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Work Ability and Associated Factors Among Nurses in a Teaching Hospital: A Cross-Sectional Study

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Abstract

Background: *Preserving nurses' work ability (WA) is essential for healthcare sustainability, especially given the current global workforce crisis and an ageing population. This study aims to assess the prevalence of inadequate WA among hospital nurses and to identify the personal, domestic, and organisational predictors that influence it, focusing on modifiable factors to inform targeted retention strategies.* **Methods:** *A cross-sectional study was conducted at an Italian university hospital (August–October 2022). Data from 182 nurses were collected during mandatory health surveillance visits using the Work Ability Index (WAI), alongside assessments of socio-demographic, occupational, and extra-work responsibilities (caregiving/education). Multivariable binary logistic regression was performed to identify independent predictors of WA, adjusting for confounders such as BMI and lifestyle factors.* **Results:** *Inadequate WA was reported by 44.5% of participants (mean age 45.8±11.1 years). A significant health burden was observed, with 41.8% suffering from musculoskeletal disorders. The regression model ($\chi^2_{(9)}$=31.026; p<0.001) revealed that the likelihood of adequate WA decreased significantly with advancing age (OR=0.93 per year; p<0.001) and high extra-work burdens (OR=0.97 per hour; p=0.041). Conversely, satisfaction with working conditions emerged as the primary modifiable protective factor, significantly increasing the likelihood of adequate WA (OR=2.41; p=0.010). No significant associations were found for sex, BMI, or smoking status.* **Conclusions:** *Nearly half of the nursing workforce exhibits vulnerable work ability. Findings suggest a detrimental 'double duty' effect where domestic responsibilities and age intersect. Organisational interventions should prioritise work-life balance and improved work climates to mitigate the impact of demographic shifts and preserve workforce sustainability.*

1. Introduction

Nurses are the largest group of healthcare professionals worldwide. They play a pivotal role in improving health, providing essential care, and advancing primary healthcare. They also deliver care in emergency settings, shape health policies, and safeguard the sustainability of health systems globally [1, 2].

Estimates suggest that by the year 2030, there will be a workforce shortage of 4.5 million nurses

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worldwide [2] and of nearly 2.5 million nurses across 23 Organization for Economic Co-operation and Development (OECD) countries [3, 4]. Italy is one of the OECD countries with the fewest nurses per 1,000 inhabitants, at 6.4, compared with an average of 9.5 in Europe as a whole. It also ranks last in nursing graduates per 100,000 inhabitants: only 17 compared with the European average of 48 [4]. A recent analysis has revealed a significant deficit of at least 65,000 nurses within the Italian healthcare system. Furthermore, the Court of Auditors has estimated that over the next decade, approximately 100,000 nurses will exit the profession due to reaching retirement age [5]. Recent years have seen a further decline in the popularity of the profession, as evidenced by the consistent decrease in applications for admission to nursing degree courses (approximately 10%) [5]. This scenario appears even more critical in light of the increasing demand for nursing care and assistance, driven by the progressive ageing of the population and the growing prevalence of chronic diseases.

An imbalance between the number of registered nurses available and healthcare demand may negatively affect care quality, with potential consequences including higher adverse event rates and increased patient mortality risk [6].

Excessive workload among nurses is associated with reduced job satisfaction, increased rates of burnout, a higher incidence of occupational diseases and workplace injuries, early retirement and attrition from the profession [7-11].

The combination of the aforementioned factors, in conjunction with the ageing nursing workforce, engenders elevated physical and mental demands for nurses who continue to practice. This underscores the need for nurses to maintain peak physical and mental health, which translates into optimal work ability (WA) [1, 12]. WA refers to an individual's ability, or their perceived ability, to meet the demands of their job. It is influenced not only by personal resources, including physical, mental, and social functioning, but also by the specific requirements of the work itself [13]. As a result, an individual's WA may vary across their working lifespan and in relation to their specific occupation and professional context.

In the 1980s, the Finnish Institute of Occupational Health developed the concept of WA and the Work Ability Index (WAI) to measure: "How good is the worker at present, in the near future, and how able is he or she to do his or her work with respect to work demands, health, and mental resources?" [14, 15]. Its goal is to promote a healthy quality of working life, and its key domains encompass workers' needs, the work environment, organizational factors, and workers' health and functional capacity [16]. The WAI demonstrates reliable predictive validity for extended sick leave, occupational incapacity, poor quality of life, early retirement intentions, and even mortality [14, 17]. Similarly, high levels of WA are associated with safer workplaces, improved performance, and enhanced quality of life and workers' well-being [16]. The WAI is therefore a preventive self-assessment tool for nurses to evaluate their ability to meet work demands based on their health status and physical, mental, and social resources. Some studies suggest that nurses' WA may be influenced by both intrinsic work characteristics (night shifts, job satisfaction, etc.) and extra-work factors (family roles, work-life balance, commuting distance, hobbies, etc.) [18, 19].

While WA has been extensively studied in various professions, little research has been conducted on nurses' WA. A recent systematic review highlighted significant risks of compromised WA in nursing staff [20]. Nevertheless, the included studies were all conducted before the pandemic, none investigated the Italian nursing context, and, crucially, most failed to provide separate prevalence data for registered nurses versus nursing assistants [20]. Grouping registered nurses and nursing assistive personnel together is methodologically inappropriate, as the latter are typically assigned more physically demanding and repetitive tasks, often with lower autonomy and fewer opportunities for professional satisfaction, factors known to negatively influence WA [21]. This highlights the need for additional research with disaggregated data by professional category.

In light of the current nursing shortage, prolonged working lives, and the simultaneous high demand for nursing services, understanding the WA of Italian nurses seems to be particularly crucial, and

identifying factors influencing WA could prove highly valuable. Given the gaps presented above, this study aimed to investigate the prevalence of WA and to determine which personal and work-related factors are associated with it, exploring their relationships and the strength of their associations with WAI scores.

2. Methods

2.1. Design and Sample

A cross-sectional study was conducted at a university hospital in Northern Italy using a convenience sample of nurses to assess WA levels and their association with socio-demographic, family, and work characteristics. The only inclusion criterion was employment at the university hospital, either on a fixed-term or permanent contract. To estimate the sample size, G*Power was used for a medium effect size at an alpha level of 0.05 and 80% power, yielding 143 nurses, to which 30 were added to account for attrition. A total of 182 nurses were recruited in the present study, all of whom completed the survey instrument.

2.2. Data Collection Procedure

All nurses attending regular health surveillance visits, as required by Italian law, between 1 August 2022 and 24 October 2022 were invited to participate in the study. A researcher provided each of them an information form about the study, detailing the study's design, objectives, and methods. The researcher assured them that their involvement was entirely voluntary, and that respondents' anonymity and the confidentiality of their information would be strictly preserved. The consent form also emphasised that participants had the right to withdraw from the study at any time. Nurses who provided their written informed consent were then given the questionnaire in an enclosed envelope. The questionnaire was completed on site and prior to the visit, in a private room without the researcher's presence. Participants were then instructed to place the completed questionnaire in a box, ensuring complete anonymity.

2.3. Instrument

The instrument consisted of the following three sections:

2.3.1. Socio-Demographic, Family, and Personal Characteristics

The first part of the questionnaire covered the following topics: age, sex, educational qualifications, family composition, presence of dependent adults, the extent of caregiving responsibilities outside the workplace, assistance and educational activities, balancing work schedules with personal and family commitments, and the time taken to get to work. Information was also requested on smoking habits, weight, and height.

2.3.2. Job Characteristics and Satisfaction

The last section of the questionnaire covered the following topics: type of employment contract; length of service; operating unit; type of work shift; and satisfaction with current working conditions. The clinical setting operates on a standardized institutional shift schedule. The nursing staff follows a 12-hour rotation system consisting of daytime shifts (07:00–19:00) and nighttime shifts (19:00–07:00). This organizational model allows for a compressed workweek, typically involving three shifts per week to reach the standard 36-hour weekly requirement. In compliance with national health regulations and safety protocols, a mandatory minimum of 11 consecutive hours of rest is guaranteed between shifts to ensure adequate psychophysical recovery.

2.3.3. Work Ability Index

The WAI is the most commonly used tool for evaluating work capacity [2-6], which, as mentioned above, is a self-assessment questionnaire designed to measure the WA of healthcare workers, developed by Tuomi et al. [15].

The index is determined on the basis of the answers to a series of questions which take into consideration the demands of work, the worker's health, and resources. It consists of 60 items distributed

in seven dimensions, that assess: (a) current WA compared with lifetime best (1 item), (b) WA in relation to the demands of the job (2 weighted items), (c) number of current diseases diagnosed by a physician (out of a list of 51 diseases), (d) estimated work impairment due to disease (1 item), sick leave during the past 12 months (1 item), (e) own prognosis of WA 2 years from now (1 item), and (f) mental resources (3 items). Scores on each dimension are summed, with a range of 7 to 49, allowing workers to be classified into four categories: poor (7 – 27); moderate (28 – 36); good (37 – 43); and excellent (44 – 49). However, since then, numerous studies have dichotomized the WAI total score by aggregating the 4 dimensions into only two categories [20]:

- *inadequate WA* when the score is between 7 and 36 (combination of the poor and moderate categories);
- *adequate WA* with a score between 37 and 49 (combination of the good and excellent categories).

The reliability of the questionnaire in the present study (Cronbach's alpha) was 0.81, while in other studies it ranged from 0.65 to 0.80 [22, 23].

2.4. Data Analysis

Descriptive statistics were used to summarise participants' socio-demographic and occupational characteristics, with continuous variables expressed as means and standard deviations and categorical variables as frequencies and percentages.

The WAI was initially categorised into four levels (poor, moderate, good, excellent) and subsequently dichotomised into a dummy variable, coded as 'adequate' when the WA score ranged from 37 to 49 and 'inadequate' when it ranged from 7 to 36, in accordance with previous studies [20]. Comparisons between groups were conducted using χ^2 tests for categorical variables and Student's t-test for continuous variables. To assess the internal consistency between the occupational indicators (job satisfaction and work-life balance) and the WAI dimensions, a bivariate correlation analysis was performed. Given the ordinal nature of the satisfaction scales, Spearman's rank correlation coefficient (r) was calculated.

A binary logistic regression analysis (enter method) was then performed to identify independent predictors of adequate WAI. The dependent variable was derived from the dichotomised WAI score (Adequate vs Inadequate). Independent variables included age, sex, marital status, presence of children, body mass index (BMI), smoking habits, weekly hours spent on caregiving, assistance or educational activities outside of work, and satisfaction with working conditions. All variables were entered simultaneously into the model. Model fit was evaluated using Nagelkerke R^2 and the Hosmer-Lemeshow test. Odds ratios (exp(B)) and corresponding p-values were calculated to assess the strength and significance of associations.

Furthermore, to investigate potential selection biases, the age distribution was compared between nightshift and daytime-only workers using an independent-samples t-test. Levene's test was used to assess the equality of variances, and the appropriate t-statistic was reported accordingly.

All analyses were two-tailed, with statistical significance set at $p<0.05$. IBM/SPSS Statistics for Windows, Version 29.0 (IBM Corp.: Armonk, NY, USA) was used for the analyses.

2.5. Ethical Considerations

The study was approved by the Ethics Committee of the "Area Vasta Emilia Nord" (n. 0017051/2022) and conducted in accordance with the Declaration of Helsinki (Ethical principles for medical research involving human participants, 2024) of the World Medical Association.

3. Results

3.1. Participants Characteristics

The 182 nurses had a mean age of 45.8±11.1 years, with males being younger than females (male M=39.4±10.6 SD years, female M=47.2±11.1 SD years; $p<0.001$). The age distribution shows that 43.4% of the sample were over 50 years old, while 30.8% were between 36 and 50 years old. The

respondents were predominantly female. Table 1 shows the sample characteristics.

Respectively, 43% of males and 48% of females reported spending more than 20 hours per week on non-work-related caregiving, assistance, and educational activities. 26.4% of the sample reported being overweight, while 14.8% reported having obesity of types I-III, with an average BMI of 25.3±4.7 SD and no sex distinctions. Regarding smoking habits, there was a clear prevalence among males (41% vs. 18% of females, p=0.008).

3.2. Job Characteristics and Satisfaction

The vast majority of respondents (98.4%) were employed on a permanent basis. Most worked in medical departments (46.2%) and during daytime shifts (61%), as shown in Table 2. On average, female participants reported significantly greater job seniority compared to males (males 11.7±11.4 SD, female 20.5±12.4 SD; p<0.001). Overall, 61.5% of the sample reported being fairly satisfied with their working conditions.

3.3. Work Ability Index Analysis by Sex

The overall mean WAI score for the study population was 37.2±6.3. When disaggregated by sex, male nurses reported a significantly higher total WAI score than their female counterparts (39.3±5.6 vs. 36.7±6.4, respectively; p=0.039), as shown in Supplemental Material, Table S1.

Table 1. Socio-demographic characteristics and extra-work commitments of the study population (N=182).

Participants characteristics	Total N=182	Male n=32 (17.6%)	Female n=150 (82.4%)	p-value
Age (years, M±SD)	45.8±11.1	39.4±11.0	47.2±10.6	**<0.001**
Educational level				
Professional Nursing Diploma	69 (37.9%)	6 (18.8%)	63 (42%)	0.066
University Diploma in Nursing	18 (9.9%)	3 (9.4%)	15 (10%)	
Nursing Degree	95 (52.2%)	23 (71.9%)	72 (48%)	
Marital status				
Married/Partnered	120 (65.9%)	17 (53.1%)	103 (69.6%)	0.073
Single	62 (34.1%)	15 (46.9%)	47 (31.3%)	
Presence of children in home				
Yes	77 (42.3%)	13 (40.6%)	64 (42.7%)	0.488
No	105 (55.7%)	19 (59.4%)	86 (57.3%)	
Adult caregiving responsibilities				
Yes	48 (26.4%)	6 (18.8%)	42 (28.0%)	0.281
No	134 (73.6%)	26 (81.3%)	108 (72%)	
Extra-work commitments (hours, M±SD)	23.4±17.9	20.2±17.9	24.15±17.9	0.285
Work-life balance				
Good	122 (67%)	23 (71.9%)	99 (66.0%)	0.932
Poor	60 (32.9%)	9 (28.1%)	51 (34.0%)	
Travel time to workplace				
< 30 minutes	141 (77.5%)	27 (84.4%)	114 (77.0%)	0.584
30-60 minutes	37 (20.3%)	5 (15.6%)	32 (21.6%)	
> 60 minutes	2 (1.1%)	0 (0.0%)	2 (1.4%)	

M: Mean; SD: Standard Deviation.

Table 2. Occupational characteristics, work settings, and job satisfaction among the surveyed nurses.

Job variables	Total (N=182)	Male (n=32)	Female (n=150)	p-value
Employment contract				
Permanent	179 (98.4%)	32 (100%)	147 (98%)	1
Temporary	3 (1.6%)	0 (0%)	3 (2%)	
Work setting				
Medical ward	84 (46.2%)	15 (46.9%)	69 (46%)	**0.016**
Surgical ward	31 (17%)	4 (12.5%)	27 (18%)	
Outpatient area	24 (13.2%)	0 (0%)	24 (16%)[a]	
Intensive care unit	22 (12.1%)	9 (28.1%)[a]	13 (8.7%)	
Service area	11 (6%)	2 (6.3%)	9 (6.0%)	
Management area	10 (5.5%)	2 (6.3%)	8 (5.3%)	
Work Shift				
Daytime	111 (61%)	11 (34.4%)	100 (66.7%)	**0.01**
Nighttime	71 (39%)	21 (65.6%)	50 (33.3%)	
Job Seniority (years, M±SD)	18.9±12.7	11.7±11.4	20.5±12.4	**<0.001**
Job Satisfaction*				
Low satisfaction	53 (29.1%)	12 (37.5%)	41 (27.7%)	0.49
Fair satisfaction	112 (61.5%)	17 (53.1%)	95 (64.2%)	
High satisfaction	15 (8.2%)	3 (9.4%)	12 (8.1%)	

** 2 missing data; [a] Adjusted standardized residual > |1.96|, indicating a significant difference in distribution between sexes within this category.*

Data are presented as n (%) or Mean ± Standard Deviation. p-values were calculated using Pearson's Chi-square test, Fisher's exact test (for categorical variables with expected counts < 5), or Independent Samples t-test (for continuous variables). Significant p-values (p<0.05) are highlighted in bold.

Analysis of the seven individual WAI dimensions revealed that the most prominent difference between groups occurred in Dimension 3 (number of diagnosed diseases), where men scored significantly higher than women (4.9±2.0 vs. 3.5±2.4; p=0.003). Furthermore, a borderline significant difference was observed in Dimension 4 (estimated work impairment due to diseases), with higher scores reported by male participants (5.3±0.9 vs. 4.9±1.3; p=0.058).

3.4. Correlation Between Job Satisfaction and Work Ability Dimensions

The analysis revealed significant positive correlations between perceived job satisfaction and work ability. Specifically, overall satisfaction with working conditions was significantly associated with total WAI scores (r=0.259, p=0.001). Furthermore, satisfaction regarding the quantity of work performed was positively correlated with WAI scores (r=0.202, p=0.009), as was the ability to balance work schedules with personal and family commitments (r=0.192, p=0.012).

3.5. Work Ability

As shown in Table 3, 55.5% of our sample demonstrated an adequate level of WA.

47.8% of our sample reported at least three pathologies, with a higher prevalence among females (54% vs. 18.8%). The most common conditions were musculoskeletal disorders (41.8%), including cervical spine (22%), lumbar spine (29%), chronic lumbosciatica (19%), limb disorders (21%), and other

Table 3. Distribution of Work Ability Index (WAI) scores according to four-category and dichotomous classifications.

	Total (N=182)	Male (n=32)	Female (n=150)	p-value
4 WAI Categories				
7-27: Poor	17 (9.3%)	1 (3.1%)	16 (10.7%)	0.201
28-36: Moderate	64 (35.2%)	8 (25.0%)	56 (37.3%)	
37-43: Good	75 (41.2%)	17 (53.1%)	58 (38.7%)	
44-49: Excellent	26 (14.3%)	6 (18.8%)	20 (13.3%)	
2 WAI Categories				
7-36: Inadequate work ability	81 (44.5%)	9 (28.1%)	72 (48.0%)	**0.04**
37-49: Adequate work ability	101 (55.5%)	23 (71.9%)	78 (52.0%)	

Table 4. Prevalence of diagnosed medical conditions and organ-system disorders in the study cohort.

Diagnosis	Total (N=182)	Male (n=32)	Female (n=150)	p-value
Musculoskeletal disorders	76 (41.8%)	8 (25.0%)	68 (45.3%)	0.340
Neurological disorders	43 (23.6%)	4 (12.5%)	39 (26%)	0.103
Metabolic and endocrine disorders	41 (22.5%)	4 (12.5%)	37 (24.7%)	0.135
Cardiovascular diseases	40 (22%)	4 (12.5%)	36 (24.0%)	0.154
Dermatological disorders	37 (20.3%)	5 (15.6%)	32 (21.3%)	0.466
Gastrointestinal disorders	28 (15.4%)	4 (12.5%)	24 (16.0%)	0.618
Respiratory disorders	23 (12.6%)	4 (12.5%)	19 (12.7%)	0.979
Vision and hearing disorders	20 (11%)	1 (3.1%)	19 (12.7%)	0.158
Genitourinary disorders	20 (11%)	**0 (0%)**	**20 (13.3%)**	**0.029**
Anxiety, insomnia	18 (9.9%)	1 (3.1%)	17 (11.3%)	0.158
Oncological disorders	16 (8.8)	1 (3.1%)	15 (10%)	0.212
Blood disorders	14 (7.7%)	1 (3.1%)	13 (8.7%)	0.286
Mental disorders (e.g., severe depression)	4 (2.2%)	1 (3.1%)	3 (2.0%)	0.694

musculoskeletal issues (9%). Beyond musculoskeletal issues, conditions with over 20% prevalence included neurological, metabolic, endocrine, cardiovascular, and dermatological disorders (Table 4).

3.6. Work Ability Among Shift Workers and Non-Shift Workers

Inadequate WA, as measured by the WAI, was significantly more prevalent among nurses who do not work night shifts (Table 5).

Nurses working night shifts, compared to their daytime counterparts, reported lower satisfaction with their working conditions, but seemed to experience less difficulties in achieving a work-life balance.

Moreover, a significant age difference was observed between work-shift categories: nurses in the night-shift rotation were significantly younger than those in daytime-only roles (38.0±10.9 vs. 50.8±8.1 years; $p<0.001$).

3.7. Work Ability Predictors

The multivariable model demonstrated a good fit (Hosmer-Lemeshow: $\chi^2=7.117$, $p=0.524$) and explained 29.3% of the variance (Nagelkerke $R^2=0.293$), correctly classifying 71.1% of cases.

Table 5. Work Ability Index, job satisfaction, and work-life balance in shift and non-shift workers.

		Shift workers	Non-shift workers	p-value
WAI	Inadequate work ability	31%	53%	**0.004**
	Adequate work ability	69%	47%	
Job satisfaction	Low satisfaction	41%	22%	**0.010**
	Fair satisfaction	55%	67%	
	High satisfaction	4%	11%	
Work-life balance	Good	41%	28%	**0.040**
	Poor	59%	72%	

WAI: Work Ability Index.

Three independent predictors of adequate WA were identified. Age was negatively associated with the outcome (OR=0.93, p=0.001), as were the hours spent on extra-work caregiving activities (OR=0.97, p=0.041), indicating that increasing age and domestic burdens significantly reduce the likelihood of maintaining adequate work capacity. Conversely, job satisfaction emerged as a strong protective factor, more than doubling the odds of reporting adequate work ability (OR=2.41, p=0.010). A notable trend was also observed for BMI, with normal-weight nurses more likely to report adequate WA than those in the overweight/obese category (OR=2.28, p=0.065).

Full regression parameters are detailed in Supplemental Material, Table S2.

4. Discussion

The aim of this study was to investigate the prevalence of WA among hospital nurses and explore its association with personal and occupational factors. Almost half of the nurses in our sample (44.5%) reported inadequate WA, a proportion closely mirroring that observed by Garzaro et al. in another Italian university hospital (45.6%) [19]. This rate is, however, higher than those reported in most studies included in the systematic review by Romero-Sánchez et al., where the prevalence of inadequate WA generally ranged between 20% and 40%, with few exceptions in Thailand (53.2%), Germany (56.2%) and Poland (66.6%) [20]. However, it should be noted that most of those studies were conducted before the COVID-19 pandemic, which likely worsened working conditions and may have led to a persistent deterioration in WA among nurses.

A substantial body of evidence indicates that nurses and nursing assistants consistently exhibit poorer WA compared to other healthcare professionals [18, 19, 24].

Hospital nurses, in particular, face intense physical, mental, and psychological demands due to multiple factors: heavy workloads, manual patient handling, responsibility for patient safety, and care of elderly patients with multimorbidity. They also experience various organizational, social, and economic stressors, including night shifts, limited autonomy and control over their work, low pay, and inadequate social support [11, 19, 20, 25]. Furthermore, nurses frequently experience verbal and physical violence from patients and their relatives [26]. The literature has documented a bidirectional association between workplace violence and reduced WA [27]. These conditions contribute to physical strain and psychological distress, both of which are recognised determinants of reduced WA.

Consistent with previous studies, advancing age was the strongest negative predictor of WA in our sample [1, 28]. The progressive ageing of the nursing workforce across Europe, where approximately one in five nurses is aged 55 years or older [29], poses a major sustainability challenge. Although ageing itself cannot be modified, organisational and technological strategies may buffer its impact. In particular, the ongoing digital transformation of healthcare could represent a double-edged sword: while automation, electronic documentation and digital monitoring systems can reduce physical workloads and

increase efficiency, they could also introduce technostress and cognitive strain, especially for older nurses with lower digital literacy. Supporting digital competence through tailored training and mentoring may thus enhance both WA and job satisfaction.

Another important finding was the negative effect of extra-working responsibilities such as caregiving and educational duties. This reflects the increasing prevalence of the so-called 'double duty' among nurses who simultaneously manage the burden of professional and family care roles [30]. As highlighted by many authors, family caregiving among nurses can exacerbate fatigue, stress, and work–life conflict, potentially compromising both self-care and patient safety [31]. The rise of hybrid or remote healthcare models following the pandemic may offer partial solutions by improving flexibility, yet these models can also create new forms of digital overload or professional isolation. Artificial intelligence (AI) and telehealth technologies could be leveraged to redistribute administrative tasks and support nurses' time management, ultimately improving work–life balance [32].

In contrast, satisfaction with working conditions emerged as a protective factor, increasing the likelihood of adequate WA. This is consistent with the Nurse forecasting in Europe (RN4CAST) project findings, which demonstrate strong links between job satisfaction, adequate staffing, and better care outcomes [33, 34]. In the Italian branch of the RN4CAST study, excessive workloads and unfavourable nurse-to-patient ratios were identified as key contributors to job dissatisfaction, burnout and intentions to leave the profession [10]. This evidence aligns with our findings, suggesting that improving nurses' satisfaction with their working conditions may be crucial to maintaining WA. Organisational cultures that promote learning, recognition, and participation, can strengthen both nurses' resilience and retention. Nurse managers play a crucial role in this process by providing visible, supportive leadership, which is known to enhance job satisfaction and reduce errors. As highlighted by Aiken et al. [8], structural interventions that improve hospital work environments and staffing may have a stronger impact on clinicians' well-being and patient safety than individual-level resilience programmes. Our findings further indicate that subjective job satisfaction is not merely a reflection of workplace climate but is significantly correlated with the constituent dimensions of the WAI. The positive association found between satisfaction with work quantity and WAI scores underscores the critical role of perceived workload management. This is consistent with the job demands-resources model [34], suggesting that when nurses perceive their work quantity as manageable and their environment as supportive, their internal resources, as measured by the WAI, are better preserved. These correlations strengthen the validity of using self-reported satisfaction as a reliable proxy for organisational health in nursing settings.

Interestingly, nurses working night shifts displayed higher WA scores than their daytime counterparts, despite reporting poorer job satisfaction. This finding appears counterintuitive, and contrasts with previous studies, which have generally shown lower WA among night or rotating shift workers, consistently associating it with adverse health outcomes, including sleep disturbances, metabolic dysregulation, and increased stress [12]. A possible explanation for this apparent discrepancy may be the 'healthy worker effect', a specific type of survivorship bias where those who remain in night work tend to be younger, healthier, and more resilient, while less healthy workers often move to daytime roles [35]. Our data strictly support this clinical dynamic: nurses in the night-shift rotation were significantly younger than those working exclusively during the day (38.0±10.0 vs. 50.8±8.5 years, respectively; $p<0.001$). This age disparity suggests that the night-shift cohort represents a 'screened' group of younger individuals whose biological resilience likely buffers the stressors of nocturnal work. In contrast, the daytime group includes a higher proportion of ageing staff who may have been transitioned to more regular schedules due to emerging health limitations identified during mandatory health surveillance. This confirms a 'healthy worker effect', where younger, more resilient staff remain in night rotations while older colleagues are transitioned to daytime roles [35]. This dynamic is further reflected in the work-life balance data: night-shift nurses reported a lower prevalence of poor work-life balance (59%) compared to daytime nurses (72%), a

difference that may be attributed to the combined effect of their younger age and the higher proportion of male nurses in the night-shift rotation. Male nurses in our sample were significantly younger and reported fewer weekly hours of extra-work caregiving responsibilities, a pattern consistent with broader evidence that male nurses often carry a lower burden of family caregiving duties compared to their female colleagues [30, 31]. Thus, the observed differences in work-life balance likely reflect demographic selection: younger, predominantly male nurses with fewer domestic responsibilities, rather than a direct protective effect of night work itself.

Moreover, night shifts may be perceived as offering greater autonomy or financial compensation, partially offsetting fatigue. Nonetheless, long-term exposure to irregular schedules remains a recognised risk for sleep disturbance, stress, and impaired performance [25, 36-39]. However, these findings underscore the importance of considering age, sex, and selection bias when interpreting the relationship between shift schedules and work ability. While night work is not without risks, the cross-sectional nature of this study captures a "surviving" cohort of younger, predominantly male nurses whose physiological resilience and, potentially, lower burden of extra-work caregiving responsibilities may temporarily buffer the occupational stressors of shift work. Longitudinal studies are needed to determine whether this cohort maintains its high work ability as it ages or eventually transitions to daytime roles, as observed in the older segment of our sample.

Musculoskeletal disorders were the most frequently reported health condition among our participants, confirming their major role in limiting WA. This is consistent with international evidence showing that 35-80% of nurses experience back injuries during their career, largely due to patient handling and physical overexertion [11, 40]. Musculoskeletal disorders are associated with absenteeism, decreased quality of care, and early exit from the profession [41]. Multicomponent ergonomic interventions combining physical exercise, equipment training and participatory redesign appear the most effective for reducing these risks [42].

The regression analysis highlights that while biological ageing (age) remains a non-modifiable constraint, organisational and personal factors play a decisive role in sustaining work ability. The significant impact of job satisfaction (OR=2.41, p=0.010) suggests that improving the psychosocial work environment can more than double the likelihood of maintaining high work capacity. Furthermore, the significance of extra-work caregiving hours underscores the 'double burden' faced by the nursing workforce, where domestic demands directly interface with professional performance. These findings suggest that interventions to support work-life balance and enhance workplace satisfaction are essential strategies for retaining ageing staff. A trend towards significance was observed for normal-weight nurses (OR=2.28, p=0.065), suggesting that weight management may also contribute to preserving work ability, warranting further investigation.

Beyond its clinical implications, inadequate WA has important organisational consequences, including increased absenteeism, turnover, and reduced patient safety [43, 44]. Studies consistently show that inadequate staffing and poor working environments are associated with higher mortality and readmission rates [6, 45]. Strengthening nurse staffing and improving work environments should therefore be considered not only workforce strategies, but patient-safety imperatives.

The emotional dimension of WA also deserves attention. Over the last century, workplace disorders have become increasingly attributable to cognitive and psychological rather than somatic factors. This shift reflects two interrelated phenomena: the rise of professions requiring sustained mental performance and the progressive decline of physically strenuous work. A study conducted in Germany in 2015 showed that around 20% of retired workers left the labour market due to incapacity for work, relying on disability pensions; however, age-related diseases appear to be influenced more by external determinants such as diet, work type, environment, lifestyle, and genetic predisposition. The high prevalence of inadequate WA in our cohort may partly reflect post-pandemic emotional exhaustion and burnout, now recognised as key contributors to nurse attrition [21, 46, 47]. The concept of sustainable emotional capacity is crucial for understanding WA in nursing, as it encompasses the professional resilience required

to consistently preserve empathetic responsiveness and ethical decision-making despite chronic occupational stress. Integrating moral distress prevention and peer-support programmes into continuing education may help preserve this dimension of WA.

Looking ahead, technological innovation could play a transformative role in safeguarding WA. Predictive analytics and AI applications are beginning to support occupational health surveillance [48], and they could play a role in integrating data from shifts, self-reports and wearable sensors to identify early signs of decline in WA. Embedding such systems into routine occupational monitoring could allow proactive interventions tailored to individual risk profiles. Similarly, promoting "green hospital" design, with natural light, quiet spaces and ergonomic layouts, has been shown to enhance staff well-being and reduce stress. These environmental strategies align with the broader goal of sustainable healthcare and may indirectly contribute to maintaining WA.

This study has some limitations that should be acknowledged. Its cross-sectional design precludes the establishment of causal relationships between WA and the factors identified. In order to clarify whether age, family responsibilities, job satisfaction and other variables act as antecedents or consequences of changes in WA over time, longitudinal designs would be required. Furthermore, data were collected in a single university hospital, which may limit the external validity of the findings.

Another limitation concerns the use of self-reported data, which may be influenced by recall or social desirability bias. However, the anonymous and voluntary nature of participation likely reduced such effects. The absence of objective measures of physical and mental health (e.g. sickness absence, clinical assessments) also limits the ability to triangulate self-perceived WA with actual performance indicators. Given the mean age of the sample and the prevalence of chronic musculoskeletal conditions, medication use could represent a further indicator of disease severity that the standard WAI does not fully capture. Nevertheless, although individual-level triangulation with clinical records was precluded by the anonymized study design, the high prevalence of self-reported musculoskeletal disorders observed in our sample is entirely consistent with the general epidemiological profile and health surveillance trends of the nursing staff within our institution. This alignment reinforces the validity of our findings, suggesting that the self-reported data accurately reflect the objective clinical burden of this professional population. Future studies could integrate administrative and clinical data, or even wearable-sensor metrics, to enhance the precision of WA assessments.

Additionally, this study did not include organisational-level variables such as staffing ratios, team climate, or leadership style, which are known to influence both job satisfaction and WA. Incorporating multi-level data could help capture the complex interactions between individual, team and institutional determinants of WA.

Despite these limitations, the study presents notable strengths. The institutional homogeneity of the sample increases internal consistency and offers a representative insight into the situation of hospital nurses in the Italian public healthcare context. Additionally, the anonymous and voluntary nature of participation likely reduced recall or social desirability bias.

Future research should therefore adopt a multidimensional and mixed-methods approach, combining quantitative modelling with qualitative inquiry into nurses' lived experiences and coping mechanisms. The integration of digital technologies, such as AI-driven predictive tools and occupational health dashboards, could open new avenues for early identification of nurses at risk of declining WA and for tailoring preventive interventions.

Finally, intervention studies are needed to evaluate the effectiveness of strategies aimed at maintaining and improving WA across the career span. These may include targeted physical and ergonomic programmes, flexible scheduling for workers with caregiving responsibilities, and organisational policies promoting emotional sustainability and job satisfaction. Implementing such evidence-based measures could strengthen the resilience and retention of the nursing workforce, contributing to the broader goal of sustainable and high-quality healthcare delivery.

5. Conclusion

In conclusion, our findings highlight the multifactorial nature of WA, shaped by the interplay

between personal characteristics, family responsibilities, organisational culture, and evolving technologies. Nearly half of hospital nurses in our sample experienced inadequate WA, driven by both individual and organisational determinants. Advancing age and external caregiving or educational duties emerged as key challenges, while satisfaction with working conditions acted as a strong protective factor. Addressing these dimensions through coordinated interventions, ranging from ergonomic and psychosocial prevention to digital training, supportive leadership and flexible scheduling, will be essential to sustain nursers' WA, enhance job satisfaction, and ensure both workforce retention and the safety of healthcare systems.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of the "Area Vasta Emilia Nord" (reference number 185/2022/SPER/AOUMO SIRER ID 4136, protocol 0017051/22).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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APPENDIX

Supplemental Material

Table S1. Work Ability Index (WAI) scores disaggregated by sex and dimensions.

WAI Dimensions	Total (N=182)	Male (n=32)	Female (n=150)	p-value
Total WAI Score (range 7-49)	37.2 ± 6.3	**39.3 ± 5.6**	**36.7 ± 6.4**	**0.039**
WAI 1: Current WA (range 0-10)	7.4 ± 1.6	7.6 ± 1.3	7.4 ± 1.6	0.512
WAI 2: WA vs job demands (range 2-10)	8.0 ± 1.3	8.3 ± 1.2	7.9 ± 1.3	0.167
WAI 3: Diagnosed diseases (range 1-7)	3.8 ± 2.3	**4.9 ± 2.0**	**3.5 ± 2.4**	**0.003**
WAI 4: Work impairment (range 1-6)	4.9 ± 1.2	5.3 ± 0.9	4.9 ± 1.3	0.058
WAI 5: 12 months sick leave (range 1-5)	3.8 ± 1.0	3.8 ± 1.1	3.8 ± 1.0	0.908
WAI 6: Own 2-year prognosis (range 1-7)	6.1 ± 1.6	6.5 ± 1.4	6.0 ± 1.6	0.092
WAI 7: Mental resources (range 1-4)	3.1 ± 0.7	3.1 ± 0.8	3.1 ± 0.8	0.918

WAI: Work Ability Index; WA: Work Ability.
Data are presented in Mean Scores ± Standard Deviations. Higher WAI scores indicate better work ability. Bold values indicate statistical significance.

Table S2. Multivariable Logistic Regression Model for Predictors of Adequate Work Ability

Predictor	B	S.E.	Wald	p-value	OR (95% CI)
Age	-0.07	0.02	10.43	**0.001**	0.93 (0.89–0.97)
Sex (Female vs Male)	0.44	0.56	0.62	0.431	1.55 (0.52–4.62)
Married/Partnered (Yes vs No)	0.13	0.53	0.06	0.804	1.14 (0.40–3.20)
Children (Yes vs No)	-0.48	0.50	0.91	0.339	0.62 (0.23–1.65)
BMI categories[a]			4.05	0.132	-
Underweight vs Overweight	1.15	0.90	1.64	0.200	3.16 (0.54–18.39)
Normal Weight vs Overweight	0.83	0.45	3.41	0.065	2.28 (0.95–5.49)
Smoking (Yes vs No)	0.55	0.56	0.96	0.328	1.73 (0.58–5.15)
Extra-work caregiving, assistance or educational activities (hours/week)	-0.03	0.01	4.17	**0.041**	0.97 (0.94–0.99)
Job Satisfaction	0.88	0.34	6.56	**0.010**	2.41 (1.23–4.71)
Constant	1.28	1.41	0.83	0.362	3.61

B: regression coefficient; S.E.: standard error; Wald: Wald chi-square statistic; OR: odds ratio; CI: confidence interval. Reference category for the dependent variable: Inadequate work ability. [a] Reference category for BMI: Overweight/Obese. Model diagnostics: Omnibus model $\chi^2(9)=31.026$, $p<0.001$; Nagelkerke $R^2 = 0.293$; Hosmer-Lemeshow test: $\chi^2 = 7.117$, $p=0.524$. Correct classification rate: 71.1%.