

Health and safety in digestive endoscopy personnel: a systematic review

Kechagias G¹, Riza EL¹, Damikouka IO¹, Dounias G¹

¹Post Graduate Program in Occupational & Environmental Health, Public Health Policy Department, School of Public Health, University of West Attica [Uniwa], Athens, Greece

Corresponding author:

Georgios Kechagias,
Post Graduate Program in
Occupational & Environmental Health,
Public Health Policy Department,
School of Public Health, University of
West Attica [Uniwa], Athens, Greece
E-mail: georgios.kechagias@gmail.com
Tel.: +306974906371
ORCID ID: <https://orcid.org/0000-0002-7834-2495>

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ABSTRACT

Introduction: Health professionals face various workplace risks, including infections, improper patient handling, toxic chemicals including high level disinfectants and detergents, radiation, excessive heat and noise, psychosocial hazards, violence and harassment, injuries and inadequate access to safe water and sanitation. The aim of this systematic review was to investigate the occupational health and safety risks for health professionals working in digestive endoscopy departments.

Methods: A Systematic Literature Review was performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses review method in the PubMed and Scopus databases. The inclusion criteria were used: cross-sectional studies, longitudinal studies, studies published in English, studies published in the last decade (2014-2024), and studies exclusively on endoscopic digestive tract workers.

Results: The majority of the review results showed the high prevalence (up to 70%) of musculoskeletal injuries of healthcare professionals associated by the majority of health professionals to their work. The consequences of these injuries are absences from work, needing medical treatment, undergoing physical therapy or surgery. Other occupational hazards included infections and exposure to radiation during procedures with fluoroscopy.

Conclusion: Undoubtedly, healthcare professionals working in endoscopic digestive departments are at high risk for occupational injuries and infections. Education of health professionals, at undergraduate level and throughout their professional life, the adoption and implementation of international guidelines and recommendations, while providing appropriate protective equipment, will improve the safety of health professionals and significantly reduce the impact on their health and the functioning of health services.

Keywords: Endoscopy, health, risk, safety, worker

Introduction

Enhancing health care coverage and ensuring that residents, especially patients, can achieve the highest possible levels of health depends on the availability, accessibility, acceptability, and quality of these services. The World Health Organization (WHO) predicts a shortage of 10 million health professionals by 2030, mainly in

low- and lower-middle-income countries. Nevertheless, nations at all levels of socioeconomic progress face challenges, to varying degrees, in training, employing, developing, retaining, and optimizing their workforce.

Healthcare workers include people engaged in activities aimed at improving health, such as doctors, nurses, midwives, public health experts, laboratory technicians, both medical and non-medical technicians, personal care assistants, community health workers, therapists, and traditional medicine practitioners. The term includes health management and support staff, including cleaners, drivers, hospital administrators, regional health directors, social workers, and other occupational categories engaged in health-related activities, as described by the International Standard Classification of Occupations (ISCO-08). Health professionals are the foundation of any functioning health system. While facilitating the enjoyment of the right to health for all, health professionals must also have the right to healthy and safe working conditions to maintain their own well-being.¹

Occupational health is a field of public health that aims to promote and maintain the optimal physical, mental, and social well-being of workers in all occupations.² Its objectives are:

- Maintaining and enhancing the health and capacity of workers to perform their occupational tasks.
- Improving working conditions and the environment to promote safety and health.
- To foster an organizational and work culture that embodies the core values of the enterprise, incorporating effective management systems, personnel policies, participatory principles, and voluntary quality management practices to promote occupational safety and health.

Occupational health encompasses various disciplines, such as occupational medicine, nursing, ergonomics, psychology, hygiene, safety, and others. The World Health Assembly urges countries to develop national policies and action plans and build institutional capacity in occupational health, expand coverage with key interventions for the prevention and control of occupational diseases and work-related injuries

and occupational health services, ensure collaboration with other relevant national health programs, such as those related to communicable and noncommunicable diseases, injury prevention, health promotion, mental health, environmental health, and health systems development.²

Healthcare professionals face a variety of risks in the workplace, including infections, improper handling of patients, toxic chemicals, radiation, excessive heat and noise, psychosocial risks, violence and harassment, injuries, and inadequate access to safe water and sanitation.³⁻⁸ WHO estimates indicate that over 54% of health workers in low- and middle-income countries have latent tuberculosis, a prevalence 25 times higher than that of the general population.

In clinical settings in Africa, between 44% and 83% of nurses experience chronic back pain, compared to 18% of office workers. Globally, 63% of healthcare professionals report having experienced some form of violence in the workplace. Throughout the COVID-19 pandemic, 23% of frontline healthcare workers worldwide have experienced despair and anxiety, while 39% have experienced insomnia. In addition, healthcare workers face an increased risk of suicide worldwide. Hazardous working conditions leading to occupational diseases, injuries, and absenteeism impose a significant economic burden on the healthcare sector, estimated at up to 2% of health expenditure. To date, only 26 of the 195 WHO member states have implemented policy tools and national programs to monitor the occupational health and safety of healthcare professionals in the healthcare sector.¹

The work at an endoscopy department reflects all these realities and presents a variety of hazards to the staff. Indeed, there is a constant flow of patients, including patients with obesity and/or trauma that need to be moved and possibly retained in various positions resulting in potential musculoskeletal strains and injuries. Endoscopes to ensure patient safety have to be reprocessed using detergents and high-level disinfectants

(HLD) that constitute a chemical hazard. Both in- and outpatients are potentially infectious as carriers or microbial, fungal or viral diseases. The nature of endoscopic procedures exposes workers through direct contact, splashes, droplets or percutaneous injuries from sharps to biologic material that may include blood, mucous, feces and provides a source of potential exposure to a variety of infective agents including viruses of hepatitis B and C, HIV and SARS-CoV-2. Exposure to radiation used during procedures with fluoroscopy such as ERCP (Endoscopic Retrograde Cholangiopancreatography) is another concern as well as the repetitive nature of endoscopic procedures, usually under a heavy workload and expectations of high productivity. The latter in combination with the potential complications of endoscopy define a high stakes clinical environment that may act as psychosocial stressors that could impact workers accordingly. Overall, work in the endoscopy department is a complex environment that entails exposure to multiple hazards. We herein aim to systematically review current research regarding occupational health and safety risks for health professionals working in digestive endoscopy departments.

Methods

The purpose of this systematic review was to investigate occupational health and safety risks for healthcare professionals working in gastrointestinal endoscopy departments. The research questions answered in this study were:

Results

A total of 15 studies were identified from the systematic literature review.¹¹⁻²⁵ Figure 1 shows the phases of the systematic review process, and

- What occupational health and safety risks do healthcare professionals working in gastrointestinal endoscopy departments experience?

A systematic literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) review method^{9,10} was conducted in the databases of the US National Library of Medicine of the National Institutes of Health and Scopus. The following inclusion criteria were used:

- Cross-sectional studies, longitudinal studies
- Studies published in English
- Studies published in the last decade (2014-2024)
- Studies exclusively on employees in endoscopic departments for the digestive system and not on healthcare professionals outside these departments.

The following keywords were used to conduct the systematic review: care, chemical, digestive, endoscopy, handling, hazard, health, infection, occupational, patient, psychological, professional, radiation, risk, safety, violence, and worker. For a more effective search and retrieval of all relevant articles, all possible combinations of keywords were entered into the Pubmed database using the advanced search service.

Table 1 (supplementary material) summarizes the data and findings of the articles included in the systematic review.

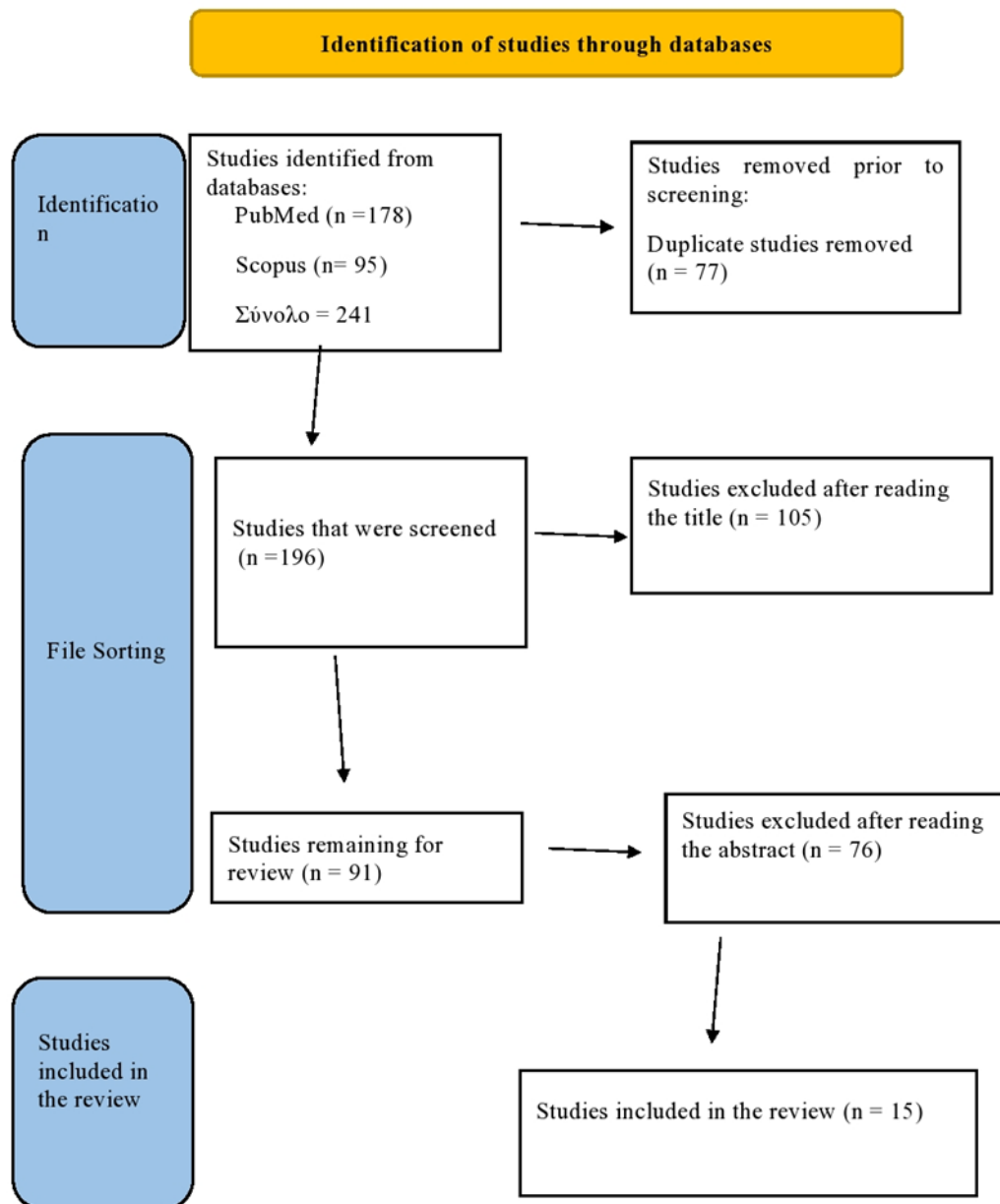


Figure 1: Flow diagram showing phases of the systematic review process

Discussion

This systematic review highlighted the significant occupational risks faced by healthcare professionals working in endoscopic digestive departments. The majority of studies highlighted musculoskeletal injuries as the main risk factors for the health of healthcare professionals. The prevalence of musculoskeletal injuries reached up to 75% of healthcare professionals. The main musculoskeletal injuries included pain in the neck, shoulders, back, and fingers. As a result of these musculoskeletal injuries and disorders, healthcare professionals were forced to take time off work and limit their social activities.

Treatment required medication and physical therapy, while some required surgery. Musculoskeletal injuries are a highly prevalent phenomenon among healthcare workers in general. In 2013, the Occupational Safety and Health Administration (OSHA) of the United States Department of Labor published a report on the safety of hospital staff.

The data show that, while injury and absence rates among hospital workers have been steadily declining since 1993, the period from 2000 to 2011 reveals that these rates in the hospital sector are

the highest among all occupational sectors.²⁶ According to the same report, healthcare workers have more days of absence from work due to injuries than workers in other sectors. These absences have consequences for the provision of health services and also reduce employee productivity.

Work-related musculoskeletal injuries represent a heterogeneous group of clinical conditions affecting the musculoskeletal system, which occur due to exposure to various risk factors in the workplace, and are the predominant injury among healthcare workers due to the physical demands of their work, such as patient handling or pushing and pulling tasks. The most commonly affected areas of the body are the lower back, neck and shoulders, and hands/wrists. When managing these disorders, not only the direct costs (insurance, compensation, medical and administrative expenses) but also the indirect costs, such as periods of sick leave, the recruitment and training of new employees during periods of absence, reduced productivity levels and the impact on production and quality of work, while some authors argue that direct costs represent a small proportion of the global economic burden of musculoskeletal injuries in the workplace. A recent national report from Portugal stated that in 2013, 5,161,343 working days were lost due to occupational accidents and that 21.2% of these incidents resulted in a period of absence exceeding 30 days. The prevalence of musculoskeletal injuries reported in a systematic review ranged from 28% to 96% over a one-year period. The lower back was the most commonly affected part of the body.²⁷

Similar findings were reported in an analysis of data on injuries to healthcare professionals in the US for the period 2012-2014.²⁸ Overall, for the 112 healthcare facilities that participated in the data analysis, rates of patient handling injuries and workplace violence were highest among nursing assistants and nurses. In contrast, physicians, dentists, residents, and fellows have low injury rates. Other studies have found that

musculoskeletal disorders are increasing among healthcare personnel. Healthcare professionals are exposed to various risk factors for musculoskeletal disorders: 1) caring for overweight/obese and acute patients, 2) high patient-to-nurse ratios, 3) long shifts, 4) current efforts to mobilize patients almost immediately after medical interventions, and 5) high workload.²⁹⁻³²

An important finding of this review is the low percentage (only 20%) of employees in endoscopy departments who have received training in ergonomics. A study has shown that in the US, medical students receive very limited training in ergonomics.^{33,34} A significant number of studies have shown the positive effect of ergonomic training programs on the prevention of musculoskeletal injuries in all healthcare professionals.³⁵⁻⁴⁰ These programs could be incorporated either into the undergraduate curriculum of healthcare professionals or into continuing professional development through educational activities that can be organized by the healthcare services where healthcare professionals work.

With regard to the exposure of healthcare professionals to infections, this systematic review showed that all indoor aerosols during medical procedures in an endoscopy unit are significant sources of aerosol production. In the context of SARS-Cov-2, the results of this study clearly show that there is a possibility of virus transmission in an endoscopy unit during medical procedures. This can occur through direct contact due to close interaction with patients or through respiratory aerosols and through contact with contaminated surfaces, equipment, accessories, and body fluids with the virus, which can remain viable for a longer period of time, thus putting uninfected patients and endoscopy staff at risk. Healthcare professionals during the COVID-19 pandemic have emerged as a vulnerable group with an increased risk of exposure, infection, severe illness, and mortality. A significant number of healthcare professionals lost their lives after

becoming seriously ill with COVID-19. The World Health Organization estimated that between 80,000 and 180,000 health and care workers may have died from COVID-19 between January 2020 and May 2021, converging on a median scenario of 115,500 deaths.⁴¹ The International Council of Nurses estimates the number of health professionals who lost their lives to COVID-19 at 115,000.⁴² Another study in this review found that face masks (FFP2 or FFP3) and negative pressure rooms were not available in 10.9% and 75.1% of health services.

Training courses on the use of PPE were provided in only 57.2% of centers. Doctors (2.9%), nurses (3.5%), and other healthcare professionals (3.5%) were diagnosed with COVID-19. Participation in a COVID-19 care team (OR: 4.96) and lack of training courses on PPE (OR: 2.65) were associated with an increased risk of COVID-19 infection.¹⁶ Guidelines and recommendations have been issued for the protection of healthcare professionals in

endoscopy departments in order to prevent infection among healthcare professionals.^{43,44}

Conclusion

Undoubtedly, healthcare professionals working in endoscopic digestive departments are at high risk of occupational injuries and infections. The training of healthcare professionals, at undergraduate level and throughout their professional life, the adoption and implementation of international guidelines and recommendations, and the provision of appropriate protective equipment will improve the safety of healthcare professionals and significantly reduce the impact on their health and the functioning of healthcare services.

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References

1. World Health Organization. Occupational health: health workers. 2022. Available from: <https://www.who.int/news-room/fact-sheets/detail/occupational-health--health-workers>
2. World Health Organization. Occupational health. 2024. Available from: <https://www.who.int/health-topics/occupational-health>
3. Adamopoulos IP, Syrou NF. Workplace safety and occupational health job risks hazards in public health sector in Greece. *Eur J Environ Public Health*. 2022;6(2):em0118. Available from: <https://doi.org/10.21601/EJEPH/12229>
4. Franklin P, Gkiouleka A. A scoping review of psychosocial risks to health workers during the COVID-19 pandemic. *Int J Environ Res Public Health*. 2021;18(5):2453. Available from: <https://doi.org/10.3390/ijerph18052453>
5. Haagsma JA, Tariq L, Heederik DJ, Havelaar AH. Infectious disease risks associated with occupational exposure: a systematic review of the literature. *Occup Environ Med*. 2012;69(2):140–6. Available from: <https://doi.org/10.1136/OEMED-2011-100068>
6. McDiarmid MA. Hazards of the health care sector: looking beyond infectious disease. *Ann Glob Health*. 2014;80(4):315–9. Available from: <https://doi.org/10.1016/j.AOGH.2014.08.001>
7. Mossburg S, Agore A, Nkimbeng M, Comodore-Mensah Y. Occupational hazards among healthcare workers in Africa: a systematic review. *Ann Glob Health*. 2019;85(1). Available from: <https://doi.org/10.5334/AOGH.2434>
8. Tipayamongkholgul M, Luksamijarulkul P, Mawn B, Kongtip P, Woskie S. Occupational hazards in the Thai healthcare sector. *New Solut*. 2016;26(1):83–102. Available from: <https://doi.org/10.1177/1048291116633871>
9. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the

- PRISMA statement. PLoS Med. 2009;6(7):e1000097. Available from: <https://doi.org/10.1371/journal.pmed.1000097>
10. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. Available from: <https://doi.org/10.1136/bmj.n71>
11. Al-Rifaie A, Gariballa M, Ghodeif A, Hodge S, Thoufeeq M, Donnelly M. Colonoscopy-related injury among colonoscopists: an international survey. *Endosc Int Open*. 2021;9(1):E102–9. Available from: <https://doi.org/10.1055/A-1311-0561>
12. Austin K, Schoenberger H, Sesto M, Gaumnitz E, Teo Broman A, Saha S. Musculoskeletal injuries are commonly reported among gastroenterology trainees: results of a national survey. *Dig Dis Sci*. 2019;64(6):1439–47. Available from: <https://doi.org/10.1007/S10620-019-5463-7>
13. Han S, Hammad HT, Wagh MS. High prevalence of musculoskeletal symptoms and injuries in third space endoscopists: an international multicenter survey. *Endosc Int Open*. 2020;8(10):E1481–6. Available from: <https://doi.org/10.1055/A-1236-3379>
14. Ikezawa K, Hayashi S, Takenaka M, Yakushijin T, Nagaike K, Takada R et al. Occupational radiation exposure to the lens of the eyes and its protection during endoscopic retrograde cholangiopancreatography. *Sci Rep*. 2023;13(1):1–8. Available from: <https://doi.org/10.1038/s41598-023-34740-5>
15. Matsuzaki I, Ebara T, Tsunemi M, Hatta Y, Yamamoto K, Baba A et al. Effects of endoscopy-related procedure time on musculoskeletal disorders in Japanese endoscopists: a cross-sectional study. *Endosc Int Open*. 2021;9(5):E674–83. Available from: <https://doi.org/10.1055/A-1352-3850>
16. Mariani A, Capurso G, Marasco G, Bertani H, Crinò SF, Magarotto A, et al. Factors associated with risk of COVID-19 contagion for endoscopy healthcare workers: a survey from the Italian Society of Digestive Endoscopy. *Dig Liver Dis*. 2021;53(5):534–9. Available from: <https://doi.org/10.1016/J.DLD.2021.03.014>
17. Musunuri B, Bhat G, Shetty A, Shetty S, Pai GC. Prevalence of work-related musculoskeletal disorders and its determinants among endoscopists in India. *Indian J Gastroenterol*. 2024;43:1062–4. Available from: <https://doi.org/10.1007/S12664-024-01625-Y>
18. Pereira ML, Bergamo RT, da Silva FM, Matte DL, Tribess A, Vilain R. Risks of infection associated with aerosol generation during medical procedures in an endoscopy unit. *J Hazard Mater Adv*. 2022;8:100174. Available from: <https://doi.org/10.1016/J.HAZADV.2022.100174>
19. Ridditid W, Côté GA, Leung W, Buschbacher R, Lynch S, Fogel EL, et al. Prevalence and risk factors for musculoskeletal injuries related to endoscopy. *Gastrointest Endosc*. 2015;81(2):294–302.e4. Available from: <https://doi.org/10.1016/J.GIE.2014.06.036>
20. Ruan W, Walsh CM, Pawa S, D'Souza SL, Banerjee P, Kothari S et al. Musculoskeletal injury and ergonomics in pediatric gastrointestinal endoscopic practice. *Surg Endosc*. 2023;37(1):248–54. Available from: <https://doi.org/10.1007/S00464-022-09455-9>
21. Moraes R, Vilas-Boas F, Pereira P, Lopes P, Simões C, Dantas E et al. Prevalence, risk factors and global impact of musculoskeletal injuries among endoscopists: a nationwide European study. *Endosc Int Open*. 2020;8(4):E470–80. Available from: <https://doi.org/10.1055/A-1038-4343>
22. Seo D, Kim KH, Kim JS, Han S, Park K, Kim J. Evaluation of radiation doses in patient and medical staff during endoscopic retrograde cholangiopancreatography procedures. *Radiat Prot Dosimetry*. 2016;168(4):516–22. Available from: <https://doi.org/10.1093/RPD/NCV373>
23. Shah SZ, Rehman ST, Khan A, Hussain MM, Ali M, Sarwar S et al. Ergonomics of gastrointestinal endoscopies: musculoskeletal injury among endoscopy physicians, nurses, and technicians. *World J Gastrointest Endosc*. 2022;14(3):142.

- Available from: <https://doi.org/10.4253/WJGE.V14.I3.142>
24. Sturm N, Leukert J, Perkhofer L, Hann A, Wagner M, Mayer B et al. The impact of endoscopic activity on musculoskeletal disorders of high-volume endoscopists in Germany. *Sci Rep*. 2022;12(1):1–12. Available from: <https://doi.org/10.1038/s41598-022-12400-4>
25. Du-Toit T, Buchel O, Smit S. *Helicobacter pylori* as an occupational hazard in the endoscopy room. *S Afr J Surg*. 2015;53(4):23–5. Available from: <https://www.ajol.info/index.php/sajs/article/view/129885>
26. Occupational Safety and Health Administration (US). Worker safety in hospitals. 2022. Available from: <https://www.osha.gov/hospitals>
27. Anderson SP, Oakman J. Allied health professionals and work-related musculoskeletal disorders: a systematic review. *Saf Health Work*. 2016;7(4):259–67. Available from: <https://doi.org/10.1016/j.SHAW.2016.04.001>
28. Centers for Disease Control and Prevention (US). Occupational traumatic injuries among workers in health care facilities—United States, 2012–2014. *MMWR Morb Mortal Wkly Rep*. 2015;64(15):405–10. Available from: <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6415a2.htm>
29. Mossburg S, Agore A, Nkimbeng M, Commodore-Mensah Y. Occupational hazards among healthcare workers in Africa: a systematic review. *Ann Glob Health*. 2019;85(1). Available from: <https://doi.org/10.5334/AOGH.2434>
30. Ofori E, Ramai D, John F, Reddy M, Ghevariya V. Occupation-associated health hazards for the gastroenterologist/endoscopist. *Ann Gastroenterol*. 2018;31(4):448. Available from: <https://doi.org/10.20524/AOG.2018.0265>
31. Rai R, El-Zaemey S, Dorji N, Rai BD, Fritschi L. Exposure to occupational hazards among health care workers in low- and middle-income countries: a scoping review. *Int J Environ Res Public Health*. 2021;18(5):2603. Available from: <https://doi.org/10.3390/IJERPH18052603>
32. Reichard AA, Marsh SM, Tonozzi TR, Konda S, Gormley MA. Occupational injuries and exposures among emergency medical services workers. *Prehosp Emerg Care*. 2017;21(4):420–31. Available from: <https://doi.org/10.1080/10903127.2016.1274350>
33. Epstein S, Tran BN, Capone AC, Ruan QZ, Fukudome EY, Ricci JA, et al. The current state of surgical ergonomics education in U.S. surgical training: a survey study. *Ann Surg*. 2019;269(4):778–84. Available from: <https://doi.org/10.1097/SLA.0000000000002592>
34. Pierce SM, Heiman AJ, Ricci JA. Evaluating the current state of ergonomics education offered to students in US medical students. *Am Surg*. 2022;89(5):1798–806. Available from: <https://doi.org/10.1177/00031348211063555>
35. Abdollahi T, Razi SP, Pahlevan D, Yekaninejad MS, Amaniyan S, Sieloff CL, et al. Effect of an ergonomics educational program on musculoskeletal disorders in nursing staff working in the operating room: a quasi-randomized controlled clinical trial. *Int J Environ Res Public Health*. 2020;17(19):7333. Available from: <https://doi.org/10.3390/ijerph17197333>
36. Albanesi B, Piredda M, Bravi M, Bressi F, Gualandi R, Marchetti A et al. Interventions to prevent and reduce work-related musculoskeletal injuries and pain among healthcare professionals: a systematic review. *J Saf Res*. 2022;82:124–43. Available from: <https://doi.org/10.1016/j.ISR.2022.05.004>
37. Alexopoulos EC, Burdorf A, Kalokerinou AA comparative analysis on musculoskeletal disorders between Greek and Dutch nursing personnel. *Int Arch Occup Environ Health*. 2006;79(1):82–8. Available from: <https://doi.org/10.1007/S00420-005-0033-Z>
38. Argudo E, Grehan J, Leidy L, Park JSA, Patterson M, Sanghavi S, et al. Development and evaluation of an online ergonomics educational program for healthcare professionals. In: *SIEDS* 2019. Available from: <https://doi.org/10.1109/SIEDS.2019.8735601>

39. Lietz J, Ulusoy N, Nienhaus A. Prevention of musculoskeletal diseases among dental professionals through ergonomic interventions: a systematic review. *Int J Environ Res Public Health*. 2020;17(10):3482. Available from: <https://doi.org/10.3390/IJERPH17103482>
40. Mao X, Jia P, Zhang L, Zhao P, Chen Y, Zhang M. Effects of human factors and ergonomics on health care and patient safety practices: a systematic review. *PLoS One*. 2015;10(6):e0129948. Available from: <https://doi.org/10.1371/JOURNAL.PONE.0129948>
41. World Health Organization. Health and care worker deaths during COVID-19. 2021. Available from: <https://www.who.int/news/item/20-10-2021-health-and-care-worker-deaths-during-covid-19>
42. International Council of Nurses. ICN says 115,000 healthcare worker deaths from COVID-19 exposes collective failure of leaders to protect global workforce. 2021. Available from: <https://www.icn.ch/news/icn-says-115000-healthcare-worker-deaths-covid-19-exposes-collective-failure-leaders-protect>
43. Zhang S, Wu X, Pan H, Wu D, Xu T, Shen N, et al. Gastrointestinal endoscopy infection control strategy during COVID-19 pandemic: experience from a tertiary medical center in China. *Dig Endosc*. 2021;33(4):577–86. Available from: <https://doi.org/10.1111/DEN.13783>
44. Zhang Y, Zhang X, Liu L, Wang H, Zhao Q. Suggestions for infection prevention and control in digestive endoscopy during COVID-19 outbreak. *Endoscopy*. 2020;52(4):312–4. Available from: <https://doi.org/10.1055/a-1128-4313>

Supplementary material

Table 1: data and findings of the articles included in the systematic review.

Country/ Research ers/ Year	Populati on	Results	Conclusions
Southern Europe T du Toit, O C Buchel, S J A Smit 2015	92 endosco py health professio nals	Thirty-two (55%) in the control group tested H. pylori(+). Twenty participants (59%) in the combined endoscopy groups (34 in total) tested H. pylori (+). The seropositive rate was higher in those who underwent endoscopy more frequently in the endoscopy groups. No findings were statistically significant.	Not confirmed that endoscopy was a risk factor for H. pylori infection in the endoscopy groups.
USA Ridititid et al., 2015	684 endosco pists	362 (53%) experienced musculoskeletal injury that was considered definitely (n=204) or probably (n=158) related to endoscopy. Factors associated with a higher rate of endoscopy-related injuries included a higher volume of procedures (>20 cases/week, $p < 0.001$), greater number of hours of weekly endoscopy (>16 hours/week, $p < 0.001$), and total number of years of endoscopy experience ($p = 0.004$). Most common sites of injury were the neck and/or upper back (29%) and the thumb (28%). Only 55% of injured endoscopists used practice modifications in response to their injuries. Specific treatments for injuries included medication (57%), steroid injection (27%), physical therapy (45%), rest (34%), splints (23%), and surgery (13%).	High prevalence of injuries among endoscopists. Higher procedure volume, more endoscopy time per week, and cumulative years of endoscopy experience are associated with more work-related injuries.
Korea Seo et al., 2016	126 ERCP	Studied endoscopic staff who had assisted in 80 consecutive therapeutic endoscopic retrograde cholangiopancreatography (ERCP) procedures. The use of radiation protective curtains placed in the radiology room was randomly determined for each procedure, and radiation doses were measured with electronic pocket dosimeters placed outside the protective apron. When protective curtains were not used, the average radiation doses to endoscopists, first assistants, second assistants, and nurses were 340.9, 27.5, 45.3, and 33.1 μSv , respectively, and the doses were reduced to 42.6, 4.2, 13.1, and 10.6 μSv , respectively, when protective curtains were used ($p < 0.01$). When the patient had to be restrained during ERCP ($n = 8$), the radiation dose to second assistants without protective curtains increased by 9.95 times ($p < 0.01$) compared to cases where restraint was not required.	During ERCP, not only endoscopists but also assistants and nurses were exposed to high doses of radiation. Radiation exposure of staff members during ERCP was reduced by the use of protective curtains.

Great Britain, Al-Rifaie et al., 2017	368 colonoscopy endoscopists	The most common areas of musculoskeletal injury were the lower back (n = 85, 36.5%), the neck (n = 82, 35.2%), and the left thumb (n = 79, 33.9%). Of the endoscopists who experienced musculoskeletal injury, 98 (30.7%) made some modification to their practice, such as stretching exercises and ergonomic changes. Of the endoscopists, 134 (42.0%) considered repetitive strain on the extremities to be a possible causative mechanism. Approximately 40% believed that twisting and awkward body positions were predisposing factors for musculoskeletal injury. Participants used various treatment methods for musculoskeletal injuries, including: physiotherapy (n = 109), medication (n = 70), rest (n = 43), splints (n = 31), steroid injections (n = 26), and surgery (n = 11).	In conclusion, we would say that a significant percentage of colonoscopists experience musculoskeletal injuries. The majority of the proposed modifications to practice can be adopted by any endoscopist. The findings of this study underscore the need to recognize musculoskeletal injuries as a significant occupational health risk for endoscopists.
USA Austin et al., 2019	165 gastroenterologists	Twenty percent reported having suffered a musculoskeletal injury. Female gender was the only factor associated with a higher rate of reported injury ($p < 0.01$). The most common injuries reported were thumb and other hand-related pain (n = 28 [64%]).	Musculoskeletal injuries can affect up to 20% of gastroenterologists. Female colleagues report injuries more frequently and may be at particularly high risk, which has not been found in previous research reports on gastroenterologists.
Portugal Morais et al., 2020	171 endoscopists	The prevalence of at least one musculoskeletal injury related to endoscopy was 69.6% (n=119), with neck pain (30.4%) and thumb pain (29.2%) being the most common. The median time to develop a musculoskeletal injury was 6 years (range 2 months-30 years). Severe pain was reported by 19.3%. A change in endoscopic technique was made by 61.3% and a reduction in endoscopic workload was made by 22.7%. Work loss was reported by 10.1%, with a median time away from work of 30 days (range 1-90). Female gender and ≥ 15 years in practice were independently associated with musculoskeletal and severe pain. Years in practice, weekly endoscopy time, and gender were significant predictors of the number of musculoskeletal injuries.	The prevalence of musculoskeletal injuries was significant among Portuguese endoscopists and had a significant impact on their regular endoscopy and professional activities.

USA Samuel Han, Hazem T. Hammad, Mihir S. Wagh 2020	45 endoscopists	Thirty-one (69%) endoscopists reported current musculoskeletal injuries, with 71% (n = 22/31) believing that these began after starting third-space endoscopy, and 48.9% (22/45) reported more symptoms after third-space endoscopy compared to endoscopic ultrasound/endoscopic retrograde cholangiopancreatography. Common musculoskeletal injuries included the shoulders (42.2%), back (37.8%), neck (33.3%), and wrist (24.4%). With regard to the lower extremities and injuries, these were reported to be most common in the feet (11.1%). A minority experienced disability (2.2%), a change in endoscopy scheduling (6.7%), or surgery (2.2%). Only 15.6% of endoscopists had previously received ergonomic training. Logistic regression did not reveal any significant predictors of musculoskeletal injuries.	More than two-thirds of endoscopists performing third-space endoscopy suffer from musculoskeletal injuries, with many reporting the onset of symptoms after beginning third-space endoscopy.
Italy Mariani et al., 2021	314 health professionals at endoscopy centers	The results of the study showed that personal protective equipment (PPE) was available in most centers, but face masks (FFP2 or FFP3) and negative pressure rooms were not available in 10.9% and 75.1% of centers, respectively. Training courses on the use of PPE were provided in only 57.2% of centers. Doctors (2.9%), nurses (3.5%), and other healthcare professionals (3.5%) were diagnosed with COVID-19. Participation in a COVID-19 care team (OR: 4.96) and lack of training courses on PPE (OR: 2.65) were associated with an increased risk of COVID-19 infection.	The risk of COVID-19 infection among endoscopy department workers was not negligible and was associated with working in a COVID-19 care team and a lack of training on the proper use of PPE.
Japan Matsuzaki et al., 2021	110 endoscopists	The most common sites of musculoskeletal injuries were the neck, waist, and shoulders. Logistic regression analyses showed that greater endoscopic submucosal clearance (odds ratio: 5.7; 95% CI: 1.3-25.0), the lowest endoscopic submucosal clearance (odds ratio 4.9; 95% CI: 1.1-22.0), and the lowest gastrointestinal treatment (odds ratio: 5.6; 95% CI: 2.3-13.3) were significantly associated with the development of musculoskeletal injuries in the lumbar region. In addition, longer duration of endoscopic submucosal dissection (odds ratio: 5.0; 95% CI: 1.2-20.2) was a risk factor for left shoulder symptoms.	This study suggests a correlation between the volume of therapeutic endoscopic procedures, including endoscopic submucosal dissections, and the risk of musculoskeletal injuries, mainly in the lumbar region and left shoulder.

Brazil Luiz Pereira et al., 2022		During these procedures, increases in the mean aerosol concentration ($< 5 \mu\text{m}$) relative to the reference concentration for colonoscopy, upper endoscopy, bronchoscopy, and bidirectional endoscopy procedures were 12, 72, and 39%, respectively. These results showed that, depending on the type of activity performed within the room, the aerosol concentration differed significantly from the reference concentration. The results also showed that aerosol-generating events during medical procedures in an endoscopy unit fall into two categories: events that generate and disperse aerosols mechanically, and events that cause the patient to produce aerosols. In the context of SARS-CoV-2, the stability characteristics of the virus and its modes of transmission make all sources analyzed high risk for COVID-19 transmission.	This study reveals that all indoor aerosols during medical procedures in an endoscopy unit are significant sources of aerosol production. Aerosol generation significantly alters the concentration and distribution of indoor aerosols, with a potential risk of infection for healthcare professionals. In the context of SARS-Cov-2, the results of this study clearly show that there is a possibility of virus transmission in an endoscopy unit during medical procedures. This can occur through direct contact due to close interaction with patients or through respiratory aerosols and through contact with contaminated surfaces, equipment, accessories, and body fluids with the virus, which may remain viable for a longer period of time, thus putting uninfected patients and endoscopy staff at risk.
Germany Sturm et al., 2022	151 endoscopists	The survey showed that most participants suffered from general musculoskeletal disorders (82.8%) and work-related musculoskeletal disorders (76.8%). The most affected parts of the body were the neck, lower back, thumb, and shoulder. Temporary absence from work due to symptoms was reported by 9.9% of respondents. Over 30% of endoscope participants reported the need for analgesics or physiotherapy due to musculoskeletal disorders. Age, professional experience, and working hours were identified as relevant risk factors for musculoskeletal health problems.	A large number of German endoscopists suffer from musculoskeletal disorders due to specific working postures and repetitive movements, which have a significant impact on their personal health.
Pakistan Zainab Shah et al., 2022	56 endoscopists and support staff	Pain and numbness were reported by 75% of participants, with pain in the neck (41.1%), lower back pain (32.1%), shoulder pain (21.4%), thumb pain (12.5%), hand pain (23.2%), elbow pain (8.9%), and carpal tunnel syndrome (7.1%). Of these, 33.3% attributed their symptoms to endoscopy, 14.2% stated that the symptoms were not caused by endoscopy, and 52.4% were unsure whether endoscopy caused their symptoms. 21.4% of endoscopists needed to take time off work, while 33.9% took medication for pain. Ergonomic modifications to prevent musculoskeletal injuries, including placing the endoscopic monitor at eye level and the monitor in front, interrupting the procedure to move patients, the seat during colonoscopy, and the use of a height-adjustable bed were used by 21.4%.	Three-quarters of endoscopists reported musculoskeletal injuries, of which more than half were unsure or attributed the problem to endoscopy.

USA Ruan et al., 2023	146 pediatric gastroenterologists and trainees	Overall, 55.6% (n = 80/144) reported experiencing a musculoskeletal injury, with 34.7% (n = 50/144) reporting an injury attributable to endoscopy. Among those with musculoskeletal injuries, the most common sites were the neck/upper back (44.0%), thumb (42.0%), hand/finger (38.0%), and lower back (36.0%). Women were more likely to experience musculoskeletal injury than men (43.4% vs. 23.4%, p=0.013). Only 20.9% of participants had formal training in ergonomics.	In conclusion, pediatric endoscopists, especially women, experience significant musculoskeletal injuries, while training in ergonomics in endoscopy is rare. Improved ergonomics training is needed for both practicing pediatric gastroenterologists and trainees.
Japan Ikezawa et al., 2023	Data from 631 ERCPs in healthcare professionals	A strong correlation was found between the eye dosimeter measurements and the radiation exposure of patients. The shielding percentages of lead glasses were 44.6%, 66.3%, and 51.7% for operators, assistants, and nurses, respectively.	This prospective study revealed the actual radiation exposure to the lens of the eye of staff during ERCP, the positive and strong correlations between occupational radiation exposure of the eye lens and patient radiation exposure values, and the effectiveness of lead glasses in reducing radiation exposure to the eye lens. Although the systematic use of eye dosimeters for accurate measurement is recommended, patient radiation exposure values can help estimate staff eye lens radiation exposure due to their strong correlation.
India Musunuri et al., 2024	148 gastroenterologists and endoscopists	The annual prevalence and point prevalence of work-related musculoskeletal injuries were 85.1% (n = 126) and 60.1% (n = 89), respectively, and nearly 45.3% (n = 67) of respondents were forced to limit their professional or personal work, such as endoscopy, housework, or hobbies, due to the occurrence of musculoskeletal injuries in the previous year. The most frequently involved sites of musculoskeletal injuries were the shoulder (27.7%), neck (25.6%), and lower back (22.9%), followed by those of the hands. The thumbs (23.6%) are the most common site involved in the hands, followed by the wrists (20.9%), fingers (17.5%), and elbows (16.2%). Among individuals who experienced musculoskeletal injuries, nearly 31.4% (n=28) had symptoms for more than a year and 40.4% (n = 36) had symptoms lasting from one month to one year, while the rest had symptoms lasting less than a month. Almost 25.8% (n = 23) had continuous bothersome symptoms, while the rest (74.2%, n = 66) had intermittent symptoms. In 28% (n = 25) of cases, the symptoms were mainly during work, while 42.7% (n = 38) had symptoms after working hours.	A high prevalence of musculoskeletal injuries was recorded, with significant impacts on the professional and social lives of participants.