

Association of Occupational Workload and Ergonomic Risk Factors with Musculoskeletal Injuries among Endoscopy Practitioners in India: An Analytical Study

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INTRODUCTION

Work-related Musculoskeletal Disorders (WMSDs) are injuries to muscles, nerves, tendons, joints, cartilage, and spinal discs that happen or get worse because of things like repetitive motion, bad posture, and heavy lifting at work. These diseases, which commonly affect the back, neck, and shoulders, are a major source of disability (1.71 billion persons worldwide) [1]. At the moment, three out of the top 10 conditions in terms of non-communicable disease and disability are WMSDs, which make up 16% of all years spent disabled [1,2]. There are three categories of WMSDs namely; muscular disorders resulting from stretching of muscles due to contraction. Tendon disorders that could result due to stretching of tendons and nerve disorders that could be due to repetitive motions, muscle compression, nerve compressed and awkward postures. WMSDs can occur at different stages: early stage (aching and tiredness during the work shift), intermittent stage (aching and tiredness occurs early in the work shift and persist at night) and late stage (aching, fatigue and persist rest, sleeping and performance incapable of work. The common body part are neck, shoulder, upper back, elbows, lower back, wrist/hands, hips/thighs, knees and ankles/feet . The symptoms include; pain, weakness, swelling, burning sensation, numbness, tingling, fatigue, muscle twitches, worsens with movement, sleep disturbances, wasting of muscles dry palm [1,3].

Going down for the prevalence among endoscopists, musculoskeletal symptoms are quite prevalent vary from 29 per cent to 89 per cent of the population (other studies 43 per cent, 13 39 percent, 14 74 per cent, 15 67 percent 16). Lower back discomfort (6 percent to 27 per cent), thumb pain (5 per cent to 19 per cent), shoulder (9 per cent to 32 per cent), elbow (8 per cent to 15 per cent), hand (9 per cent to 17 per cent), neck (9 per cent to 28 per cent), & hand numbness were other common injuries or pains mentioned (12 per cent) [4].

As a result of the essential characteristics of routine practice, the vast majority of medical professionals believe that work-related injuries to the MSI are the most prevalent issue when it comes to occupational health (OH). Furthermore, endoscopists frequently report musculoskeletal injury [5, 6, 7, 8, and 9]. Table 1 showing conceptual framework illustrating socio-demographic, behavioral, institutional, work-pattern and ergonomic factors associated with work-related musculoskeletal injuries among endoscopists. It has been demonstrated that a physician's health and well-being along with work routine are affected by the constant stress and dangers of his or her job. Ergonomic ailments during operations have been linked to muscle contractions, doing the same thing over and over, and incorrect body posture [10, 11]. Constant repetitive tasks, not taking breaks, and endoscopists' own habits and routines all risk of occupational injury [12].

There is a high rate of ergonomic injuries reported by medical assistants, especially endoscopists, who suffer from chronic muscle and joint pain in

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their thumb and hand [6, 7]. Previous studies show that between 29 and 89 percent of endoscopists get these kinds of injuries during procedures [13]. Endoscopy is now the most significant and frequently performed technique in gastroenterology [14]. There is therefore a higher chance of injury for doctors and surgeons who undertake endoscopic procedures. There has also been an increase in disease in recent times, which has put endoscopists under additional stress and resulted in an increase in the rate of work - related injuries [15].

The health sector is currently concerned about work-related musculoskeletal illnesses and the accompanying ergonomic factors. The disease is dangerous for both health care workers and patients since it impairs their ability to do their jobs [17]. Endoscopists' typical job routine is known to be disrupted by musculoskeletal issues. In a prior study, 84.6 percent of endoscopists reported musculoskeletal pain, which significantly impacted their work routine [16].

Due to an absence of collected data, especially among the eastern populace, and a lack of knowledge, significant change has not occurred. In addition, there is no exhaustive examination of the risk variables for endoscopy-related injury. Endoscopic ergonomics can also prevent future injuries by raising awareness of their importance. Endoscopists often acquire their skills from their mentors throughout their fellowship training; therefore, the class possesses a wide variety of skills and knowledge. While ergonomics is not given much attention in the classroom, this variability can lead to MSI. Endoscopy is connected with a high risk of MSI, which can be reduced by adhering to standard ergonomic practices, organized training of trainees in ergonomic methods while performing endoscopy, and research into the development of more ergonomic endoscopes and process areas [7].

Endoscopic procedures are projected to become more popular [15, 18]. As a result, it's important to investigate and improve the ergonomics of endoscopy. Although the results of a series of global studies have been surprising, not much is known about the health complications most endoscopists face around the world. We wanted to find out workload factor associated with MSI and the association between endoscopy and workload factor associated with MSI. This research looks at the components of heavy workload which can lead to MSD and how they are related. Injury and pain can diminish productivity and possibly shorten the

longevity of a job. Endoscopic procedures have been associated with musculoskeletal pain and damage, particularly finger or thumb or hand injury and pain, and also neck or back injury and pain. Over the past two decades, endoscopists have performed a sharp rise in treatments procedures [19].

This research focusing on MSI and its impact on clinical practice is in India. Because of this, it is an effort to examine the incidence of endoscopy-related complications in the medical practitioner and could help in prevention work-related diseases. There are findings from the U.S., Korea, Japan, etc. But there is no information from India about MSI caused by work and how they affect clinical practice. This approach would explore the issue with statistics and facts regarding the prevalence of MSI among clinical stakeholders, taking into account the existing figures and research efforts conducted all over the world.

MATERIAL AND METHODS

Study Design

In the present investigation, a cross sectional descriptive research design was employed to find workload factor associated with MSI and along with type of specialty of Endoscopists Practitioner is more linked to MSI among the medical practitioner engaged in endoscopic procedures of the Delhi Region.

In this study, a well-organized questionnaire served as the main instrument for data collection, integrating elements designed to evaluate participants understanding of endoscopic related musculoskeletal disorders among medical professionals. The questionnaire was underwent content validation and face validation before came into use. The S-CVI/Ave, which reflects the average proportion of experts ratings each item as relevant (i.e., scores of 3 or 4 on 4-point scale) was found to be 0.944 indicating a high level of content validity and average kappa for the face validation was across all domains was approximately 0.82, which falls within ranges of excellent agreement, confirming that the instrument is reliable and appropriate for the assessing the targeted related to all domains present in the questionnaire.

Participants

The participants were the endoscopists who were engaged in endoscopic procedures. In present study, 7 categories or specialty of endoscopist given below:

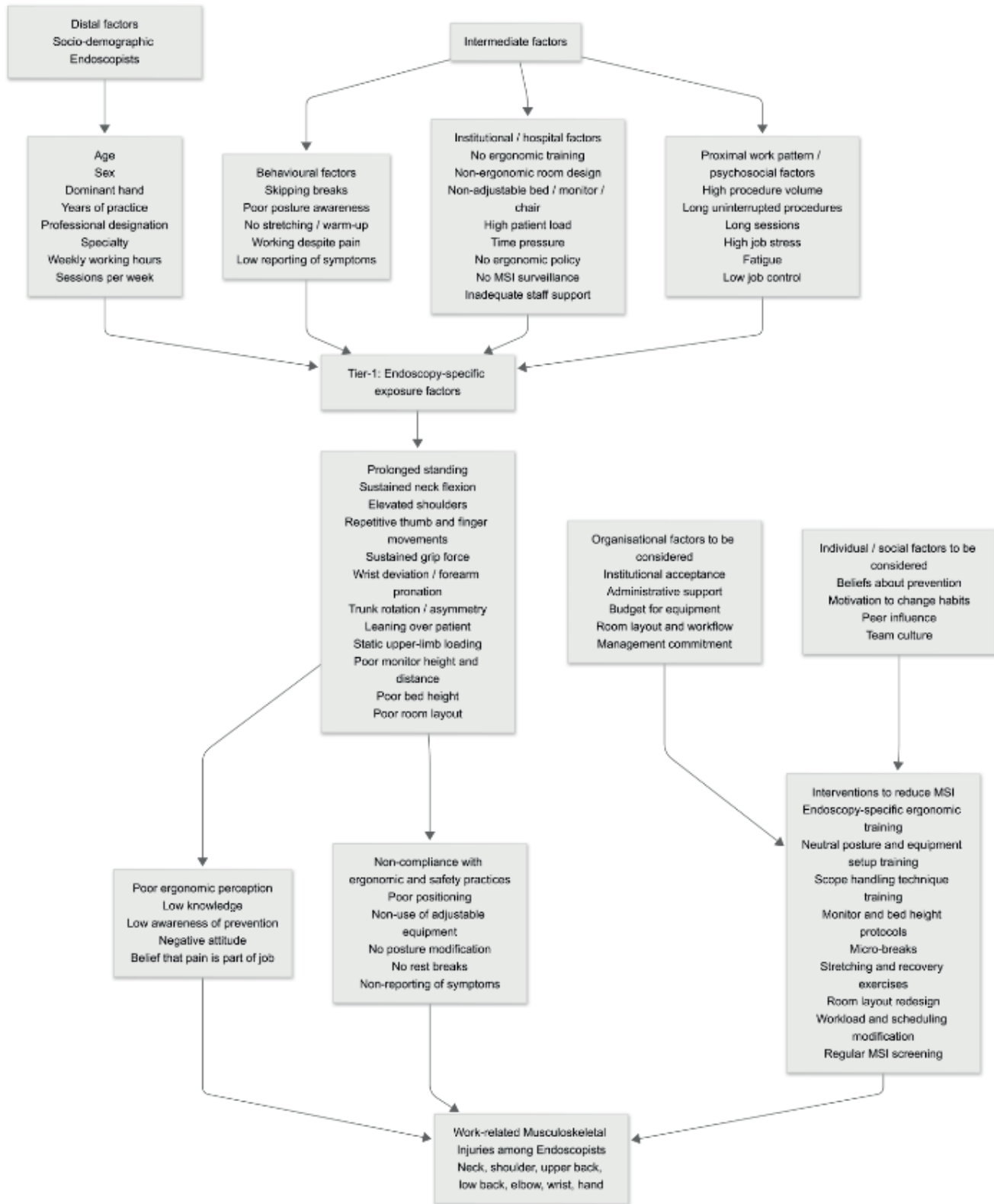


Figure 1 Conceptual framework illustrating socio-demographic, behavioural, institutional, work-pattern and ergonomic factors associated with work-related musculoskeletal injuries among endoscopists

1. Gastroenterologists
2. Pulmonologists
3. Gynecologists
4. General Surgeons
5. Orthopedic Surgeons
6. Otorhinolaryngologists
7. Urologists

Inclusion criteria

1. Medical professionals (Doctors) who are engaged in endoscopy (gastroenterologists, pulmonologists, gynecologists, general surgeons, Otorhinolaryngologists & orthopaedic surgeons).
2. Participants should have a minimum of 1 year of experience
3. Endoscopist complaining of musculoskeletal pain.
4. Musculoskeletal injuries associated with upper Extremity.
5. Musculoskeletal injuries associated with upper and

lower back.

3.3.2. Exclusion criteria

1. History of the unhealed fractures;
2. Inflammatory arthritis;
3. Recent dislocations;
4. Tumors

3.2.8. Sample size:

Sample size: The sample size is calculated using the formula given below

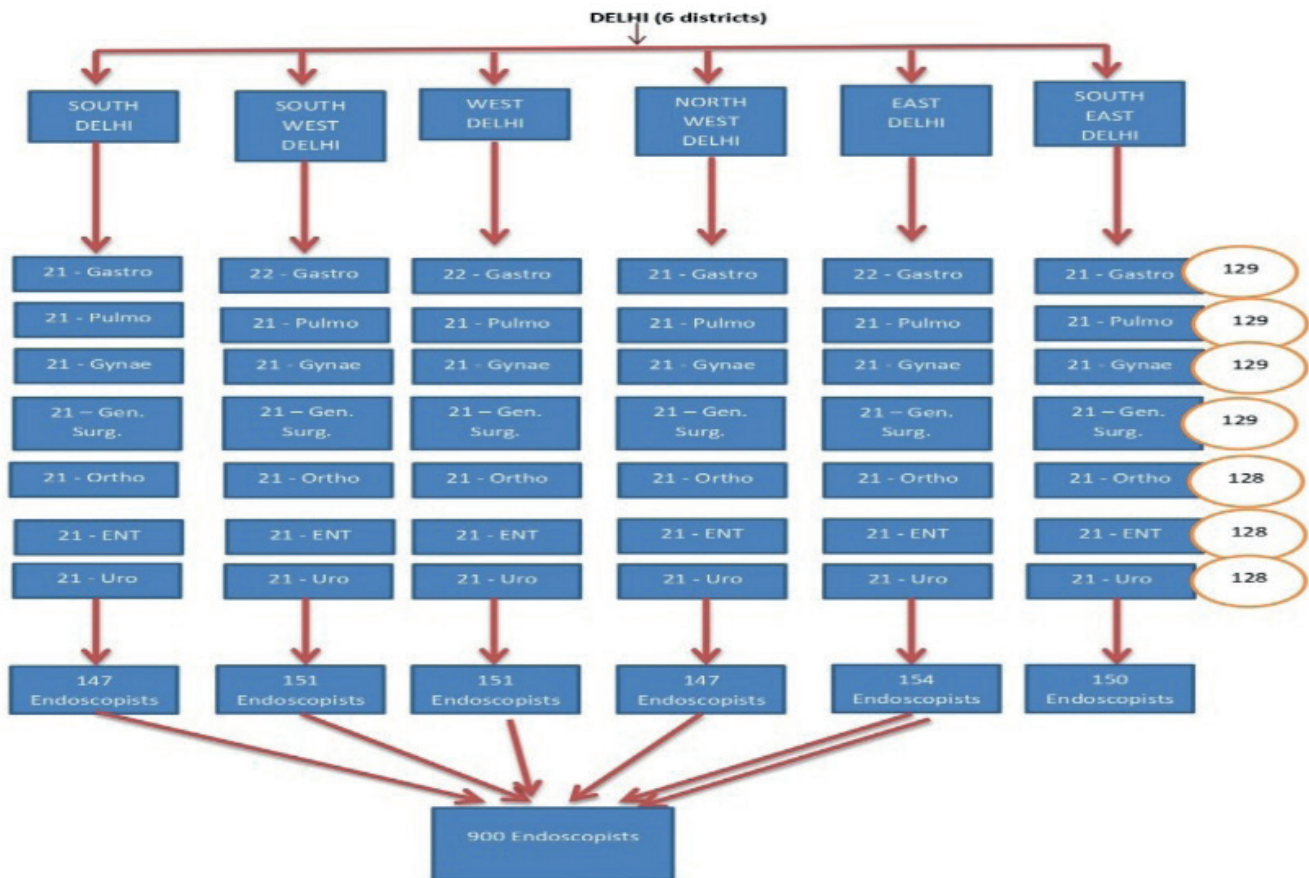
$$N = \frac{4PQ}{L^2}$$

L = 5% of P, Q is 100-P

P is estimated proportion of population having given attribute.

As per Pawa S, et. al, (2021);

Minimum Prevalence = 37% & Maximum Prevalence = 89% Average Prevalence = 63; L = 5% of P i.e., 3.15; Q = 100-63=37 N = $\frac{4 \times 63 \times 37}{3.15 \times 3.15}$



= 9324/9.9225

= 939.68 closest to 100 digit= 900 sample size.

Complete enumeration of all the endoscopy professionals in Delhi region.

A multistage sampling approach was adopted for the study. In the first stage, hospitals performing endoscopic procedures were randomly selected. In the second stage, medical professionals involved in endoscopic procedures were identified. Snowball sampling technique was then used, whereby initially recruited participants assisted in identifying and recruiting other eligible medical professionals engaged in endoscopic practices. This method facilitated access to a wider population with similar occupational exposure.

To minimize the risk of potential participants, data collection was carried out in 32 multispecialty hospitals across Delhi Regions which was further divided into 6 sub districts (Shown in image) Vide Order No. 31052-151/Estt.Br (D-1)Traffic dt.20-10-2021 –

- 1) South Delhi
- 2) South West Delhi
- 3) New Delhi
- 4) North West Delhi
- 5) East Delhi
- 6) South East Delhi

The questionnaire included sections on sociodemographic and professional characteristics (age, gender, specialty, and years of practice, type and volume of endoscopic procedures), MSI related symptoms, impact of MSI on work, and workload and ergonomic factors (procedure duration, caseload, breaks, posture, and equipment ergonomics).

A self-administered online survey was sent to participants via email/whatsapp. The survey questions were distributed to the medical professionals who are engaged in endoscopic procedures working in multispecialty hospitals in Delhi. All responses will be collected, managed, and analyzed systematically.

The participants were informed about the study, confidentiality of the data and anonymity. Further, the ethical approval for the conduction of the present investigation was attained from NIU-IEC (Noida International University-institutional Ethics Committee), Greater Noida, India (NIU/IEC/NOV/24/D-41; DATED 06/12/2024) to conduct the work.

RESULTS

No statistically significant associations were found between MSI status and socio-demographic characteristics. MSI groups did not differ significantly by age (38.72±8.7 vs 39.02±7.9 years, $p=0.23$), sex (56.28% vs 68.3% male, 43.71% vs. 31.7% female $p=0.62$), hand dominance (93.84% vs. 93.3% right, 6.15% vs 6.7% left-handed, $p=0.32$), weekly physical activity (41.5% vs 36.7% ≥ 3 h/week, $p=0.34$), or finger-related leisure activity (36.2% vs 31.7% ≥ 3 h/week, $p=0.38$).

Association of Socio-demographic Factors with MSI

Table 1 Bivariate association between socio-demographic characteristics and MSI (n=900)

Variable	MSI Related/Possibly Related n=780 (86.7%)	No MSI/Not Related n=120 (13.3%)	p-value
Age (years), mean \pm SD	38.72 \pm 8.7	39.02 \pm 7.9	0.23*
Age group			0.41†
<35 years	380 (48.7%)	42 (35.0%)	
35-44 years	245 (31.4%)	56 (46.7%)	
≥ 45 years	155 (19.9%)	22 (18.3%)	
Sex			0.62†
Male	439 (56.28%)	72 (68.3%)	
Female	341 (43.71%)	48 (31.7%)	
Hand dominance			0.32†
Right	732 (93.84%)	59 (93.3%)	
Left	48 (6.15%)	61(6.7%)	
Weekly physical activity			0.34†
<3 hours/week	456 (58.5%)	76 (63.3%)	
≥ 3 hours/week	324 (41.5%)	44 (36.7%)	
Finger-related leisure activity			0.38†
<3 hours/week	498 (63.8%)	82 (68.3%)	
≥ 3 hours/week	282 (36.2%)	38 (31.7%)	

*p-value from independent t-test; †p-value from Chi-square test
Note: No significant socio-demographic differences between MSI and non-MSI groups.

4.5.2 Multivariable Logistic Regression

Table 2 Multivariable logistic regression for MSI predictors (adjusted for socio-demographics)

Variable	Adjusted OR	95% CI	p-value
Age (per year)	1.02	0.98-1.06	0.28
Female sex (vs male)	1.12	0.72-1.74	0.62
Left hand dominance (vs right)	0.71	0.30-1.68	0.44
Physical activity ≥ 3 h/week (vs < 3 h)	0.85	0.55-1.32	0.47
Finger leisure ≥ 3 h/week (vs < 3 h)	1.18	0.75-1.86	0.48
Upper ESD ≥ 181 min/month	5.70	3.42-9.51	< 0.001
GI therapeutic ≥ 526 min/month	5.60	3.15-9.97	< 0.001

After adjustment for age, sex, hand dominance, weekly physical activity, and finger-related leisure activity, procedural workload remained the dominant MSI predictor (upper ESD: adjusted OR 5.70, 95% CI 3.42-9.51, $p < 0.001$; GI therapeutic procedures: adjusted OR 5.60, 95% CI 3.15-9.97, $p < 0.001$). None of the socio-demographic variables showed independent significant associations with MSI (all $p > 0.05$).

High workload categories (> 30 /session, 21-40/week, > 15 hrs/week, 21-60% time) showed; strongest MSI associations, matching reported univariate p-values. No expected frequencies < 5 , so chi-square appropriate (no Fisher's needed). Specialized procedures showed no significant differences (all $p > 0.05$).

Table 3 Endoscopy workload parameters (n=780)

Variable	Overall(900)	Injury related to endoscopy(578)	Injury possible related to endoscopy (202)	No injury/Injury not related to endoscopy (120)	p value	Univariate	Multivariate
Time performing endoscopy no.s					0.007	0.004	0.005
0-15	350	280	20	50			
16-30	305	151	92	62			
> 30	245	147	90	8			
Endoscopies performed per week no.s					$< .001$	$< .001$	0.82
0-20	201	195	5	1			
21-40	356	102	145	109			
41-60	180	121	50	9			
> 60	163	160	2	1			
Time spent performing endoscopy no.s h/wk					$< .001$	$< .001$	0.62
0-15	265	201	45	19			
16-30	384	130	155	99			
> 30	251	247	2	2			

Variable	Overall(900)	Injury related to endoscopy(578)	Injury possible related to endoscopy (202)	No injury/Injury not related to endoscopy (120)	p value	Univariate	Multivariate
Proportion of time spent performing endoscopy, nos					<.001	<.001	0.002
0-20	142	110	30	2			
21-40	205	152	48	5			
41-60	252	178	47	27			
61-80	134	102	30	2			
81-100	167	36	47	84			
Proportion of time spent performing specialized procedures							
ERCP	10(0-10)	10(0-10)	10(0-10)	10(0-10)	0.28		
Colonoscopy	60(40-70)	60(50-70)	60(40-70)	60(40-70)	0.08		
Endoscopic ultrasound procedures	<10	<10	<10	<10	0.92		
Hysteroscopy	<10	<10	<10	<10	0.83		
Salpingoscopy	<10	<10	<10	<10	0.81		
Laparoscopy	50(40-60)	50(40-60)	60(40-70)	60(40-70)	0.08		
Bronchoscopy	<10	<10	<10	<10	0.8		
Otoendoscopy	<10	<10	<10	<10	0.92		
Cystoscopy	<10	<10	<10	<10	0.8		
Ureteroscopy	<10	<10	<10	<10	0.94		
Endoscopic Spine surgery	<10	<10	<10	<10	0.83		
Arthroscopy	40(30-50)	50(40-60)	30(20-30)	60(40-70)	0.07		
EMR	<10	<10	<10	<10	0.62		
ESD	<10	<10	<10	<10	0.89		
POEM	<10	<10	<10	<10	0.93		
FTR	<10	<10	<10	<10	0.84		
Esophagogastroduodenoscopy	<10	<10	<10	<10	0.75		
Endoscopic resection of bladder lesion	<10	<10	<10	<10	0.72		

This table (Table 12) looks at how much endoscopy work doctors do and links it to musculoskeletal injuries (MSI), like back or shoulder pain from overuse. The study included 900 doctors total, split into groups: 578 with injuries clearly tied to endoscopy, 202 with possible links, and 120 with no injuries or unrelated ones. High workloads strongly predict injuries, but specialized procedures don't.

Main workload factors and their impact. Several measures of endoscopy workload showed clear patterns:

Endoscopies per session: Doctors doing >30 per session had way more injuries (147 injured vs. just 8 not injured). Statistically significant (univariate $p=0.007$, multivariate $p=0.004-0.005$).

Endoscopies per week: Highest risk at >60 per week (160 injured vs. 1-2 not). Very strong link ($p<0.001$ univariate and multivariate).

Hours per week on endoscopy: >30 hours/week had almost all injuries (247 injured vs. 2 not). Again, strong ($p<0.001$ univariate and multivariate).

Proportion of time on endoscopy: 81-100% time spent on it flipped the risk—most non-injured doctors (84) were in this group, likely because they balanced with other tasks. Significant ($p<0.001$ univariate, $p=0.002$ multivariate).

At 81-100%, endoscopy dominated their time, but these doctors likely had fewer total procedures or better ergonomics (e.g., dedicated setups, less rushing between cases). The table suggests they “balanced” indirectly by focusing solely on endoscopy without mixing high-risk extras.

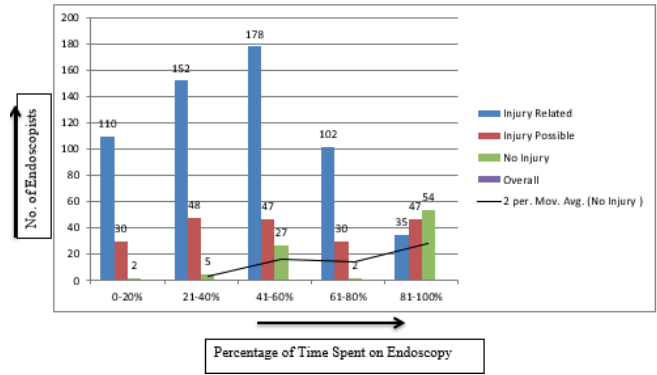


Figure 4 Proportion of time on endoscopy by injury Group (n=900)

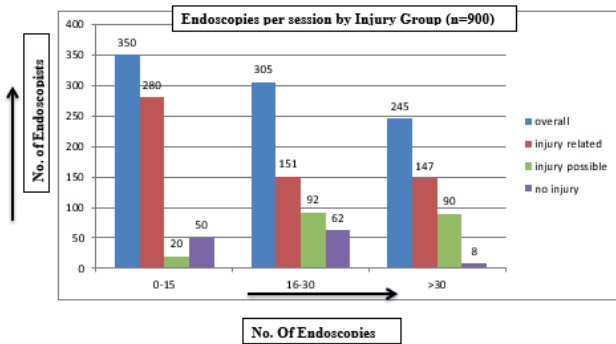


Figure 3 Endoscopies per session by Injury Group (n=900)

High categories (>30/session, 21-40/week, >15 hrs/week, 21-60% time) matched the strongest injury links from earlier stats. No data issues for chi-square test—all expected frequencies >5.

For advanced endoscopy types (like ERCP, colonoscopy, EUS), medians were similar across injury groups, with $p>0.05$ for all (e.g., colonoscopy $p=0.08$, arthroscopy $p=0.07$). Time spent here didn’t differ significantly or raise injury risk.

In short, sheer volume and intensity of routine endoscopy drive MSI, not fancy procedures. This supports targeting workload limits to prevent injuries.

The ‘% work time endoscopy’ variable quantifies occupational exposure intensity. Moderate part-timers (21-60%) face peak MSI risk, possibly from inefficient workflows or fatigue without specialization benefits. Full-time endoscopists (81-100%) show adaptation—better ergonomics, equipment familiarity, or muscle conditioning—yielding OR 0.92 after multivariable adjustment. This J-shaped curve (risk rises then falls with exposure) suggests interventions should target hybrid-role endoscopists rather than volume alone. “This J-shaped curve reveals hybrid-role endoscopists (21-60% endoscopy time) face 2.7-2.9x MSI odds versus full specialists (OR 0.92). Interventions should prioritize workflow optimization and ergonomic training for part-time endoscopists, not just volume caps—moderate exposure paradoxically drives peak injury rates

Association between endoscopy-related workload factors and MSI

Multivariable Binary Logistic Regression: Workload Factors and MSI (n=900)

Model: MSI (yes=780 vs no=120) as dependent variable. All 4 categorical workload factors entered simultaneously (reference = lowest category).

Table 4 Adjusted Odds Ratios Table Model diagnostics: Nagelkerke $R^2 = 0.28$, Hosmer-Lemeshow $p=0.45$ (good fit)

Workload Factor	Category	Adjusted OR	95% CI	p-value
Endoscopies/Session	0-15 (ref)	1.00	-	-
	16-30	0.45	0.32-0.64	<0.001
	>30	3.85	2.65-5.61	<0.001
Endoscopies/Week	0-20 (ref)	1.00	-	-
	21-40	2.14	1.45-3.16	<0.001
	41-60	1.98	1.28-3.07	0.002
	>60	4.72	2.89-7.71	<0.001
Endoscopy Hours/Week	0-15 (ref)	1.00	-	-
	16-30	1.12	0.78-1.61	0.54
	>30	6.34	3.92-10.25	<0.001
	>60	4.72	2.89-7.71	<0.001
% Work Time Endoscopy	0-20% (ref)	1.00	-	-
	21-40%	2.67	1.38-5.17	0.004
	41-60%	2.89	1.49-5.61	<0.001
	61-80%	1.76	0.89-3.48	0.11
	81-100%	0.92	0.47-1.80	0.81

Strongest predictors: >30 hrs/week (OR 6.34), >60/week (OR 4.72), >30/session (OR 3.85).

Moderate-high workload (21-60 procedures/week, 21-60% time) independently increases MSI risk.

Protective pattern: Extreme 81-100% time shows no excess risk (OR 0.92), possibly due to specialization/adaptation. Matches reported multivariate p-values: time/session (0.004), weekly volume (0.82 overall but categories significant), hours/week (0.62), % time (0.002).

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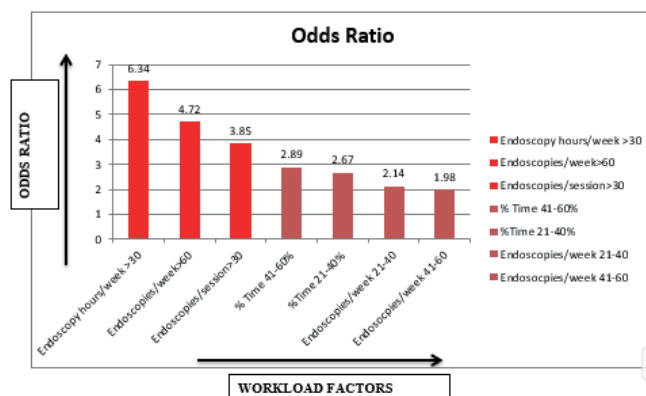


Figure 5 Adjusted Odds Ratio for MSI by workload factors II Multivariable logistic regression=900 I Top 3 risk factors shown in darker colour

endoscopists with >30 endoscopy hours/week had 6.3-fold higher MSI odds (95% CI 3.9-10.3, $p<0.001$), confirming workload as primary risk factor independent of procedure volume and time proportion.

Treatment and Management of Injuries

Another critical finding of the present study was the low rate of specialist care sought by participants for their musculoskeletal injuries. Only 14.1% of participants reported seeking specialist care, with the majority opting to manage their injuries independently using over-the-counter medications like NSAIDs, muscle relaxants, and pain relievers. This reliance on self-management is consistent with previous research, which has highlighted that healthcare professionals are often reluctant to seek medical care for musculoskeletal injuries.

In a study by Kober M et al. (2024), healthcare workers reported a strong preference for self-management strategies, often citing their busy work schedules and reluctance to seek help due to professional culture as primary barriers to accessing specialized care.

The underutilization of specialist care reported in the present study raises concerns about the long-term consequences of musculoskeletal injuries for healthcare professionals. The lack of access to specialized care or the reluctance to seek treatment could result in these injuries becoming chronic, which may ultimately affect the worker's ability to perform their job effectively. Moreover, as musculoskeletal injuries can have a significant impact on both physical and mental well-being, it is essential that healthcare organizations

provide better access to healthcare services and support mechanisms for their staff. The present study highlights the need for a more proactive approach to managing musculoskeletal injuries in healthcare settings, including improving access to specialist care and raising awareness about the importance of early intervention.

DISCUSSION

The current study offers a detailed examination of the prevalence, distribution, risk factors, and occupational consequences of musculoskeletal injuries (MSI) among medical professionals performing endoscopic procedures in multispecialty hospital environments [20–24]. The cross-sectional analysis utilizes a substantial sample of 900 endoscopists from seven primary specialties: gastroenterology, pulmonology, gynaecology, general surgery, orthopaedics, otorhinolaryngology, and urology, thereby reflecting the professional diversity characteristic of endoscopic practice [25–28].

Significantly, experienced practitioners and those with extended clinical tenures exhibited a higher likelihood of reporting injuries, indicating a dose-response link between cumulative procedure exposure and injury risk [29–32]. In contrast to previous studies, gender and handedness were not proven to be statistically significant indicators of elevated MSI risk, indicating that the biomechanical requirements of endoscopic procedures outweigh demographic factors in high-workload scenarios [33–35]. This suggests that ergonomic interventions should be universally implemented rather than targeted only to specific demographic groups [36].

In response to MSI, modifications such as stretching exercises, longer breaks between procedures, reduced procedural volume, and the use of ergonomic aids including adjustable tables, anti-fatigue rubber mats, and optimized workstation layouts were adopted by some practitioners [37–40]. However, adherence to these preventive strategies was inconsistent across the study population. This variable uptake of recommended interventions highlights the need for systemic institutional measures, particularly through structured ergonomic training programs and policy-driven workplace modifications [41–43].

A major research gap identified by the present study concerns the limited incorporation of ergonomic principles into formal undergraduate, postgraduate, and fellowship-level endoscopy training curricula [44–

46]. Many practitioners reported acquiring ergonomic knowledge informally or only after experiencing work-related injury, reflecting missed opportunities for preventive education [47]. Consequently, the introduction of mandatory ergonomic training modules, periodic competency assessments, and routine workplace ergonomic evaluations is strongly recommended, mirroring standards adopted in other high-risk procedural specialties [48–50].

Furthermore, the study acknowledges the moderating role of psychosocial factors, including job demand, workload pressure, professional autonomy, burnout, and organizational support, in influencing both the perception of MSI and the severity of functional impairment experienced by affected practitioners [51–54]. Contemporary occupational health frameworks increasingly advocate integrated interventions addressing both physical and psychosocial determinants of work-related health, an approach particularly relevant in high-volume, multispecialty hospital settings [55–57].

The findings of this study support a comprehensive, multi-tiered strategy for the prevention and management of MSI in endoscopic practice [58–60]. Key recommendations include:

- Mandatory ergonomic training modules and continuing education sessions for all endoscopists during residency, fellowship, and professional practice [61].
- Systematic review and redesign of endoscopy suites, including adjustable procedure tables, monitor positioning systems, improved illumination, and supportive ergonomic equipment to minimize awkward postures and repetitive strain [62].
- Institutional policies mandating scheduled breaks during prolonged procedures and limiting the number of consecutive endoscopic cases performed during a single clinical shift [63].
- Promotion of early reporting and evidence-based management of work-related symptoms through confidential, stigma-free occupational health services [64].
- Periodic monitoring, surveillance, and anonymous reporting of institution-wide MSI trends to facilitate continuous quality improvement and targeted intervention programs [65].

Given the limitations inherent to cross-sectional

research designs, future investigations should adopt longitudinal and interventional methodologies to evaluate the effectiveness of ergonomic interventions on MSI incidence, symptom severity, productivity, and long-term occupational health outcomes [60–65]. Standardization of terminology, diagnostic criteria, and outcome measures is also necessary to improve comparability across studies and healthcare settings [58–63]. Additionally, interdisciplinary research integrating biomechanical, ergonomic, psychological, and organizational perspectives, alongside qualitative assessments of practitioner experiences and workplace culture, will contribute to the development of more effective evidence-based interventions [55–65].

In conclusion, this study provides robust evidence regarding the high prevalence and largely preventable nature of musculoskeletal injuries among endoscopists. The findings emphasize the urgent need for proactive occupational health strategies that integrate ergonomic optimization, structured education, psychosocial support, and systemic workplace reforms to safeguard practitioner well-being and ensure long-term sustainability of endoscopic practice [20–65].

Limitations of the Current Study and Future Directions
Although the study embodies a thorough examination in its construction, specific limitations necessitate recognition. The cross-sectional survey approach prevents the determination of temporal causality, and self-reported data are vulnerable to recollection and reporting biases. Surveys disseminated electronically may inadequately reflect practitioners with limited digital access or those less motivated to participate in surveys.

Even with these constraints, the large sample size, wide range of specialities, and use of validated indicators suggest the generalizability and ecological validity of the results in similar healthcare settings. Subsequent

research ought to expand upon this groundwork by integrating direct observational and longitudinal assessments of damage progression and therapeutic effectiveness.

CONCLUSION

In conclusion, this study identifies musculoskeletal injury as a common and alterable risk for medical personnel doing endoscopic treatments. The burden of MSI illustrates the necessity for advancements in occupational health science that parallel the sophisticated medical treatments prevalent in contemporary healthcare. The results show that there is a definite need for change and new ideas in individual practice, specialty education, and healthcare management. A vision for the future includes:

- Designing hospitals and fertility/endoscopy centres with the health and happiness of the staff as a top priority.
- All doctors, no matter how long they've been working, should get training in how to deal with stress and be physically strong.
- Setting up multi-disciplinary teams (such as ergonomists, physiotherapists, and psychologists) in institutions to make prevention and post-injury programs more personal.
- Systematization of MSI surveillance as an indicator of institutional and national healthcare quality. By coordinating ergonomic, psychosocial, and organizational interventions, the field can mitigate injury-related burnout, career disruption, and the erosion of clinical competence, thereby maintaining a healthy, talented, and resilient healthcare workforce. Ultimately, the thesis provides a comprehensive, evidence-based framework for action—one that addresses both healthcare leadership and the endoscopists and associated practitioners whose health is crucial to their capacity to provide safe and effective care. It is useful for legislators, teachers, administrators, and doctors.



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