ASSOCIATIONS BETWEEN MATERIALS USED AND WORK-RELATED MUSCULOSKELETAL HAND COMPLAINTS AMONG HAEMODIALYSIS NURSES

Eva Westergren [1], *Mette Spliid Ludvigsen* [2,3], *Magnus Lindberg* [1,4]
[1]Faculty of Health and Occupational Studies Department of Caring Sciences, University of Gävle, Gävle, Sweden
[2]Randers Regional Hospital, Department of Clinical Medicine, Faculty of Nursing and Health Sciences, Aarhus University, Denmark
[3]Nord University, Bodø, Norway
[4]Department of Public Health and Caring Sciences Uppsala University, Uppsala, Sweden

SUMMARY

Background: One in every two haemodialysis nurses has reported musculoskeletal complaints concerning their hands, which is twice that reported for hospital nurses in general. It is possible that there is an association between the materials used by haemodialysis nurses and the occurrence of hand complaints.

Objectives: To examine the association between the type of dialysis machine and disposables used with the occurrence of hand complaints among haemodialysis nurses. To compare occupational risks of developing work-related musculoskeletal disorders based on the materials used for haemodialysis.

Design: Cross-sectional.

Participants: Two hundred and eighty-two nurses working in 27 haemodialysis centres in Sweden participated in a survey, and 19 nurses at five centres were observed during priming procedures.

Measurements: Nurses supplied demographic data and answered the Nordic Musculoskeletal Questionnaire. Centre level data regarding machines and disposables used for haemodialysis during the past year were also collected.

Results: There were no differences in the prevalence of hand complaints based on the type of haemodialysis machines, dialysers or tubing used. There were no differences found in physical exposure to the hands during priming, based on machine type used.

Conclusion: The results of this study could not reveal any association between disposable materials used and the occurrence of hand complaints among haemodialysis nurses. Additionally, there were no occupational risks detected based on the types of machines used. Hence, the results of the present study strongly indicate that a deeper ergonomic analysis of the work environment is needed to understand the prevalence of hand complaints among nurses working in haemodialysis settings.

KEY WORDS Ergonomics • Haemodialysis • Work-related musculoskeletal disorders

BIODATA

Eva Westergren *registered nurse, master of caring science, faculty of health and occupational studies, department of caring sciences, university of Gävle, Sweden. Her interest lies in musculoskeletal disorders and work ability in haemodialysis nurses. She is also interested in haematology and caring science.*
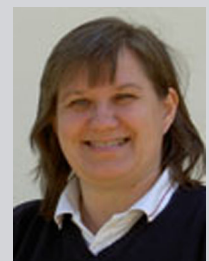
CORRESPONDENCE
Eva Westergren, Faculty of Health and Occupational Studies Department of Health and Caring Sciences, University of Gävle, Sweden
Email: eva.westergren@hig.se

INTRODUCTION

In Europe, there is a high prevalence of musculoskeletal disorders (MSDs) such as lower back, neck and shoulder pain in the adult population that take a heavy toll on individuals, employers and society (European Agency for Safety and Health at Work 2010). People working in the nursing profession are at high risk of developing work-related MSDs (Harcombe *et al.* 2014; Davis & Kotowski 2015; Passali *et al.* 2018; Zamora-Macorra *et al.* 2019). It is well-known that nurses routinely perform physically demanding manual handling; and these tasks are associated with work-related musculoskeletal problems (Engels *et al.* 1996; Serranheira *et al.* 2015; Nourollahi *et al.* 2018). Nursing tasks performed more than 10 times a day have been found to increase the probability of developing work-related musculoskeletal problems (Serranheira *et al.* 2015). MSD discomfort or pain in at least one region of the body affects many nurses (Davis & Kotowski 2015; Nourollahi *et al.* 2018; Passali *et al.* 2018). Since nurses' working conditions can vary among different nursing disciplines, it is important to ascertain whether the prevalence of MSDs varies with the specific working tasks associated with the different types of nursing (Serranheira *et al.* 2015). The focus of this study will be on haemodialysis nursing.

LITERATURE REVIEW

The term work environment encompasses all of the surroundings while working, and it refers to the physical, social and psychological characteristics of the work place. The psychological work environment for haemodialysis nurses has been described as being stressful and intense (Hayes & Bonner 2010; Böhmert *et al.* 2011). The high-dependency nature of haemodialysis centres (Thomas-Hawkins *et al.* 2008; de Kleijn *et al.* 2017) are known for their heavy workloads. High levels of burnout are typical among nurses working in haemodialysis settings (Hayes *et al.* 2015; Trbojević-Stanković *et al.* 2015). While caring for patients receiving haemodialysis, they experience high levels of stress in their daily work (Dermody & Bennett 2008; Karkar *et al.* 2015; Vioulac *et al.* 2016), with the main stressors being time management, treatment complications/emergencies and technical problems (Karkar *et al.* 2015; Vioulac *et al.* 2016). Coping with death and dying (Lee & King 2014), which is associated with greater levels of stress, only exacerbates the problem (Hayes *et al.* 2015). The social work environment deals with conditions and prerequisites for the work that includes social interaction, collaboration and social support from managers and colleagues. Hayes *et al.* (2015) showed that flexible management and a feeling of being valued by management are the main contributors to job satisfaction among haemodialysis nurses.

While there is a growing body of research examining the occupational health problems due to psychological factors, there are few studies focusing on the physical problems encountered among nurses working in haemodialysis settings. Prestes *et al.* (2016) describe how physical problems, such as MSDs involving back or leg pain, are the predominant cause of absenteeism among Brazilian haemodialysis nurses. In addition, nine out of 10 Scandinavian haemodialysis nurses have experienced musculoskeletal problems in some part of their body during the past 12 months, and the anatomical locations with the most complaints were the neck, lower back and hands. Every second haemodialysis nurse reported complaints concerning their hands (Westergren *et al.* 2019), which is twice that reported for hospital nurses in general (Occhionero *et al.* 2014; Heidari *et al.* 2018). The human hand is involved in a broad spectrum of activities. Hands are involved in self-care activities, they perceive sensations such as temperature and pressure and are also often needed in occupational activities (Howland *et al.* 2016). The function of a hand can be significantly affected by any type of pain (acute, chronic or neuropathic), and therefore discomfort or pain in a hand can make work tasks difficult or even impossible to perform. In Scandinavia, one out of 10 haemodialysis nurses have reported absenteeism from work due to problems with their hands (Westergren *et al.* 2019). On the basis of this and complaints from haemodialysis nurses that disposable materials used in haemodialysis treatments often do not fit well together, e.g. there is a form of resistance and difficulty attaching the tubing to different components and to the dialysis machine; we hypothesised that there is an association between disposable materials used and the occurrence of hand complaints among haemodialysis nurses.

The aims of this study were therefore (1) to examine the association between the type of dialysis machine and disposables used with the occurrence of hand complaints among haemodialysis nurses and (2) to compare occupational risks [revised strain index (RSI)] of developing work-related MSDs of the distal upper extremities based on the materials used for haemodialysis.

MATERIAL AND METHODS
ETHICAL APPROVAL

The study protocol was approved by the Regional Ethical Review Board in Uppsala (registration number 2017/229). All

participants were informed of the aim of the study and participated voluntarily.

SAMPLE AND SAMPLING PROCEDURE

This study used a convenience sample (Polit & Beck 2016) of haemodialysis centres in Sweden. All of the 58 haemodialysis centres listed in the Swedish national renal registry when the study commenced in November 2017, were eligible for inclusion. A written request for study involvement was sent by regular mail to the head of each centre. Twenty-seven centres (46.6%) participated, which included local hospital-based, regional hospital-based, university hospital-based and satellite centres. There were 445 nurses employed at these centres, and 282 (63.4%) responded to the online survey. Their mean age was 46.3 years. They had worked as nurses for an average of 18.9 years and as a haemodialysis nurse for an average of 9.7 years.

In evaluating the risks of developing distal upper extremity MSDs, 19 nurses were observed at five haemodialysis centres. To ensure the inclusion of all types of haemodialysis machines used in the country in the data collection, the centres were conveniently selected based on the haemodialysis machines used. The observed nurses had a mean age of 45.3 years. They had worked as nurses for an average of 16.3 years and as a haemodialysis nurse for an average of 9.2 years.

DATA COLLECTION TOOLS

The validated Nordic Musculoskeletal Questionnaire (Kuorinka et al. 1987) was used to gather data regarding the nurses' hand complaints that occurred during the past year. Demographic data of the participating nurses were also recorded. In addition, a study-specific form was used to generate centre level data. The head of the centre responded to questions regarding the type of haemodialysis machines (manufacturer and model) and disposables used for haemodialysis (tubing and dialysers) during the past year.

Additional data collection was carried out between 2 May 2019 and 14 June 2019 by a single observer (E.W., first author), who is a registered nurse with substantial experience within haematology and nephrology nursing, but not in the haemodialysis setting. Each observation was conducted during the daytime shift between 7.00 and 15.00. Prior to the start of an observation, information regarding the purpose of the study and its approach was held with each nurse. The focus of the observations concerned potential occupational risks occurring during the priming procedure of the haemodialysis machines. In carrying out the observations; a timer, an observation protocol, a clipboard and a pencil were used. During the priming procedure data were documented regarding the five variables: intensity of exertion, duration of exertion, exertions per minute, hand/wrist posture and duration of the task per day (Garg et al. 2017). These variables originated from the Strain Index (Moore & Garg 1995), but the RSI matrix was used in this study since, which compared with the original version provides better discrimination of risk predictors and avoids misclassification (Garg et al. 2017). RSI is an ergonomist evaluation method that focuses specifically on the risks of developing distal upper extremity MSDs among workers who perform the same task (Garg et al. 2017).

ANALYSIS

Generated data were entered into a spreadsheet and all analyses were performed using IBM SPSS Statistics for Windows, Version 24.0 (IBM Corp, Armonk, NY). A $p < 0.05$ (two-tailed) was considered statistically significant. χ^2 tests determined differences between groups (machines and disposables used) for categorical data and nurses with/without hand complaints. Binary logistic regression was utilised to determine the odds ratio (OR) and 95% confidence interval of risk factors (dialysis machine and disposables used, gender and hours worked per week), and the probability of developing hand problems was estimated. Evaluation of model fit was performed at two levels. The first level evaluated the fit of the full-model and was done using a likelihood-ratio χ^2 test and the Hosmer–Lemeshow test. Evaluation of the individual predictors contribution to the overall model fit, the second level, was done with the Wald test. Data from the observations violated the assumption of homogeneity of variances. Consequently, a Welch F-test with Games–Howell post hoc test was used instead of the more well-known one-way analysis of variance (ANOVA) to determine whether there were any differences between the mean numbers of repetitive manoeuvres during the priming procedures in the three most common types of haemodialysis machines. The RSI data were calculated in accordance with the manual (Garg et al. 2017). It was possible to test differences with the one-way ANOVA, that is, the comparison of the means between the types of machines.

RESULTS

There were no differences in the prevalence of hand complaints based on the haemodialysis machines $\chi^2 = 0.513$ (df2) $p = 0.773$ (Figure 1), dialysers $\chi^2 = 2.157$ (df4) $p = 0.707$ (Figure 2) or tubing $\chi^2 = 7.248$ (df4) $p = 0.123$ (Figure 3) used at the centres.
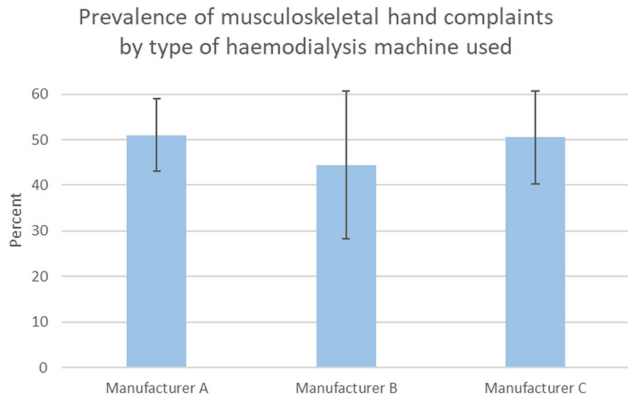
Figure 1: *Prevalence of musculoskeletal hand complaints by type of haemodialysis machine used, Ī = 95% confidence interval error bars.*

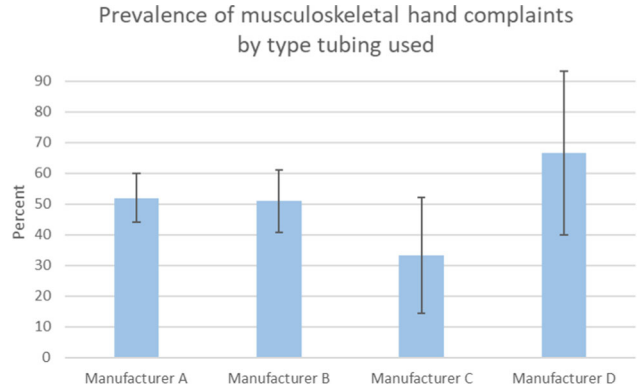Figure 3: *Prevalence of musculoskeletal hand complaints by type of tubing used, Ī = 95% confidence interval error bars.*

Moreover, there were no statistically significant differences between group means regarding the observed number of clamping grips used (F (2,18.55) = 1.950, p = 0.17) or the number of times physical pressure was used (F (2,18.77) = 2.79, p = 0.09) during the priming procedures as determined by Welch F-test. However, there was a statistically significant difference between machine type used and the observed number of twisting/turning movements made by the hands during the priming procedure of the haemodialysis machines when determined by Welch F-test (F (2,18.41) = 14.30, p = 0.0002). The range and mean number of observed hand twists/turns during priming and the post hoc analysis results are presented in Table 1.

The result of the binary logistic regression analysis is presented in Table 2. The Omnibus Tests of Model Coefficients results indicate that the model fits the data significantly better than a null model, $\chi^2(10) = 20.530$, p = 0.025. The non-significant

	Machine A (n=10)	Machine B (n=13)	Machine C (n=10)
Range in number of observed hand twists/turns during priming procedures of the haemodialysis machines	11-25	12-38	8-17
Mean (SD)	18.0 (5.4)	25.6 (7.9)	13.1 (3.1)
P-value		=0.0002	
	=0.031		

Table 1: *Number of observed hand twists/turns during the priming of the different haemodialysis machines (n = 33).*
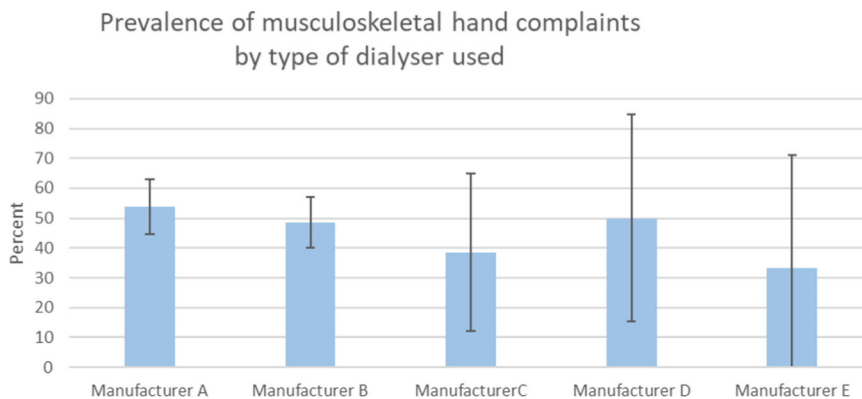
SD, standard deviation.

Figure 2: *Prevalence of musculoskeletal hand complaints by type of dialyser used, Ī = 95% confidence interval error bars.*

	Odds ratio (OR)[a]	95% CI of OR	Wald test (df)	p value
Gender				
Male	1			
Female	2.73	0.90–8.27	3.172 (1)	0.075
Hours/week worked	0.98	0.96–1.0	3.314 (1)	0.069
Dialysis machine				
Manufacturer A	1			
Manufacturer B	3.27	0.69–15.64	2.208 (2)	0.137
Manufacturer C	1.47	0.64–3.41	0.824	0.364
Dialyser				
Manufacturer A	1			
Manufacturer B	2.80	0.28–28.42	0.758 (4)	0.384
Manufacturer C	5.48	0.59–51.17	2.228	0.135
Manufacturer D	3.70	0.28–49.78	0.975	0.324
Manufacturer E	1.68	0.13–21.89	0.155	0.694
Tubing				
Manufacturer A	1			
Manufacturer B	0.16	0.03–0.92	4.241 (2)	0.039
Manufacturer C	0	0	0.020	0.999

Table 2: Odds ratios and 95% confidence intervals (CI) for complaints in the hands.

[a]Male gender and manufacturer A used as the analysis reference point.

results of the Hosmer and Lemeshow test also indicate a good model fit $\chi^2(7) = 5.426$, $p = 0.608$. Gender, hours worked per week, type of dialysis machine and the dialyser used are all non-significant predictors of hand complaints among haemodialysis nurses. The use of tubing from the manufacturer B is a negative and significant (b = −1.809, SE = 0.878, p = 0.039) predictor in the probability of developing hand complaints; with the OR (0.164) indicating that haemodialysis nurses using that tubing when priming dialysis machines were to a small degree less likely to develop hand complaints when compared with the use of the tubing from the manufacturer used as a reference.

The RSI occupational risk assessment tool used in this study to evaluate the level of risk of developing a MSD of the hand during priming procedures showed that the three included types of dialysis machines manufactured by different companies posed a low risk of developing a disorder of the hand, wrist, forearm or elbow (RSI ≤ 10). The physical exposure to the hands during priming could therefore be considered to be probably safe, as there were no statistically significant differences between the machine types and the RSI (F (2,30) = 1.439, p = 0.253). Mean RSI for dialysis machine manufacturer A was 1.4 [standard deviation (SD 0.4), range 0.8–1.7], for manufacturer B 1.5 (SD 0.6, range 0.8–3.0) and for manufacturer C 1.1 (SD 0.4, range 0.8–1.7).

DISCUSSION

The prevalence of hand complaints is twice as high among Scandinavian nurses working in haemodialysis settings (Westergren et al. 2019) than among nurses in general (Occhionero et al. 2014; Heidari et al. 2018) and the reason for this is still unknown. The data we have presented does not support our predefined hypothesis. Neither the disposable materials used, the type of haemodialysis machine, the hours worked per week, nor the nurses' gender have any association with the occurrence of work-related hand complaints among haemodialysis nurses. This could however be related to low statistical power, i.e. to small sample to find significant association for some type of machine. The significant difference we did find between the numbers of hand twists/turns performed during priming procedures based on the dialysis machine used, was found to be unrelated to the reported work-related hand complaints. Hence, our research could not reveal any potential reasons for the high prevalence of hand complaints among haemodialysis nurses. Further research is therefore needed to better understand the underlying causes of these occupational problems as other work activities not studied might increase the risk of developing hand complaints. Despite the fact that an association could not be revealed, one should not ignore the impression haemodialysis nurses have of the seemingly "incompatible" nature of the materials that require exorbitant force to assemble, i.e. the tubing and dialysers. We therefore also recommend qualitative research that incorporates reflective interviews as well as a deeper ergonomic analysis of the experiences haemodialysis nurses have during priming procedures.

Of interest are the exposure assessment results obtained from the RSI. They indicate that, irrespective of the type of haemodialysis machine used, the priming procedures are safe in regard to the risk of developing distal upper extremity MSDs. However, it is important to point out as a cautionary note that the RSI is designed to determine the risk of developing distal upper extremity MSDs among a cohort of workers and not for an individual worker (Garg et al. 2017). Consequently, the analysis is performed on a group level that compares RSI means between the three types of machines. These results indicate that the working tasks involved in the priming procedures again seem to be unimportant relative to the presence of hand complaints among haemodialysis nurses.

Literature on the physical occupational health problems among nurses working in haemodialysis settings appears sparse.

Prestes *et al.* (2016) studied work-related health problems among Brazilian haemodialysis nurses and concluded that back and leg pain were the most prevalent physical problems, that the levels of stress were bearable and that no social problems were identified. More recently, Westergren *et al.* (2019) reported a high prevalence of MSD complaints with most of the problems located in the neck, lower back and hands. As a result of the findings by Westergren *et al.* (2019), this study focused on exploring associations between the type of dialysis machine and disposables used and the occurrence of hand complaints. As this seems to be the first study in this area, there is no existing knowledge to compare and discuss the results with.

LIMITATIONS

Due to this study's cross-sectional design and the self-report method for gathering the data from nurses only, certain potential biases should be considered. One primary limitation of the cross-sectional study design is that there is generally no evidence of causal relationships. Hence, we can only draw firm conclusions about any associations to, not the cause of, the hand complaints reported. Moreover, the present study does not include reports from other dialysis staff such as support workers who may be involved in haemodialysis set up. The finding might therefore not be generalisable to dialysis settings using mixed staffing.

The online nature of the survey has certainly contributed to the lower than desirable 63.4% response rate from the invited nurses. Blumenberg and Barros (2018) concluded in their literature review that web-based surveys systematically have lower response rates than alternative data collection methods. The ideal response rate in survey techniques is considered to be at least 70%, but the majority of studies conducted among registered nurses have response rates below the desirable threshold (Corner & Lemonde 2019).

Another limitation is that the observations were only performed during the priming procedure, which only captures a limited part of the nurses' duties. Haemodialysis nurses' duties can be divided into three main parts: (1) preparation for treatments, i.e. priming, (2) connection of patients to machines and delivery of dialysis treatments and (3) termination of haemodialysis treatments and cleaning of dialysis machines and patient surroundings. Since the focus of the study was to examine possible associations between the disposable materials used and the occurrence of hand complaints, it was considered to be sufficient to include only the priming procedure in this study. Moreover, the RSI is to the best of our knowledge not previously used or validated in haemodialysis settings which inherently poses some threats to the internal validity of the present study. The RSI is however considered applicable to a wide variety of tasks (Garg *et al.* 2017).

IMPLICATIONS FOR CLINICAL PRACTICE

The health and wellbeing of haemodialysis nurses are basic elements required for quality nursing care. As complaints concerning the hands are common, and also related to absenteeism from work, it is of particular importance that manufacturers of dialysis equipment and nurse managers acknowledge these occupational health and safety hazards in their efforts to create good work environments. Since nurses' work environments have a significant impact on patients' outcomes, the healthcare organisations and nurse managers who wish to ensure safe services with high quality care should according to Prezerakos *et al.* (2015), ensure good working conditions. It is estimated that the number of patients requiring renal replacement therapy will more than double by 2030 (Liyanage *et al.* 2015). The increased number of treatments will consequently have an impact on the workload of haemodialysis nurses. Since the frequency in which repetitive work tasks are performed has a direct relationship with musculoskeletal complaints (Serranheira *et al.* 2015), it is paramount that nurse managers acknowledge the number of repetitive manoeuvres required during (for example) priming procedures when allocating work duties.

CONCLUSION

The results of this study could not reveal any association between disposable materials used and the occurrence of hand complaints among haemodialysis nurses. Neither were there any detectable occupational risks of developing distal upper extremity MSDs based on the types of haemodialysis machines used. Hence, the results of the present study strongly indicate that a deeper ergonomic analysis of the work environment is needed to understand the prevalence of hand complaints among nurses working in haemodialysis settings.

CONFLICT OF INTERESTS

The last author was the Associate Editor of JORC at submission of the manuscript but was not involved in any decisions regarding this submission. The first and second authors have no financial or other relationships that might lead to a conflict of interest.

AUTHOR CONTRIBUTIONS

The authors' contribution to the manuscript: EW, MsL, and ML were responsible for design and coordination, interpretation of data, and preparation of the final manuscript. EW and ML also performed the data collection and data analysis.

REFERENCES

Blumenberg C. & Barros A.J.D. (2018). Response rate differences between web and alternative data collection methods for public health research: a systematic review of the literature. *International Journal of Public Health*, **63**(6), 765–773. https://doi.org/10.1007/s00038-018-1108-4

Böhmert M., Kuhnert S. & Nienhaus A. (2011). Psychological stress and strain in dialysis staff-a systematic review. *Journal of Renal Care*, **37**(4), 178–189. https://doi.org/10.1111/j.1755-6686.2011.00236.x

Corner B. & Lemonde M. (2019). Survey techniques for nursing studies. *Canadian Oncology Nursing Journal*, **29**(1), 58–60.

Davis K.G. & Kotowski S.E. (2015). Prevalence of musculoskeletal disorders for nurses in hospitals, long-term care facilities, and home health care: a comprehensive review. *Human Factors*, **57**(5), 754–792. https://doi.org/10.1177/0018720815581933

de Kleijn R., Uyl-de Groot C., Hagen C. *et al.* (2017). Differences in care burden of patients undergoing dialysis in different centres in the netherlands. *Journal of renal care*, **43**(2), 98–107. https://doi.org/10.1111/jorc.12193

Dermody K. & Bennett P.N. (2008). Nurse stress in hospital and satellite haemodialysis units. *Journal of Renal Care*, **34**(1), 28–32. https://doi.org/10.1111/j.1755-6686.2008.00007.x

Engels J.A., van der Gulden J.W., Senden T.F. *et al.* (1996). Work related risk factors for musculoskeletal complaints in the nursing profession: results of a questionnaire survey. *Occupational and Environmental Medicine*, **53**(9), 636–641. https://doi.org/10.1136/oem.53.9.636

European Agency for Safety and Health at Work. (2010). OSH in figures: work-related musculoskeletal disorders in the EU-facts and figures: European Risk Observatory Report. https://doi.org/10.2802/10952

Garg A., Moore J.S. & Kapellusch J.M. (2017). The revised strain index: an improved upper extremity exposure assessment model. *Ergonomics*, **60**(7), 912–922. https://doi.org/10.1080/00140139.2016.1237678

Harcombe H., Herbison G.P., McBride D. *et al.* (2014). Musculoskeletal disorders among nurses compared with two other occupational groups. *Occupational Medicine*, **64**(8), 601–607. https://doi.org/10.1093/occmed/kqu117

Hayes B., Bonner A. & Douglas C. (2015). Haemodialysis work environment contributors to job satisfaction and stress: a sequential mixed methods study. *BMC Nursing*, **14**(1), 1–13. https://doi.org/10.1186/s12912-015-0110-x

Hayes B. & Bonner A. (2010). Job satisfaction, stress and burnout associated with haemodialysis nursing: a review of literature. *Journal of Renal Care*, **36**(4), 174–179, https://doi.org/10.1111/j.1755-6686.2010.00194.x

Heidari M., Borujeni M.G. & Khosravizad M. (2018). Health-promoting lifestyles of nurses and its association with musculoskeletal disorders: a cross-sectional study. *Journal of Lifestyle Medicine*, **8**(2), 72–78. https://doi.org/10.15280/jlm.2018.8.2.72

Howland N., Lopez M. & Zhang A.Y. (2016). Pain and hand function. *Hand Clinics*, **32**(1), 1–9. https://doi.org/10.1016/j.hcl.2015.08.002

Karkar A., Dammang M.L. & Bouhaha B.M. (2015). Stress and burnout among hemodialysis nurses: a single-center, prospective survey study. *Saudi J Kidney*, **26**(1), 12–18. https://doi.org/10.1016/j.ifacol.2015.10.256

Kuorinka I., Jonsson B., Kilbom A. *et al.* (1987). Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics*, **18**(3), 233–237. https://doi.org/10.1016/0003-6870(87)90010-X

Lee V.L. & King A.H. (2014). Exploring death anxiety and burnout among staff members who work in outpatient hemodialysis units. *Nephrology Nursing Journal*, **41**(5), 479–485.

Liyanage T., Ninomiya T., Jha V. *et al.* (2015). Worldwide access to treatment for end-stage kidney disease: a systematic review'. *The Lancet*, **385**(9981), 1975–1982. https://doi.org/10.1016/S0140-6736(14)61601-9

Moore J.S. & Garg A. (1995). The strain index: a proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, **56**(5), 443–458. https://doi.org/10.1080/15428119591016863

Nourollahi M., Afshari D. & Dianat I. (2018). Awkward trunk postures and their relationship with low back pain in hospital nurses. *Work*, **59**(3), 317–323. https://doi.org/10.3233/WOR-182683

Occhionero V., Korpinen L. & Gobba F. (2014). Upper limb musculoskeletal disorders in healthcare personnel. *Ergonomics*, **57**, 1166–1191. https://doi.org/10.1080/00140139.2014.917205

Passali C., Maniopoulou D., Apostolakis I. *et al.* (2018). Work-related musculoskeletal disorders among Greek hospital nursing professionals: A cross-sectional observational study. *Work*, **61**(3), 489–498. https://doi.org/10.3233/WOR-182812

Polit D.F. & Beck C.T. (2016). *Nursing Research: Generating and Assessing Evidence for Nursing Practice*. Philadelphia: Wolters Kluwer.

Prestes F.C., Beck C.L.C., Magnago T.S.B.S. *et al.* (2016). Danos à saúde dos trabalhadores de enfermagem em um serviço de hemodiálise, Health problems among nursing workers in a haemodialysis service. *Revista Gaucha de Enfermagem*, **37**(1), e50759. https://doi.org/10.1590/1983-1447.2016.01.50759

Prezerakos P., Galanis P. & Moisoglou I. (2015). The work environment of haemodialysis nurses and its impact on patients' outcomes. *International Journal of Nursing Practice*, **21**(2), 132–140. https://doi.org/10.1111/ijn.12223

Serranheira F., Sousa-Uva M. & Sousa-Uva A. (2015). Hospital nurses tasks and work-related musculoskeletal disorders symptoms: a

detailed analysis. *Work*, **51**(3), 401–409. https://doi.org/10.3233/WOR-141939

Thomas-Hawkins C., Flynn L. & Clarke S.P. (2008). Relationships between registered nurse staffing, processes of nursing care, and nurse-reported patient outcomes in chronic hemodialysis units. *Nephrology Nursing Journal*, **35**(2), 123–131.

Trbojević-Stanković J., Stojimirović B., Soldatović I. *et al.* (2015). Work-related factors as predictors of burnout in serbian nurses working in hemodialysis. *Nephrology Nursing Journal*, **42**(6), 553–563.

Vioulac C., Aubree C., Massy Z.A. *et al.* (2016). Empathy and stress in nurses working in haemodialysis: a qualitative study. *Journal of Advanced Nursing*, **72**(5), 1075–1085. https://doi.org/10.1111/jan.12899

Westergren E., Ludvigsen M.S. & Lindberg M. (2019). Prevalence of musculoskeletal complaints among haemodialysis nurses—a comparison between Danish and Swedish samples. *International Journal of Occupational Safety and Ergonomics*, 1–6. https://doi.org/10.1080/10803548.2019.1688018

Zamora-Macorra M., Reding-Bernal A., Martínez Alcántara S. *et al.* (2019). Musculoskeletal disorders and occupational demands in nurses at a tertiary care hospital in Mexico city. *Journal of Nursing Management*, **27**, 1–7. https://doi.org/10.1111/jonm.12776