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THE IMPORTANCE OF INTEGRATED INPUT DATA FOR THE DIGITALIZED MODEL OF TEXTILE WORKERS' WELLBEING

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Abstract. The research task of the paper is to compile the input data system for the artificial intelligence (AI) model to implement in the textile industry. The methods employed for the purpose are: 1) analysis of the scientific literature in this field over the world, including Estonia and Latvia; 2) analysis of models previously created by the authors of the current paper taking into account the climate conditions in the workplaces; 3) the assessment of the work-related musculoskeletal disorders; 4) the analysis of the opinion of the workers' on the working conditions and their health complaints connected with work; 5) the measurements of working conditions at Latvian and Estonian textile workplaces. Work-related musculoskeletal disorders (WRMSDs) are the most common workplace health hazards among sewing, ironing and packing workers, which can be caused by repetitive work, static posture, monotonous work, etc. The key result is that the model for AI input data was compiled, which consists of 3 parts: 1) operating working environment factors influencing people, the influence of them on the organ systems, functional stages of occupational disorders, loss of work capacity; 2) computer software on textile workers; 3) possible preventive actions. The significance of the findings – a better work environment is organized for the textile workers with the AI model.

Keywords: *Digitalization, ergonomics, textile industry, initial data model, musculoskeletal disorders, safety.*

JEL Classification: J28

INTRODUCTION

In 2020, the European Agency for Safety and Health (EU-OSHA, 2022) initiated a four-year research programme on the digitalization of occupational safety and health (OSH). Based on this document, the current paper is focused on the Estonian and Latvian textile industry workers' health state, mainly based on the investigations

of Estonian and Latvian authors. Health disorders are often connected with working conditions in the industrial premises. The ergonomics of the workplace of a textile worker (chairs, tables, etc.) are thoroughly investigated by the safety and occupational health (OHS) specialists over the world, but the connections between the health disorders and working conditions (microclimate, noise, lighting, dust, etc.) are not very clear and can change timely, therefore the digital solutions can help. This factor is considered one of the topics of the current paper. The countries producing the greatest number of textiles are China, Turkey, Pakistan, South Korea, Bangladesh, and India (Curran et al., 2019; Jahan et al., 2015; Ottari et al., 2018; Van et al., 2015).

Musculoskeletal diseases are the most common occupational diseases in the European Union and in the world, particularly in the textile industry. Over the years, working in awkward posture and doing the same movements increase the risk of musculoskeletal system disorders (MSD), and in a longer perspective, could cause a work disability. Occupational health doctors are checking periodically the health state of the workers (EU-OSHA, 2010; Hansen et al., 2023; Hasan et al., 2023). As for ergonomics, the climate conditions at workplaces have to be considered: the workroom cannot be too cold or hot, too dusty or too noisy. The climate conditions in the workrooms have to be in correspondence with the state regulations; they have to be checked by the managers of the companies (Reinhold, 2005; Remeza & Shestakova, 2005; Urbane, 2004; Vilcane et al., 2015). The responsibilities of the managers of industrial premises have increased.

The occupational health doctors in Estonia use a three-stage model of development the health complaints connected with repetitive and monotonous work. Occupational illnesses develop in stages. At the first early stage, the rehabilitation is effective, and the worker can return to work after a short time of treatment. At the next stage, treatment is possible, but it takes more time, and sometimes the worker has to change the character of work in order not to be disabled in the future. In the case of occupational diseases, complaints and musculoskeletal changes are usually irreversible, but it is possible to use some rehabilitation methods to alleviate the suffering of patients (Pille, 2016).

AI in workforce management systems in the workplace can provide potential opportunities to improve OSH (occupational safety and health) as they can be used to improve workplaces' hazard monitoring (EU-OSHA, 2022; Jankauskaite et al., 2022; Tsiskaridze et al., 2023).

Based on the previous, the paper aims to compile the initial data for the AI model for the textile industry. The following aspects have to be investigated:

1. The review of the previous studies in the field of occupational health and safety (work-related musculoskeletal disorders).
2. The model for considering the working conditions at workplaces.
3. The model for counting the possible musculoskeletal disorders connected with the current workplace.
4. The current and changing situation in textile industrial premises in Estonia and Latvia.
5. The AI model for textile industry workers.
6. The recommendations for better ergonomics at workplaces (from the AI-model and by scientists' proposals).

1. THE LITERATURE SOURCES

1.1. Previous Studies

Safety at work is important to ensure employees' health and safety (Stochkendahl et al., 2022), as well as to increase their working productivity and motivation. A global study of workers across 52 countries (Zimmer et al., 2021) declared that pain impacts people daily. There are wide cross-national variations (the age of workers was 25+). A minimum number of people feeling pain are working in China (9.9 %), and the maximum number in Morocco (50.3 %). It is back pain mainly, reported by the workers, sitting in an awkward posture. They feel pain daily. Psychological problems also arise there, and these complications increase year by year, as the workforce is ageing and the work world is changing very rapidly. In the field of the garment industry, the authors point out the high WRMSD development possibility (Pille et al., 2016; Van Eerd et al., 2016; Wang et al., 2007).

To achieve good results for the model – present state of musculoskeletal disorders (WRMSD) at workplace → digitalization model → ergonomically improved workplaces, it is necessary to have the cooperation between occupational health doctors and managers and participation of workers competent to do this job. The current paper is focused on the data analysis on WRMSD in scientific literature for AI model in textile industry in the world, and the results are directed to the Asian countries where the big factories are yet working.

The studies analysed give the prevalence of musculoskeletal disorders, intensity and duration of pain in a different body region and assess the changes in the functional status of the musculoskeletal system before and after intervention (Mahendran & Tiwari, 2023; Öztürk & Esin, 2011).

There are various WRMSDs, and the variety of risk factors (force, draught, cold, dust, etc.) causing the changes in muscles is large. Most sewing operators sense dust as a hazard in the work environment. Employers provide workers with facial masks as personal protection equipment as a rule. Previous studies in Lithuania have discovered that over 58 % of workers who began to work in the textile industry started to feel irritation and redness of the eyes, a sore throat, a dry cough and different skin complaints (Naruševiciute-Skripkiene et al., 2015) caused by textile dust. To classify the forms of diseases of the soft textures, different disorders, such terms as WRMSDs, repetitive strain or cumulative trauma disorders are used.

The aim of the AI model is to get better ergonomic conditions for textile (but not only) workers as presented by EU-OSHA in 2022 (EU-OSHA, 2022). Information on AI in ergonomics, particularly musculoskeletal disorders in the garment industry, was obtained using the following databases: ChatGPT, Microsoft Bing Image Creator, and Midjourney.

WRMSDs cause huge costs to the institutions in the industrial field and to the health care system. The WRMSDs were diagnosed already in the eighteenth century by the Italian physician Bernardino Ramazzini (NIOSH, 1997). He clarified the connections between the work conditions and certain disorders of the WRMSD system. These disorders happened due to not-regular movement and forced

postures. The WRMSDs affecting the upper body and limbs are recognized as one of the leading causes of pain and disability in occupational health also in Estonia (The National Labor Inspectorate of Estonia, 2018). The loss of life years per 1000 inhabitants in Estonia, caused by the temporary inability to work, was the largest in Europe in 2010 (Merisalu et al., 2016). WRMSDs are the most common work-related diseases in the US and Australia (Saeid et al., 2021). In big countries like Italy (Ottari, 2018), the prevalence of musculoskeletal disorders is high.

In view of the lack of systematic research in the area of factors in the development of WRMSDs of textile workers, we can assume the research question of the current paper: Is there enough data to compile the AI model for the prevention of health disturbances of textile workers and what fields have yet to be covered?

1.2. The Estonian and Latvian Data-based Literature Sources

In the papers published by the Estonian and Latvian authors previously, it is possible to acquire the initial data for AI technology, so the aim is to systematize the sources and ensure better working conditions and work positions for the workers after the AI model implementation.

The term "musculoskeletal disorders" denotes health problems of the locomotor apparatus such as muscles, tendons, skeleton, cartilage, vascular system, ligaments, and nerves (Roja et al., 2013, Reste et al., 2013; UAB Civitta, 2020; Vilcane et al., 2015). The tasks of the studies (Vilcane et al., 2015) were working conditions measurements (like temperature, humidity, noise, and lighting level) in fashion workshop rooms. The aim was to evaluate the design and ergonomics of the workspace, to provide conclusions and to offer solutions to increase safety. All measurements were taken in April 2019. The measurement results showed that lighting complies with the Latvian norms (750 lux); new, silent sewing machines that avoid exceeding the noise level (average noise in a working environment (47.5 dB), the humidity in winter was > 30 %, the room had a good ventilation system, the temperature corresponded to the norms (23 °C). The following problems for improvement were raised: incorrect height of the table and chair, non-adjustable desks, narrow passages, little space for storing things near the sewing machines, insufficient number of shelves and cupboards for things, boring room design, no first kit in the workplaces. In another Latvian study (Kaluznaja et al., 2022), a systematic investigation of the pain felt by workers was presented (the workers aged 18–74 were involved in the investigation). The data were analysed using SPSS Statistics v27 and MS Excel 2016 software. The results were as follows: mild pain was mentioned by 46 %, moderate pain by 31 % and severe pain by 30 % of workers. The pain was mainly observed in low back, feet, legs, neck, and hands and also headache was pointed out by the workers (Kaluznaja et al., 2022) ($p < 001$).

The comparison of WRMSDs of three groups of workers is given by Pille (2016): office workers (OW), garment (textile) workers (GW), and patients with occupational diseases (ODP) were investigated. The pain intensity in different workers' groups shows that the sensation of pain is the strongest in the garment (textile) workers (GW) group and in the group of patients with occupational diseases (ODP). The prevalence of pain sites in different worker groups shows that the patients with occupational diseases feel pain in many regions (26 % of ODP feel

pain in eight regions of the body). It has to be taken into consideration that occupational disease patients, on average, have 3–5 specific diagnoses (carpal tunnel syndrome, epicondylitis, rotator cuff syndromes, and different tenosynovitis in the hand regions). So, this third stage of WRMSDs has to be prevented. They are also affected by psychosocial aspects like chronic diseases and loss of work. Workers who have muscle pains need more attention, work environment adjustments, treatments and encouragement to be more active in the treatment process.

Fig. 1a. Sewing operator's workplace.

Fig. 1b. Cutting department of clothes.

Fig. 1c. Stitching machinery in Latvia.

Fig. 1d. Digital printing lab.

The sewing operator`s work is very monotonous (Traumann et al., 2020), in a constant sitting position, with repetitive one-side movements of the upper limbs and legs (Figs. 1a, 1b, 1c, 1d). Working in awkward posture over the years and doing the same movements increases the risk of developing the WRMSDs, and in a longer perspective, this situation could cause work disability. The aim of the Estonian study (Traumann et al., 2020) was to analyse the prevalence of musculoskeletal disorders, intensity and duration of pain in different body regions and to assess the changes in the functional status of the musculoskeletal system before and after intervention among the workers with partial work ability. Regarding this study, we have to turn attention to the ageing workforce in the textile industry. Mostly 80 % of sewing operators in the investigated company were over 40 years old. Therefore, the dissatisfaction with microclimate conditions could be connected with age. WRMSDs of sewing operators are definitely caused by means of the work environment, but they can also be connected with risk factors of ageing (Merisalu et al., 2016).

The investigations in Latvia were carried out in the following time intervals: 2005–2007, 2009–2010, 2012–2013. Work conditions and risks in Latvia were

investigated in 2017–2018 (UAB Civitta, 2020). For Latvian society, musculoskeletal disorders (MSDs) are becoming an urgent problem, like in the majority of European countries. Physical overload is one of the most important aetiological factors for the development of WRMSDs. The problems associated with pain in several body regions due to work-related musculoskeletal disorders (WRMSDs), repetitive movement and negative stress at work are quite common in many manufacturing industries of Latvia, including the clothing industry (Roja et al., 2013; Reste et al., 2013). The study by Roja et al. (2013) aimed to evaluate the efficiency of the psychotherapeutic intervention using a medical hypnotherapy (MH) program for mind-body relaxation with pain-blocking images and cognitive restructuring of unpleasant physical and emotional experiences. 300 sewers and 50 cutters with chronic pain were involved. Self-rated WRMSD symptoms, pain intensity and interference, were assessed using the extended version of the Nordic Musculoskeletal Questionnaire and Brief Pain Inventory Scale. Assessment of the functional state of muscles was carried out using myotonometric (MYO) measurements.

2. THE INPUT DATA MODELLING BASED ON EXPERIMENTS AND MEDICAL EXAMINATIONS

2.1. The Model for Considering the Working Conditions

In this working conditions' risk assessment model (Fig. 2), a 4-step assessment is used.

> 1	≥ 1	≤ 1	≥ 0.05	Dust, mg/m^3
16 < *T* > 24	16 ≤ *T* ≥ 24	16* – 24	17* – 23	Air temperature, ºC
RH < 20 or > 70	20 < *RH* < 70	25 < *RH* < 60	30 < *RH* < 50	Air humidity, %
< 0.1	≤ 0.2	≤ 0.3	> 0.2	
> 2500	< 2500	≤ 1000	< 1000	Air velocity, m/s
< 1500	< 1000	≤ 1000	≥ 750	
> 85	≥ 85	≤ 85	< 80	CO_2, ppm (over the outdoor level)
Old chairs, bad lighting, bad ventilation, no natural lighting	The standard workplace for everybody	The desires of workers have been considered in some points (the chair, illumination)	The workers have designed the workplace themselves	Lighting, lux Noise, dB(A) Physical overload
4th category of comfort	3rd category of comfort	2nd category of comfort	1st category of comfort	Variables
ME** twice a year	***ME** once a year***	***ME**once in 3 years***	***ME** once in 3 years***	

*Lowest limit in the cold season; **Medical examinations

Fig. 2. Conceptual model for risk assessment of working conditions (Traumann, 2014).

The 1st category of comfort says: the workers have taken part in the design of workplaces; the 2nd category of comfort: the wishes of workers have been taken into account in some places; the 3rd category of comfort: the standard conditions in the work environment; the 4th category of comfort postulates: bad working conditions, there is a need for improvement.

Management of working conditions' correspondence to the risk assessment model is the responsibility of the managers of enterprises. Measurement values of microclimate shall consider the cold and warm season norms made by moderate physical work. According to data of relevant legislation and standards, the suggested criteria for risk levels of occupational hazards are presented in Fig. 2.

2.2. The Model for Considering Musculoskeletal Disorders

Viive Pille, one of the authors of the current paper, presented previously a model (Pille, 2016, Fig. 3.11) compiled for WRMSDs of 1) textile (garment) workers and 2) office workers. The third part of the study and input to the model were workers who were already disabled (the occupational disease had been diagnosed). For this model the responsibility lies on the occupational health doctors. The study (Pille et al., 2016) is based on the experimental data for 505 people using statistical methods (Excel, SSPS, etc.). The statistical analysis (Pille, 2016) confirms:

- **H1** – The stages of ailment and the duration of pain in different regions of the body had no correlation for textile (garment) workers (GW), except the elbow pain.
- **H2** – There was a significant difference between proved in the case of elbow pain.
- **H3** – There was a correlation between the duration of pain in the neck, wrist and back regions and the worker's age. There was no correlation of pain in the shoulder and elbow regions.
- **H4** – The relationship between the pain regions, pain duration, and occupation was confirmed in the neck region of textile workers. Nowadays, the WRMSDs may develop in younger workers.
- **H5** – The statistics on the relationship between the duration of pain and the stages of illnesses (three stages) inside workers groups were confirmed only regarding shoulder pain in textile workers.

This hypothesis confirmation is possible to use as one part of the initial data for the AI model for textile workers.

2.3. Current Situation in the Textile Industry in Estonia and Latvia

2.3.1. Material and Methods

The measurement of working conditions was carried out in 3 Estonian and 3 Latvian premises using accredited methods for this purpose (Table 1). To involve the workers in the ergonomics improvement, the interviews were carried out in 6 (3 EE + 3 LV) premises using the questionnaire (Table 2, questions in the 1st column). The survey included questions about the pain location of the body regions (with the possibility of adding a comment about a specific region) and pain severity

scored using a 10-point scale, where 10 indicated very strong pain, and 1 very weak pain.

The questionnaire (Table 2, 1st column) was validated at TTK University of Applied Sciences and Riga Technical University (both have laboratories of textile engineering) in 2022, where the workers were asked about their the influence of air temperature, noise, draught, etc. – working conditions that possibly are the developers of health disorders, like back pain, neck and shoulder pain (WRMSDs), decreased sleep quality, headache, fatigue, etc., COVID and other viruses influence on the health and work. Over 100 workers in the garment industry (49 in Estonia and 53 in Latvia) were involved. The same questionnaire has been used previously by the Latvian investigators (Kaluznaja, 2022).

2.3.2. Results

Table 1. Results of Measurements in Small Rooms and in a Large Hall (mean data)

Knitting room EE/ LV	***T*, °C cold/warm season *U* = 0.5 °C**	***R*, % cold/warm season *U* = 2.0 %**	***L*, lux *U* = 10.4 %**	***D*, mg/m³ cold/warm season *U* = 10 %**	***v*, m/s cold/warm season *U* = 10 %**	***N*, dB(A) *U* = 10 %**
EE	22–23/ 24–25	30.6/59.0	892–1010	0.1–0.11	0.1/0.15	78.0
LV	21–22/ 23–24.5	28.4/34.5	762–1020	0.06/0.09	0.09/0.19	76.5

U – the uncertainty of measurements; *T* – temperature of the air; *R* – relative humidity; *L* –lighting; *D* – dust concentration in the air; *v* – air velocity; *N* – noise.

Table 2. Answers to the Questionnaire

1	**2**	**3**
Business sector	Estonian knitwear companies (3)	Latvian knitwear companies (3)
Professions	*operators of knitted products	**cutting operators
Age of the workers, years	20–49, mean 40.2	45–70, mean 50.1
Sex (female/male)	90 %/10 %	80 %/20 %
Work experience, years	10–20	2–30
Ergonomic factors		
Forced posture work, pain[1]	2–5	1–10
Work in sitting/standing position, pain[1]	2–10	2–10
Shoulder pain[1], % of workers[2]	–	before 42/ after 25[2]; right hand: 0[1]; left hand 17[1]
Elbow pain[1], % of workers[2]	2–7[1]	before: 25/after: 33[2]; 3–9[1]
Lower back[1], % of workers[2]	1–10[1]	before: 83/after: 42[2]; 3–9[1]
Arms, wrists/hands[1], % of workers[2]	1–10[1]	before: 67/ after: 25[2]; 3–9[1]
Neck pain[1]	3–7[1]	before: 25/ after: 50[2]; legs 1[1]
Knee pain[1]	4–7[1]	before: 25/after: 50[2]
Eye, pain[1]	5–6	2–10
Workplace conditions		
Humidity, influence[3]	2–3	2–10

Ventilation[3]	Installed in 30 % of premises	Not installed
Temperature[3]	5–6	5–10
Draught[3]	3–4	2–3
Lighting[3]	4–5	4–6
Vibration[3]	1–2	1–5; legs 1–5
Noise[3]	1–5	1–10

* Cutting operators, sewing operators, knitting operators, cleaners.
**Cutting operators, cleaners, sewing operators, seamstresses, product washing operators, operators of knitted products, storekeepers, ironing operators, operator of knitted products, shop assistants.
[1] Pain (scale 1–10), 10 – the strongest.
[2] % of workers: before improvements/after improvements.
[3] Influence, assessed by the worker, 10 – the strongest.

All the measurements and the questionnaire were carried out during the autumn of 2023 (at the mean outdoor temperature of 5–10 °C).

3. THE INPUT DATA SYSTEM FOR TEXTILE INDUSTRY WORKERS' AI MODEL

The previously postulated aim, considering the EU document (Jankauskaite et al., 2022), will end with the following conception: the operating factors (physical, chemical, psychological, ergonomic) → organ systems (nervous system: functional stages I, II, III) → AI-software → improved workplace → better health of the worker (Fig. 3).

The main pain was mentioned in the neck and shoulders, hands and wrists, fatigue, and eye fatigue. The working conditions that mainly disturbed the workers were: air temperature, the lighting means, noise and vibration.

The AI model consisting of 3 parts on how to achieve the improvement of workers' working conditions and the decrease in WRMSDs is presented in Fig. 3.

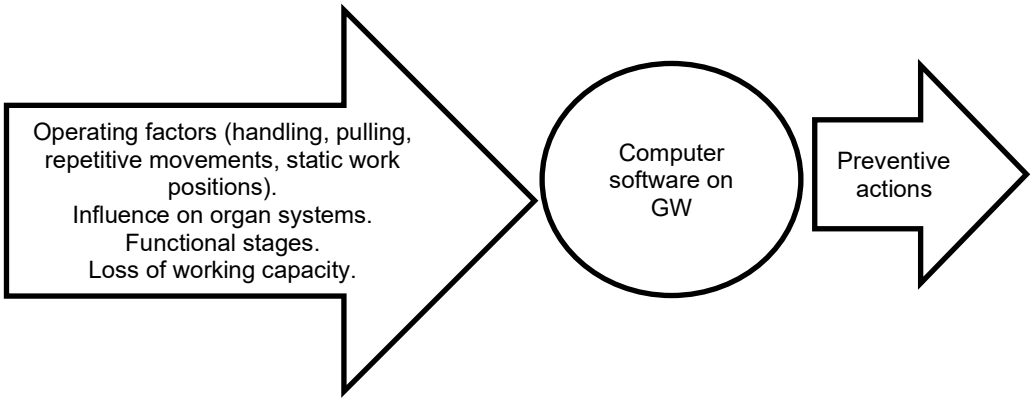

Fig. 3. Artificial intelligence model (AI) (for GW – textile workers) considering the hazardous factors in the work environment and the possible prevention actions.

In every single AI model (Fig. 3), the previous data will be used and analysed by the IT specialists with the help of scientists in the occupational health and safety field. AI technology is advanced, you can enter relevant search words, and an image

will be created using the corresponding software. Using Microsoft Bing Image Creator, the following words were asked to create the images: “operating factors (handling, pulling, repetitive movements, static work positions)” and “influence on organ systems, functional stages, loss of working capacity” (Figs. 4a and 4b).

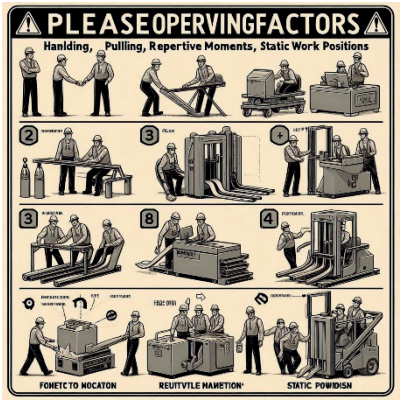

Fig. 4a. Operating factors Open AI.

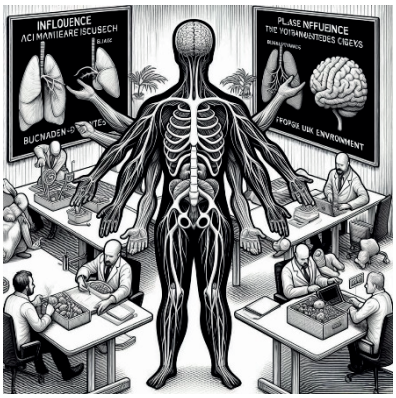

Fig. 4b. Influence on organ systems.

CONCLUSIONS AND RECOMMENTATIONS

On the basis of the investigations in the current study, we can conclude that the connections between the work environment conditions, operation factors influencing workers in the textile industry, and possible musculoskeletal disorders have been clarified. Considering these connections, the AI model consisting of three parts is presented (Fig. 3). In every single AI model, the results of the current investigation are analysed by the IT specialists together with the occupational health doctors.

During a work shift, it is recommended to take regular rest breaks, stand up and stretch yourself and do exercises for the eyes; very important is a healthy diet and exercise after the working day; gymnastics should pay more attention to exercises, aimed at the neck and wrist, as those parts present most distress of the body for sewing machine operators; gymnastics and stretching range and the intensity should be individually adjusted according to the employee’s musculoskeletal ailments and the seriousness of other health complaints; to conduct training courses of ergonomics that employees would be able to self-monitor and adjust the correct position by themselves; employees must be able to adapt job movements to prevent aggravation of WRMSDs. The rehabilitation of WRMSDs is possible using balneotherapy (Pille et al., 2015).

While we cannot stop the ageing process, it is possible to take care of the body and minimize the risk of back pain at work (and after working hours). We can use AI technology to obtain preventive information to better explain the importance of occupational health and safety in the everyday work environment.

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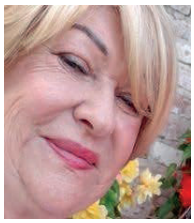

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