological Medicine*, **42** (02), 327–334, doi:10.1017/S0033291711001218, URL <http://dx.doi.org/10.1017/S0033291711001218>.

3.4 Symptoms and subjective health

A large number of reports analyse associations of ERI with self-reported data on health and well-being (for review see van Vegchel et al. 2004). Some recent publications are:

- van den Berg, T., Schuring, M., Avendano, M., Mackenbach, J. and Burdorf, A. (2010). The impact of ill health on exit from paid employment in Europe among older workers. *Occupational and Environmental Medicine*, **67** (12), 845–852, doi:10.1136/oem.2009.051730.
- Buddeberg-Fischer, B., Klaghofer, R., Stamm, M., Siegrist, J. and Buddeberg, C. (2008a). Work stress and reduced health in young physicians: prospective evidence from Swiss residents. *International Archives of Occupational and Environmental Health*, **82** (1), 31–38, doi:10.1007/s00420-008-0303-7.
- Dragano, N., Verde, P. and Siegrist, J. (2005). Organisational downsizing and work stress: testing synergistic health effects in employed men and women. *Journal of Epidemiology and Community Health*, **59**, 694–699.

- Ertel, M., Pech, E., Ullsperger, P. and Knesebeck, O. (2005). Adverse psychosocial working conditions and subjective health in freelance media workers. *Work & Stress*, **19**, 293–299.
- Härter, R., Rotenberg, L., Landsbergis, P. and Vasconcellos-Silva, P. R. (2011). Combined use of job stress models and self-rated health in nursing. *Revista de Saúde Pública*, **45** (1), 145–152, doi:10.1590/S0034-89102011000100017.
- Inoue, M., Tsurugano, S. and Yano, E. (2011). Job Stress and Mental Health of Permanent and Fixed-term Workers Measured by Effort-reward Imbalance Model, Depressive Complaints, and Clinic Utilization. *Journal of Occupational Health*, **53** (2), 93–101.
- Janzen, B., Muhajarine, N. and Zhu, T. (2007). Effort-reward imbalance, overcommitment, and psychological distress in Canadian police officers. *Psychological Reports*, **100**, 525–530.
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- Kudielka, B., Hanebuth, D., von Kanel, R., Gander, M., Grande, G. and Fisher, J. (2005). Health-related quality of life measured by the SF12 in working populations: Associations with psychosocial work characteristics. *Journal of Occupational Health Psychology*, **10**, 429–440.
- Li, J., Shang, L., Wang, T. and Siegrist, J. (2010). Measuring effort-reward imbalance in school settings: a novel approach and its association with self-rated health. *Journal of Epidemiology / Japan Epidemiological Association*, **20**, 111–118.
- Li, J., Yang, W. and Cho, S. (2006). Gender differences in job strain, effort-reward imbalance, and health functioning among Chinese physicians. *Social Science & Medicine*, **62**, 1066–1077.
- Mäki, K., Vahtera, J., Virtanen, M., Elovainio, M. et al. (2008). Work stress and new-onset migraine in a female employee population. *Cephalalgia*, **28**, 18–25.
- Niedhammer, I., Teck, M., Starke, D. and Siegrist, J. (2004). Effort-Reward Imbalance Model and self reported health: Cross-sectional and prospective results from the GAZEL Cohort. *Social Science & Medicine*, **58** (8), 1531–1541.
- Pikhart, H., Bobak, M., Siegrist, J., Pajak, A. et al. (2001). Psychosocial work characteristics and self-rated health in four post-communist countries. *Journal of Epidemiology and Community Health*, **55**, 624–630.
- Rugulies, R., Aust, B., Siegrist, J., Bultmann, U. et al. (2009a). Distribution of effort-reward imbalance in Denmark and its prospective association with a decline in self-rated health. *Journal of Occupational and Environmental Medicine*, **51**, 870–878, doi:10.1097/JOM.0b013e3181a9086c.
- Salavecz, G., Chandola, T., Pikhart, H., Dragano, N. et al. (2010). Work stress and health in Western European and post-communist countries: an East-West comparison study. *Journal of Epidemiology and Community Health*, **64**, 57–62, doi:10.1136/jech.2008.075978.

- Shimazu, A. and de Jonge, J. (2009). Reciprocal relations between effort-reward imbalance at work and adverse health: A three-wave panel survey. *Social Science & Medicine*, **68**, 60–68, doi:10.1016/j.socscimed.2008.09.05.
- Van Vegchel, N., de Jonge, J. and Meijer, T. (2001). Different effort constructs and effort-reward imbalance: effects on employee well-being in ancillary health care workers. *Journal of Advanced Nursing*, **34**, 128–136.
- Wada, K., Sakata, Y., Theriault, G., Aratake, Y. et al. (2007). Effort-reward imbalance and social support are associated with chronic fatigue among medical residents in Japan. *International Journal of Occupational and Environmental Health*, **81**, 331–336.
- Watanabe, M., Tanaka, K., Aratake, Y., Kato, N. and Sakata, Y. (2008). The Impact of Effort-reward Imbalance on Quality of Life among Japanese Working Men. *Industrial Health*, **46**, 217–222.
- Willis, T., O'Connor, D. and Smith, L. (2008). Investigating effort-reward imbalance and work-family conflict in relation to morningness-eveningness and shift work. *Work & Stress*, **22** (2), 125–137, doi: 10.1080/02678370802180558.
- Yu, S., Gu, G., Zhou, W. and Wang, S. (2008). Psychosocial Work Environment and Well-Being: A Cross-Sectional Study at a Thermal Power Plant in China. *Journal of Occupational Health*, **50** (2), 155–162.

3.5 Sickness absence

Both short-term and long-term sickness absence are explored in association with ERI. Examples of respective research are:

- Derycke, H., Vlerick, P., Van de Ven, B., Rots, I. and Clays, E. (2012). The Impact of Effort-Reward Imbalance and Learning Motivation on Teachers' Sickness Absence. *Stress and Health*, n/a–n/a, doi:10.1002/smi.2416, URL <http://dx.doi.org/10.1002/smi.2416>.
- Fahlén, G., Goine, H., Edlund, C., Arrelöv, B., Knutsson, A. and Peter, R. (2008). Effort-reward imbalance, “locked in” at work, and long-term sick leave. *International Archives of Occupational and Environmental Health*, **82**, 191–197, doi:10.1007/s00420-008-03215.
- Godin, I. and Kittel, F. (2004). Differential economic stability and psychosocial stress at work: associations with psychosomatic complaints and absenteeism. *Social Science & Medicine*, **58** (8), 1543–1553.
- Head, J., Kivimäki, M., Siegrist, J., Fernie, J. et al. (2007). Effort-reward imbalance and relational injustice at work predicts sickness absence: the Whitehall II Study. *Journal of Psychosomatic Research*, **63**, 433–440.
- Peter, R. and Siegrist, J. (1997). Chronic work stress, sickness absence and hypertension in middle managers: general or specific sociological explanation? *Social Science & Medicine*, **45**, 1111–1120.
- Roelen, C., Koopmans, P. and Groothoff, J. (2009). Occupational rewards relate to sickness absence frequency but not duration. *Work*, **34** (1), 13–19, doi:10.3233/WOR-2009-0898.
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Vahtera, J., Laine, S., Virtanen, M., Oksanen, T., Koskinen, A., Pentti, J. and Kivimaki, M. (2010). Employee control over working times and risk of cause-specific disability pension: the Finnish Public Sector Study. *Occupational and Environmental Medicine*, **67** (7), 479–485, doi:10.1136/oem.2008.045096, URL <http://oem.bmj.com/content/67/7/479.abstract>.

3.6 Stress-related mechanisms

Several research strategies are realized in order to explain psychobiological mechanisms linking ERI-induced stressful experience with adverse health outcomes. These research strategies include ambulatory monitoring in naturalistic settings, experimental studies and analyses of innovative biomedical markers in high risk groups identified in the context of epidemiological studies. Selected recent publications include:

Bellingrath, S. and Kudielka, B. (2008). Effort-reward-imbalance and overcommitment are associated with hypothalamus-pituitary-adrenal (HPA) axis responses to acute psychosocial stress in healthy working schoolteachers. *Psychoneuroendocrinology*, **33**, 1335–1343, doi:10.1016/j.psyneuen.2008.07.008.

Bellingrath, S., Rohleder, N. and Kudielka, B. M. (2010). Healthy working school teachers with high effort-reward-imbalance and overcommitment show increased pro-inflammatory immune activity and a dampened innate immune defence. *Brain, Behavior, and Immunity*, **24** (8), 1332–1339, doi:10.1016/j.bbi.2010.06.011, URL <http://www.sciencedirect.com/science/article/pii/S0889159110001443>.

Bellingrath, S., Weigl, T. and Kudielka, B. (2007). Chronic work stress and exhaustion is associated with higher allostatic load in female school teachers. *Stress: The International Journal on the Biology of Stress*, **12**, 37–48.

Bellingrath, S., Weigl, T. and Kudielka, B. (2008). Cortisol dysregulation in school teachers in relation to burnout, vital exhaustion, and effort-reward imbalance. *Biological Psychology*, **78**, 104–113, doi:10.1016/j.biopsycho.2008.01.006.

Bosch, J., Fischer, J. and Fischer, J. (2009). Psychologically adverse work conditions are associated with CD8+ T cell differentiation indicative of immunosenescence. *Brain, Behavior, and Immunity*, **23**, 527–534, doi:10.1016/j.bbi.2009.02.002.

Eller, N. H., Kristiansen, J. and Hansen, Å. M. (2011). Long-term effects of psychosocial factors of home and work on biomarkers of stress. *International Journal of Psychophysiology*, **79** (2), 195–202, doi:10.1016/j.ijpsycho.2010.10.009, URL <http://www.sciencedirect.com/science/article/pii/S0167876010007233>.

Eller, N. H., Nielsen, S. F., Blønd, M., Nielsen, M. L., Hansen, Å. M. and Netterstrøm, B. (2012). Effort reward imbalance, and salivary cortisol in the morning. *Biological Psychology*, **89** (2), 342–348, doi:10.1016/j.biopsycho.2011.11.007, URL <http://www.sciencedirect.com/science/article/pii/S0301051111002912>.

Fischer, J., Kudielka, B., von Kanel, R., Siegrist, J., Thayer, J. and Fischer, J. (2009). Bone-marrow derived progenitor cells are associated with psychosocial determinants of health after controlling for classical biological and behavioural cardiovascular risk factors. *Brain, Behavior, and Immunity*, **23** (4), 419–426.

Hamer, M., Williams, E., Vuonovirta, R., Giacobazzi, P. et al. (2006). The effects of effort-reward imbalance on inflammatory and cardiovascular responses to mental stress. *Psychosomatic Medicine*, **68**, 408–413.

- Hansen, A., Larsen, A., Rugulies, R., Garde, A. and Knudsen, L. (2009). A review of the effect of the psychosocial working environment on physiological changes in blood and urine. *Basic & Clinical Pharmacology & Toxicology*, **105** (73-83), 73–83, doi:10.1111/j.1742-7843.2009.00444.x.
- Hintsanen, M., Elovainio, M., Puttonen, S., Kivimäki, M., Koskinen, T., Raitakari, O. and Keltikangas-Järvinen, L. (2007). Effort-reward imbalance, heart rate, and heart rate variability: the cardiovascular risk in young finns study. *International Journal of Behavioral Medicine*, **14**, 202–212, doi:10.1007/BF03002994.
- Inoue, A., Kawakami, N., Ishizaki, M., Tabata, M., Tsuchiya, M. et al. (2009). Three job stress models/concepts and oxidative DNA damage in a sample of workers in Japan. *Journal of Psychosomatic Research*, **66**, 329–334, doi:10.1016/j.jpsychores.2008.09.016.
- Kanel, R., Bellingrath, S. and Kudielka, B. (2009). Overcommitment but not effort-reward imbalance relates to stress-induced coagulation changes in teachers. *Annals of Behavioral Medicine*, **37**, 20–28, doi:10.1007/s12160-009-9082-y.
- Loerbroks, A., Schilling, O., Haxsen, V., Jarczok, M. N., Thayer, J. F. and Fischer, J. E. (2010). The fruit of ones labor: Effort-reward imbalance but not job strain is related to heart rate variability across the day in 34-44-year-old workers. *Journal of Psychosomatic Research*, **69**, 151–159, doi:10.1016/j.jpsychores.2010.03.004, URL <http://www.sciencedirect.com/science/article/pii/S0022399910001169>.
- Maina, G., Bovenzi, M., Palmas, A. and Larese, F. (2009). Associations between two job stress models and measures of salivary cortisol. *International Archives of Occupational and Environmental Health*, **89** (9), 1141–1150, doi:10.1007/s00420-009-0439-0.
- Siegrist, J. (2005). Social reciprocity and health: New scientific evidence and policy implications. *Psychoneuroendocrinology*, **30** (10), 1033–1038, doi:10.1016/j.psyneuen.2005.03.017.
- Siegrist, J., Menrath, I., Stöcker, T., Klein, M. et al. (2005). Differential brain activation according to chronic social reward frustration. *NeuroReport*, **16**, 1899–1903.
- Stephoe, A., Siegrist, J., Kirschbaum, C. and Marmot, M. (2004). Effort-reward imbalance, overcommitment, and measures of cortisol and blood pressure over the working day. *Psychosomatic Medicine*, **66**, 1899–1903.
- Vrijkotte, T., van Doornen, L. and de Geus, E. (1999). Work stress and metabolic and hemostatic risk factors. *Psychosomatic Medicine*, **61**, 796–805.
- Vrijkotte, T., van Doornen, L. and de Geus, E. (2000). Effects of work stress of ambulatory blood pressure, heart rate, and heart rate variability. *Hypertension*, **35** (4), 880.
- Wirtz, P., Siegrist, J., Rimmele, U. and Ehlert, U. (2008). Higher overcommitment to work is associated with lower norepinephrine secretions before and after acute psychosocial stress in men. *Psychoneuroendocrinology*, **33**, 92–99.
- Wright, B. J. (2011). Effort-Reward Imbalance Is Associated With Salivary Immunoglobulin A and Cortisol Secretion in Disability Workers. *Journal of Occupational & Environmental Medicine*, **53**, 308–312, doi:10.1097/JOM.0b013e31820c90b7.

3.7 Other outcomes

Research on ERI at work has also been extended to outcomes that are not (or at least not directly) associated with health. Examples include job satisfaction, burnout, and deviant behaviour, e.g.:

- Bakker, A., Killmer, C., Siegrist, J. and Schaufeli, W. (2000). Effort-reward imbalance and burnout among nurses. *Journal of Advanced Nursing*, **31** (4), 884–891.
- Bethge, M. and Radoschewski, F. (2010). Physical and psychosocial work stressors, health-related control beliefs and work ability: cross-sectional findings from the German Sociomedical Panel of Employees. *International Archives of Occupational and Environmental Health*, **83**, 241–250, doi: 10.1007/s00420-009-0442-5.
- Bethge, M., Radoschewski, F. and Muller-Fahrnow, W. (2009). Work stress and work ability: cross-sectional findings from the German sociomedical panel of employees. *Disability and Rehabilitation*, **31**, 1692–1699, doi:10.1080/09638280902751949.
- Bridger, R., Dew, A., Brasher, K., Munnoch, K. and Kilminster, S. (2009). Chronic and acute psychological strain in naval personnel. *Occupational Medicine*, **59**, 454–458, doi:10.1093/occmed/kqp104.
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- Burgel, B. J., White, M. C., Gillen, M. and Krause, N. (2010). Psychosocial work factors and shoulder pain in hotel room cleaners. *American Journal of Industrial Medicine*, **53** (7), 743–756, doi:10.1002/ajim.20832, URL <http://dx.doi.org/10.1002/ajim.20832>.
- Dai, J., Collins, S., Yu, H. and Fu, H. (2008). Combining Job Stress Models in Predicting Burnout by Hierarchical Multiple Regressions: A Cross-sectional Investigation in Shanghai. *Journal of Occupational and Environmental Medicine*, **50** (7), 785–790.
- de Jonge, J., Bosma, H., Peter, R. and Siegrist, J. (2000). Job strain, effort-reward imbalance and employee well-being: a large scale cross-sectional study. *Social Science & Medicine*, **50**, 1317–1327.
- D'Errico, A., Punnett, L., Cifuentes, M., Boyer, J. et al. (2007). Hospital injury rates in relation to socioeconomic status and working conditions. *Occupational and Environmental Medicine*, **64**, 325–333, doi:10.1136/oec.2006.027839.
- Devreux, I. C., Al-Awa, B., Mamdouh, K. and Elsayed, E. (2012). Relation of Work-related Musculoskeletal Disorders and Over-commitment of Rehabilitation Staff in Saudi Arabia. *Life Science Journal*, **9**, 781–785.
- Feuerhahn, N., Kühnel, J. and Kudielka, B. (2012). Interaction effects-reward imbalance and overcommitment on emotional exhaustion and job performance. *International Journal of Stress Management*, **19** (2), 105–131, doi:10.1037/a0028338.
- Freude, G., Jakob, O., Martus, P., Rose, U. and Seibt, R. (2010). Predictors of the discrepancy between calendar and biological age. *Occupational Medicine*, **60**, 21–28, doi:10.1093/occmed/kqp113.
- Gillen, M., Yen, I., Trupin, L., Swig, L. et al. (2008). The Association of Socioeconomic Status and Psychosocial and Physical Workplace Factors With Musculoskeletal Injury in Hospital Workers. *American Journal of Industrial Medicine*, **50** (4), 245–260, doi:10.1002/ajim.20429.

- Hasselhorn, H., Tackenberg, P., Peter, R. and NEXT Study Group (2004). Effort-reward imbalance among nurses in stable countries and in countries in transition. *International Journal of Occupational and Environmental Health*, **10**, 401–408.
- Hintsala, T., Hintsanen, M., Jokela, M., Pulkki-Raback, L. and Keltikangas-Jarvinen, L. (2010). Divergent influence of different type a dimensions on job strain and effort-reward imbalance. *International Archives of Occupational and Environmental Medicine*, **52**, 1–7, doi:10.1097/JOM.0b013e3181c559ea.
- Hoggan, B. and Dollard, M. (2007). Effort-reward imbalance at work and driving anger in an Australian community sample: Is there a link between work stress and road rage? *Accident Analysis and Prevention*, **39**, 1286–1295, doi:10.1016/j.aap.2007.03.014.
- Hyvönen, K., Feldt, T., Kinnunen, U. and Tolvanen, A. (2011). Changes in personal work goals in relation to the psychosocial work environment: A two-year follow-up study. *Work & Stress*, **25** (4), 289–308, doi:10.1080/02678373.2012.630587, URL <http://www.tandfonline.com/doi/abs/10.1080/02678373.2012.630587>.
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- Kouvonen, A., Kivimäki, M., Cox, S. and Cox, T. (2005). Relationship between work stress and body mass index among 45,810 female and male employees. *Psychosomatic Medicine*, **67**, 577–583.
- Kouvonen, A., Kivimäki, M., Virtanen, M., Heponiemi, T. et al. (2006). Effort-reward imbalance at work and the co-occurrence of lifestyle risk factors: cross-sectional survey in a sample of 36,127 public sector employees. *BMC Public Health*, **6**, 24.
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- László, K. and Koop, M. (2009). Effort-Reward Imbalance and Overcommitment at Work are Associated With Painful Menstruation: Results From the Hungarostudy Epidemiological Panel 2006. *Journal of Occupational and Environmental Medicine*, **51** (2), 157–163, doi:10.1097/JOM.0b013e318197ca89.
- Lee, M., Paek, D., Eum, K., Siegrist, J. et al. (2009a). Paternal work stress and prolonged time to pregnancy. *International Archives of Occupational and Environmental Health*, **82** (2), 209–216.
- Lee, T., Lin, J., Yen, C., Loh, C. et al. (2009b). Extrinsic high-effort and low-reward conditions at work among institutional staff caring for people with intellectual disabilities in Taiwan. *Research in Developmental Disabilities*, **30**, 284–293, doi:10.1016/j.ridd.2008.04.006.
- Mäki, K., Vahtera, J., Virtanen, M., Elovainio, M. et al. (2008). Work stress and new-onset migraine in a female employee population. *Cephalalgia*, **28**, 18–25.
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- McClinton, S. and Dollard, M. (2010). Work stress and driving anger in Japan. *Accident Analysis and Prevention*, **42**, 174–181, doi:10.1016/j.aap.2009.07.016.

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- Rödel, A., Siegrist, J., Hessel, A. and Brähler, E. (2004). Fragebogen zur Messung beruflicher Gratifikationskrisen. Psychometrische Testung an einer repräsentativen deutschen Stichprobe. *Zeitschrift für Differentielle und Diagnostische Psychologie*, **25** (4), 227–238, doi:10.1024/0170-1789.25.4.227.
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- Trudel, L., Vonarx, N., Simard, C., Freeman, A. et al. (2009). The adverse effects of psychosocial constraints at work: a participatory study to orient prevention to mitigate psychological distress. *Work*, **34**, 345–357, doi:10.3233/WOR-2009-0933.
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4 Intervention

The model of ERI at work is useful in designing worksite stress prevention and health promotion programs. As a first step, stressful conditions at work can be measured in a standardized way using the psychometrically validated questionnaire available in a number of languages. As a second step, interventions measures can be derived from the model at the personal/interpersonal level and at the structural level.

At the personal/interpersonal level, techniques of stress management including stress inoculation through strengthening of psychological and interpersonal resources are indicated. In order to be effective these techniques need to address cognitions, attitudes and work-related motivations in addition to the rather non-specific relaxation techniques. Improved self-observation and perception of arousal, coping with anger and reinforced self-reliance are important elements of this type of intervention. Another application of stress prevention at the interpersonal level concerns the improvement of leadership skills among supervisors and superiors, in particular the awareness of an important role of esteem, recognition and appropriate feedback, as indicated by the ERI-model.

Structural measures of work site health promotion derived from this theoretical approach include the implementation of models of gain-sharing and of non-monitory incentives including options of flexible work time arrangements, comparatively high compensation contingent on performance, tailoring of promotion prospects and status according to achievements, improved job security and further measures of organisational and contractual fairness.

It is important to note that the creation of healthy work places produces economic benefits in the long run, in addition to beneficial effects on health and well being. Policy implications of the ERI model are not restricted to occupational life, but may be extended to the design of voluntary work and to ways of improving social capital within communities.

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4.2 Other publications

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