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The EFORT White Book
"Orthopaedics and Traumatology in Europe"

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Foreword President EFORT

On behalf of our entire Board it is a great honour for me to introduce the EFORT White Book "Orthopaedics and Traumatology in Europe" as a landmark publication for the future management of musculoskeletal disorders in Europe.

Degenerative and inflammatory joint disorders, osteoporosis and fragility fractures, musculoskeletal infections and tumours, injuries and many other related problems are affecting our population significantly. The main goal of EFORT is, to promote the exchange of scientific knowledge and experience in the field of prevention and both the conservative and surgical treatment of these disorders. To implement this goal, it is necessary not only to assess the current position and identify relevant gaps, but also to develop a perspective of musculoskeletal health challenges that lie ahead of us. Therefore, our Board has decided to introduce this White Book as a comprehensive reference on current conditions and future needs, which can be used to facilitate decision making in our scientific societies as well as in European health politics. We also intend this initiative to contribute to the United Nations "Decade of Healthy Ageing" (2021-2030).

This first edition shall summarize the best available data to quantify the burden of musculoskeletal disorders, as well as the currently available infrastructure for its management. In addition, we asked the contributors to provide an overview on musculoskeletal education and the landscape of orthopaedic and trauma research. To master future challenges it is not only necessary to devote appropriate resources during daily clinical care, but also to ensure sufficient training of future health care providers and to select the most effective therapeutic strategies.

The EFORT Board highly appreciates the efforts of all contributing authors and is especially grateful to our past Presidents Jan Verhaar and Per Kjaersgaard-Andersen, who served as scientific editors. Despite the pandemic and resulting restrictions during which this work was undertaken they all have worked with great enthusiasm, emphasis and professionalism on this project. I am convinced, that this concerted effort adds significant value to the care of our patients with musculoskeletal problems.

October 2021

Klaus-Peter Günther
EFORT President 2020/2021
Dresden, Germany

Foreword Editors

A few years ago, the Board of the EFORT, the European Federation of Orthopaedics and Traumatology, initiated a project aiming to inform European decision and policy makers. The injuries and musculoskeletal diseases that orthopaedic and trauma surgeons treat every day will continue to increase enormously in the coming years. The drivers of that increase include ageing of the population, obesity and decreasing activity levels. The outcome of treatments administered has a significantly positive influence on the quality of life. However, until the Covid-19 Pandemic, key opinion leaders and indeed many in the population had not realised the many impacts of limited activity levels - not being able to go to your work or not being able to travel.

During the last two years medical resources have been focussed on Covid Care and other urgent medical care. In all countries the waiting times for orthopaedic care have increased. This has further increased the burden of musculoskeletal diseases such as osteoarthritis on society.

To improve knowledge of musculoskeletal conditions this White Book has been produced. Its overall aim is to provide information that will inform strategies to reduce the burden of musculoskeletal disorders and trauma on society. The breadth of conditions treated by Trauma and Orthopaedic Surgeons are considered. The authors conclude that to offset the burden of MSK-disease society needs:

- Better prevention programmes (lifestyle)
- Good access to care with limited waiting times to get the right care
- Improved efficiency of healthcare
- Improving outcomes and thereby quality of life
- Improving cost effectiveness
- Better information for the patient about the expected outcome of treatment
- Increase of treatment capacity
- High quality research

The Editors would like to thank the contributors to this White Book October 2021.

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Executive Summary

The Burden of Musculoskeletal Disorders in Europe

The musculoskeletal system comprises the bones and joints between them, and the muscles that act on the joints to produce the movement that allows us to care for ourselves and others, work and enjoy recreation. It is subject to a wide range of disease processes and these are common: nearly 150 million Europeans, or 30% of the population, experienced a musculoskeletal disorder in 2019. The burden of musculoskeletal disease is huge and is growing. Over the age of 65, more than half the population is affected, as the joints are prone to 'wear and tear' with ageing, causing osteoarthritis (OA) and spinal pain. Classically in Europe, the more rare diseases caused by inflammatory joint disease are managed by Rheumatologists, often with advanced new drugs. The much larger burden of degenerative joint diseases are treated surgically and non-surgically by Orthopaedic and Trauma Surgeons, who also repair traumatic damage to the musculoskeletal system.

Of the musculoskeletal diseases, an ageing population means that degenerative problems are most common. In 2019 again, more than 66 million Europeans had persistent back pain and another 21 million reported neck pain. Back pain is the main reason why patients access rehabilitation services. 40 million were affected by OA of the knee, 21 million by OA of the hand, 6.7 million by hip OA and 8 million by OA in other joints such as the shoulder, elbow and ankle. The impact is variable between individuals, but 80% of people with OA have limitation of movement and 25% are unable to perform their activities of daily living. The management of OA often includes joint replacement, which is highly successful but not without its own consequences. The development of periprosthetic infection is fortunately rare, but when it does occur the mortality is higher than that of the 5 most common cancers. Inflammatory arthritis, often caused by malfunctioning of the immune system, is managed medically by Rheumatologists, though some patients develop problems that need surgical intervention. 2 million Europeans have Rheumatoid Arthritis.

Overall, musculoskeletal diseases are the leading cause of disability and restricted function in Europe as expressed by 'Years lived with disease (YLD)', accounting for 20% of all YLD currently. However degenerative arthritis is only one cause. In the five largest European countries osteoporosis affects 21% of women and 6% of men between the age of 50 and 94 (more than 20 million citizens). Osteoporosis is the underlying cause of fragility fractures (low energy fractures which can occur spontaneously or after simple slips and trips), which are increasingly prevalent as the population becomes proportionately older. Currently there are 2.5 million new fragility fractures every year including 0.5 million hip fractures in Europe. Patients, both men and women, suffering a fragility fracture have at least double the risk of death. All consume orthopaedic services, many needing surgery.

Trauma is also a huge economic burden in the younger population: major trauma due to road traffic accidents is the leading cause of disability in adults under 40. It is also the leading cause of disability and death in adolescents and children. 21000 children aged 5-14 suffer death due to trauma every year, 36% of these being road traffic related. Fractures are much more frequent but, surprisingly, there is no reliable data on their overall incidence in Europe. However, 13% of those who suffer a fracture may lose their employment as a consequence.

Musculoskeletal conditions are the most prominent work-related health problem in the EU, three out of every 5 workers reporting such.

As cancer treatment improves, more patients are surviving with metastases, which commonly affect the skeleton. 7-15% of patients with the 5 most common cancers (including lung, breast, prostate and bowel) develop bone metastases that require orthopaedic consultation.

In addressing this enormous burden the response of each country is different and the distribution of MSK health professionals, resources and rates of surgery vary widely. In 2016 the number of orthopaedic surgeons per country varied from 5-12 per 100000. The rate at which knee replacement was carried out in 2016 ranged from 20-250 per 100000 population per year and hip replacement (including hip replacement for fractures) from 30-310.

Proposed action points

EFORT calls for immediate action to manage the tidal wave of MSK disease that is impending, in order to improve the outlook for patients and ensure sustainable healthcare. The present workforce will be inadequate and suboptimal care of MSK disorders is highly detrimental to European finances. In its White Book on Trauma and Orthopaedic services in Europe, EFORT starkly outlines the present situation and identifies key activities that are needed to mitigate the impact of the increasing burden of MSK disorders on healthcare systems and the economy. These are:

- **Improved collaboration** between healthcare professionals, healthcare management, payers, politicians and patients. Initially this should increase awareness of the burden of MSK disease and its consequences on individuals, families, employers, economies and countries. This should lead to a jointly engineered action plan.
- Adopt effective **prevention strategies** to reduce the avoidable components of this burden including
    - Injury prevention in all age groups
    - Osteoporosis and fragility fractures
    - Low back pain
    - Obesity, tobacco and alcohol consumption (which are all modifiable risk factors for surgical procedures)
- Ensure that **'the right patient reaches the right hospital at the right time'** through
    - European-wide guidelines for the treatment of MSK diseases and trauma
    - Implementation of regional trauma networks
    - Referral networks for rare diseases including primary bone cancers, ensuring these are managed in appropriate multidisciplinary units
    - Centralisation of the management of bone and joint infections, including infected arthroplasty.
- Create and financially support (as this will be cost-effective) **large centralised data collections** in the form, for example, of **registries** to allow future management to be based on reliable and valid outcome data. A first step would be the creation of arthroplasty, trauma, fragility fracture, spinal and tumour registries in every EU member state.

- Use **patient reported outcome measures** (PROM's) where appropriate in the evaluation of healthcare interventions, including the treatment of MSK disorders and trauma.
- Recognise the Europe-wide need to address **patient safety** by using open analysis systems to evaluate any potentially adverse outcomes of treatment.
- Reduce the **large regional variations** in the distribution of healthcare personnel, resources and treatments in Europe through
    - Evidence based clinical practice guidelines for the management of high-volume procedures
    - Channelling of funding specifically to analyse and identify best practice on the European continent
- Recognise the economic impact of MSK disorders by addressing the chronic underfunding of **MSK research**. This is needed at all stages, from preclinical to the clinical and post-market evaluation of management strategies to
    - Assess the efficiency and cost effectiveness of surgical treatment and non-surgical alternatives
    - Develop innovative solutions for the management of MSK diseases and injuries
    - Facilitate networks of collaborative research among O&T departments, universities and private laboratories with integrated funding
- Establish European standards of **MSK education** including
    - Appropriate prominence of MSK education in Undergraduate curricula for medical students, raising awareness appropriate to the prevalence of these disorders
    - Evolution and implementation of the Core Curriculum for training in Trauma and Orthopaedic Surgery to ensure those achieving European Certification have reached the same standards and are competent in both surgical and nonsurgical management of MSK disorders.
    - Development of training standards applying to those entering specialisation beyond certification level.
    - Integrate forms of assessment at all stages of training that can be recognised and implemented in all countries.
- Vigilance and removal of **discrimination**, exclusion and restriction that may be intentional or unintentional on the grounds of protected characteristics such as gender, race etc. The reasons that the workforce is currently not representative of the population it serves are doubtless complex, but steps are needed to ensure there are equal opportunities in selection, progression and reward.

Section 1

The Burden

Section 1
The Burden

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1. Summary

Musculoskeletal conditions (MSC) are the main causes of chronic pain, disability and loss of quality of life in Europe and the world. Every one in three Europeans reports a MSC, totalling 150 Million sufferers. The main complaints are back pain, joint diseases and osteoporosis. There is a clear increase in prevalence with increasing age. MSC are the main cause of Years Lived with Disability (YLD) in Europe. MSC are also the most prevalent work-related health problems in the EU, three out of every five workers reporting MSC problems. Musculoskeletal (MSK) problems consume a large quantity of healthcare resources in both the inpatient and outpatient sectors. About every third patient in a GP clinic is there with MSK problems. In hospitals, MSC (9% of all cases) and injuries (8%) together form by far the largest group of conditions treated. About every third surgical operation is performed for MSC or injuries. Direct costs for MSC and injuries represent together the largest cost segment in health care. In addition, these disorders lead to very significant loss of productivity and social expense in the working population, equivalent in some countries to 1-2% of GDP. The ageing of societies will further increase these problems in Europe, as well as in less developed countries. Urgent activities must be initiated to address this burden by appropriate prevention, treatment and rehabilitation

2. Introduction

Musculoskeletal diseases, defined as diseases which affect the locomotor system including the muscles, bones, joints, tendons and ligaments, are having a growing impact worldwide. This impact is measurable using Disability-Adjusted Life Years (DALYs), which combine the Years Lived with Disability (YLDs) and the Years of Life Lost (YLLs) through premature death. Previous studies have pointed to high prevalence and high disability linked to selected MSK diseases. However, compared with other major healthcare issues, such as cardiovascular disease and cancers, MSK disorders have been assigned lower importance because of low case fatality and the irreversibility of many of the conditions concerned (Sebbag et al. 2019, Jin et al. 2020).

Musculoskeletal Disorders (MSD) lead to pain, functional disability and work incapacity, but also often to psychological problems, an increased risk of all-cause mortality and to the development of chronic diseases. The burden of MSD is extremely high not only in Europe, but globally. MSD rank as the fifth most common cause of DALYs and the commonest in terms of YLD, accounting for 5.6% of the total DALYs and 15.9% of the total YLD respectively in 2017. Along with the rise in life expectancy and population growth we are witnessing, a bigger increase in the burden of MSD is expected.

Globally, in 2017, the incidence of MSD increased by 58% from 211.80 million in 1990 to 334.74 million in 2017. Females (180.77 million) had a relatively higher case incidence than males (153.97 million in 2017). The incidence of cases increased across all regions in 1990–2017, with the biggest increases observed in the regions with the worst Social Deprivation Index (Jin et al. 2020).

There have been some Burden of Disease calculations done based on the 2017 dataset for specific MSDs on global, regional and national levels, for back pain (Wu et al. 2020), neck pain (Safiri et al. 2020a), osteoarthritis (Safiri et al. 2020b), rheumatoid arthritis (Safari et al. 2019), gout (Safiri et al. 2020c) and other musculoskeletal disorders (Safiri et al. 2021).

3. Population in Europe

The demographic reality presents a relevant challenge for healthcare systems, policy makers and general society, who have to deal with a progressive increase in the prevalence and impact of chronic conditions and comorbidities. Today, the proportion of the population aged 50 and older is higher in Europe (about 38%) than in any region in the world. This proportion is higher still when considering Northern and Western Europe only and is continuing to rise rapidly. Since the prevalence of chronic pain and physical disability increase with age, MSCs may pose a particularly significant challenge for population health in Europe (Eurostat 2020). After Japan, the 27 EU states (EU-27) had the next highest share of older people among the G20 nations (20.3 % in 2019) (Figure 1).

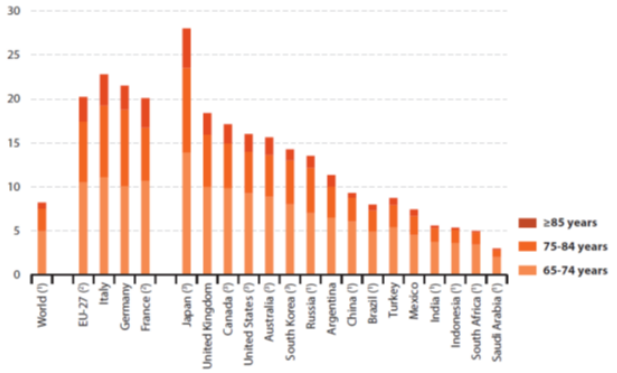


Figure 1. People aged ≥65 years, by age class, 2019 (% share of total population).

Source: Eurostat Ageing Europe — looking at the lives of older people in the EU — 2020 edition, p. 25

United Nations Statistics Division (Demographic Statistics Database) and United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019. Accessed September 2021.

In 2018, a woman aged 65 years living in the EU-27 could expect to live a further 21.6 years, while the corresponding figure for a man aged 65 years was lower, at 18.1 years. Women outnumber men at older ages within the EU-27 population: in 2019, there were more than twice as many very old women (aged 85 years or more) as very old men.

Eurostat population data estimate that the population of people over 65 years old in Europe will increase from 17.3% in 2010 to 29.4% in 2050. The EU-27 population will increase significantly, rising from 90.5 million at the start of 2019 to reach 129.8 million by 2050 (Figure 2).

It is projected that there will be close to half a million centenarians in the EU-27 by 2050 (Eurostat 2020).

4. Burden of Disease

Disease burden is the impact of a health problem as measured by financial cost, mortality, morbidity, or other indicators. It is often quantified in terms of Quality-Adjusted Life Years (QALYs) or DALYs. Both of these metrics quantify the YLD. The overall disease burden can be thought of as a measure of the gap between current health status and the ideal health status (which theoretically exists when the individual lives to old age free from disease and disability).

The World Health Organization (WHO) has provided a set of detailed guidelines for measuring disease burden at the local or national level. Having conducted its overview for the first time in 1990, it now quantifies the health effects of more than 350 diseases

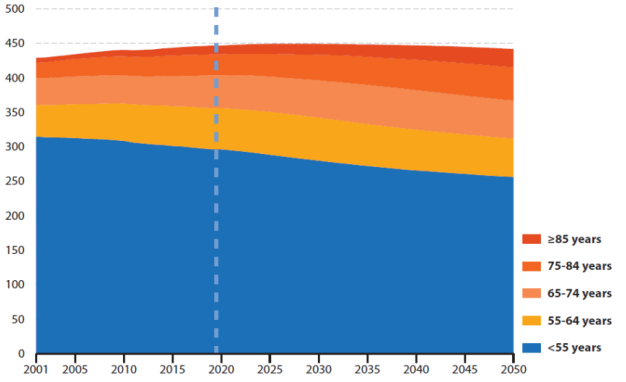


Figure 2. Population predictions, by age class, EU-27, 2001-2050 (million inhabitants).

Source: Eurostat Ageing Europe – looking at the lives of older people in the EU – 2020 edition, p. 25. Available from https://ec.europa.eu/eurostat/de/web/products-statistical-books/-/ks-02-20-655. Accessed September 2021.

and injuries in 195 countries for eight regions of the world, giving estimates of morbidity and mortality by age, sex, and region.

The calculations are generated from more than 80,000 different data sources used by researchers to produce the most scientifically rigorous estimates possible. However, not all data are available for all countries. Therefore, some estimates from the 'Global Burden of Disease' study are extrapolated from data of countries with similar population criteria and may differ from national statistics due to differences in data sources and methodology.

Unlike other leading non-communicable diseases (cardiovascular, cancer, diabetes, chronic respiratory disorders) MSD very seldom lead directly to death. Therefore, YLL and DALYS are of limited utility when analysing the Global Burden of Musculoskeletal Disorders. YLDs more appropriately reflect the burden, as physical disability and pain are the main MSK problems.

The WHO-defined region of Europe extends to the far eastern border of Russia. In the Burden of Disease Database this region is further divided into Western, Central and Eastern Europe. Western Europe also includes, beside the western countries of the European Union (EU), Turkey, but excludes some of the EU members on the Balkan coast. For the purposes of specific analysis in this chapter we have focussed on the countries of the EU in 2019 (including the United Kingdom) (Figure 3).

Figure 3. European Union

Source: BBC News

There has been extensive analysis of the global burden of disease 2017 for MSK problems in general (Sebbag et al. 2019) and the major MSK conditions on the global, regional and national levels (Jin et al. 2020, Safiri et al. 2019, Safiri et al. 2020a, Safiri et al. 2020b, Safiri et al. 2021), but unfortunately only for the WHO and IHME regions. We have now analysed the GBD 2019 data for the European Union and its participating countries, as well as for the WHO and IHME region.

5. Incidence and Prevalence

MSDs are very frequent in the European Union. Nearly 150 Million Europeans had a MSC in 2019, which is around 30% of the European population. This burden was spread quite evenly over all countries, with Denmark and Portugal reporting the highest rates at 34.6% and Norway the lowest at 28.2%. (Figure 4)

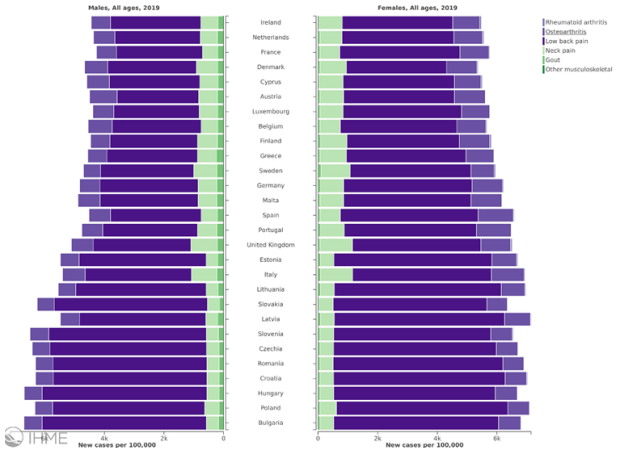


Figure 4. Prevalence of musculoskeletal disorders in the EU in new cases per 100.000 by country and sex 2019.

Source: Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2020. Available from https://vizhub.healthdata.org/gbd-compare/. http://ihmeuw.org/5hcx. Accessed September 2021.

There has been a significant increase, by 30%, between 1990 and 2019 from 114.3 to 148.3 million Europeans affected by MSD. This effect was not simply the result of an increase in the population, since the rate also increased from 23,900 to 28,800/100,000.

Significant differences exist between the sexes and between different age groups: 62 million men and 86 million women are affected (prevalence 26.6% and 33.9% respectively). The prevalence increases with age. While there are only few people below the age of 35 years with MSD (rate 13%), there are 75 million people between 35 and 65 years affected (rate 32%) and 57 million above 65 years (rate 55%) (Figure 5).

The incidence of MSC in the European Union was 29.6 M per year, the incidence rate 6 per 100.

Condition-specific estimates

In 2019 more than 66 million Europeans had persistent low back pain; another 21 million had neck pain. Over 63 million sought treatment for osteoarthritis (OA). 2 million people had rheumatoid arthritis (RA), 5 million people had gout and another 24.5 million other MSDs. More than 40 million were affected by osteoarthritis of the knee, 21 million by OA of the hand, 6.7 million by hip OA and nearly 8 million by OA in other regions. There was a 50% increase in prevalence over the last 30 years; the annual incidence was 4.8 million.

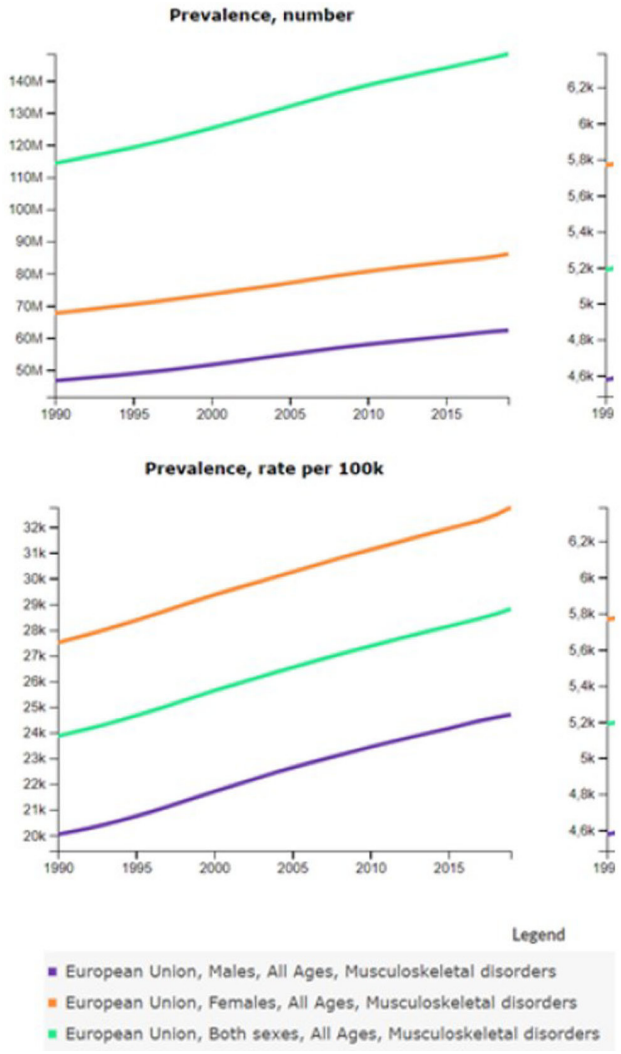


Figure 5. Prevalence of musculosketelal disorders in the EU 1990 – 2019 by number and rate per 100.000.

Source: Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2020. Available from https://vizhub.healthdata.org/gbd-compare/. http://ihmeuw.org/5hcx. Accessed September 2021.

The risk of developing OA increases with age. A third of women and almost a quarter of men between 45 and 64 have sought treatment for OA; this rises to almost half of all people aged 75 and over. The prevalence of OA is generally higher in women than men. The difference is most apparent for hand and knee OA and among people over 50 years of age. Women accounted for roughly 60% of hip and knee replacement operations in England, Wales and Northern Ireland in 2017 - over 90% of which were carried out for OA according to the National Joint Registry (NJR).

Rheumatoid arthritis affects adults of any age. The prevalence increases with age, with the peak age of onset between 40–60 years and prevalence highest at 70 years and over. Around three quarters of people with rheumatoid arthritis are of working age when they are first diagnosed (National Audit Office (NAO) - Rheumatoid arthritis is two to three times more common among women than men (NAO).

Gout is generally three to four times more common in men than women. Men can develop gout as early as their mid–20's, though it becomes more common in women after the menopause. Around 1% of Europeans have gout, which is equivalent to around 5.1 million people. In certain areas the prevalence is much higher (2.49% in the UK). Between 1990 and 2019, the prevalence increased significantly by 63%.

Low back pain is one of the most common disorders in Europe; the prevalence is 13.6 % (highest in Portugal at 15.4%, lowest in Spain with 10.6%). It affects people in all age groups, but there are more women (60%) affected than men.

Neck pain is also frequent, 3.7% of all men and 5.1% of all women suffer from neck pain, the predominant age band affected being between 40 and 60 years.

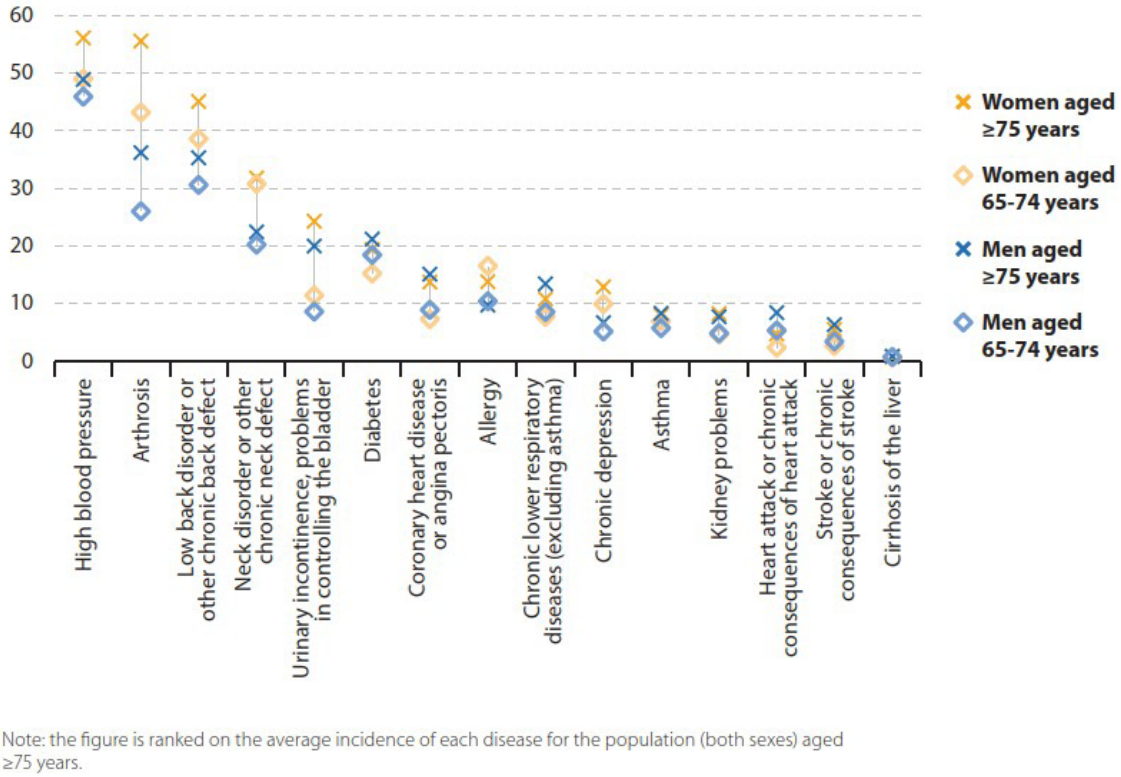
Osteoporosis affects around 21% of women and 6% of men between the ages of 50 and 84, accounting for more than 20 million individuals in the five largest European countries. Globally, as many as one in two women and one in five men over 50 will experience a fragility fracture in their lifetime.

The burden of fragility fractures varies across Europe, with much higher rates in northern European countries compared to countries in the south, such as Spain and Portugal (Hernlund et al. 2013). Fragility fractures are associated with increased risks of death and disability, and with more frequent hospital admission. There are about 2.5 million such new fractures in the five largest EU countries including 500,000 hip fractures (Borgström et al. 2020). These fractures have been found to be associated with at least a doubling of the risk of death for both men and women (Katsoulis et al. 2017). In 2010, 43,000 deaths in the EU were causally related to fractures (Kanis et al. 2013).

Figure 6 shows some of the most common chronic diseases affecting older people in the EU27. In 2014, more than half (53.3 %) of all people aged 75 years or more during the 12 months preceding the survey suffered from high blood pressure and 47.9% from osteoarthritis. This was closely followed by two further musculoskeletal diagnoses affecting relatively high proportions of people in this age group: 41.2% suffered from back problems and 31% from neck pain. It was a common observation that a higher proportion of women (rather than men) in the EU27 and aged 75 years or more suffered from chronic disease. This was particularly notable for osteoarthritis, back and neck problems (EUROSTAT).

Country specific data

In the UK, in 2016, MSK conditions accounted for more than 22.1% of the total burden of morbidity in England, with low back and neck pain being the leading causes of morbidity. This is consistent with analysis of indicators from the General Practice Patient Survey, which suggested that the proportion of people reporting at least one long-term MSK condition was 17% in 2017/18. The percentage of people reporting long-term MSK conditions significantly increased with age; 2.8% of 18 to 24 year olds reported having an MSK condition compared to 43.7% of those aged 85 years and over. Women reported a significantly higher prevalence of MSK conditions than men (19% compared with 14.9%). Although prevalent across all areas of society, people in the poorest communities have a 60% higher prevalence of long-term conditions than those in the richest. A higher percentage of people in the most deprived decile areas report a long-term MSK condition compared to the least deprived decile areas (Versus Arthritis 2019). In Germany, based on data from the population-based German National Cohort, frequencies of musculoskeletal symptoms and diseases are recorded, including back pain, osteoporosis, osteoarthritis and arthritis. Having ever



Note: the figure is ranked on the average incidence of each disease for the population (both sexes) aged ≥75 years.

Figure 6. Self-reported chronic diseases, by sex and age class EU 27, 2014.

Source: Eurostat Ageing Europe – looking at the lives of older people in the EU – 2020 edition, p. 80. Available from https://ec.europa.eu/eurostat/de/web/products-statistical-books/-/ks-02-20-655. Accessed September 2021.

been diagnosed with recurrent back pain (22.5%) or osteoarthritis (20.6%) were the most common complaints reported in the interview; osteoporosis (2.9%) and rheumatoid arthritis (1.9%) were more seldom reported. According to the hand examination, 6.0% of all participants experienced pain in at least one finger joint. Resting pain was present in at least one knee among 8.2% and in at least one hip among 5.1% of the participants, as assessed during the clinical examination. Women were more likely to report musculoskeletal disorders and symptoms than men. The proportion of adults affected by musculoskeletal diseases increased significantly with age (Schmidt et al. 2020).

6. Pain

Musculoskeletal pain is a serious and common problem in Europe. It limits mobility in older people, culminating in more rapid cognitive decline, sarcopenia (loss of muscle mass with associated weakness), frailty and loss of independence (Table 1).

Data from the European Social Survey of 2014 reported high prevalence rates of MSD across European countries. At a pan-European level, back and neck pain was the most prevalent with 40% of survey participants experiencing such pain, then hand and arm pain at 22%, followed by foot and leg pain at 21%. There was considerable cross-national variation in pain across European counties, as well as significant socioeconomic inequalities in the prevalence of pain, with social gradients or socioeconomic gaps evident for both men and women. Socioeconomic inequality was most pronounced for hand and arm pain and least pronounced for back and neck pain. The magnitude of socioeconomic pain inequalities differed between countries, but they were generally higher for women (Todd et al. 2019) (Figure 7 and 8).

Table 1. Prevalence of Pain in 19 European countries

Source: Todd et al. European Journal of Pain 2019; 23(8):1425-36.

		Back/neck (%)	Hand/arm (%)	Foot/leg (%)
Europe (pooled)		40.00	22.34	21.09
North	Denmark	48.87	26.72	24.96
	Finland	53.77	31.67	25.16
	Norway	43.08	26.58	26.65
	Sweden	47.56	25.02	26.87
West	Austria	34.25	15.85	15.26
	Belgium	51.76	26.88	26.50
	Switzerland	40.68	22.63	19.19
	Germany	54.05	25.28	22.20
	France	51.84	26.32	30.91
	Ireland	22.64	13.32	11.02
	Netherlands	41.39	21.18	20.89
	UK	38.98	27.42	23.44
Central/Eastern	Poland	34.99	22.17	24.57
	Slovenia	42.85	20.25	20.72
	Lithuania	26.67	13.00	10.54
	Czech	26.07	13.08	11.65
	Hungary	16.08	14.16	12.60
South	Spain	40.96	25.92	26.31
	Portugal	47.56	30.10	31.84

Note: Prevalence´s were weighted using EES post-stratification weights and adjusted to the standard European population in accordance with the European Standard population (ESP) of 2013. Source: European Social Survey (2014).

A cross-sectional analysis was performed as part of wave 5 of the Survey of Health, Ageing and Retirement in Europe (SHARE). Chronic pain was defined as being bothered by joint and/or back pain for the previous 6 months. A total of 61,157 participants aged ≥50 years were included. The overall prevalence of chronic musculoskeletal pain was 35.7%, ranging from 18.6% in Switzerland to 45.6% in France. The prevalence was found to be higher in women than in men at 41.3% versus 29.1%. Chronic musculoskeletal pain was less frequent in men aged >75 years than in the younger (50–59) group. The most frequent pain-related diseases were osteoarthritis and other causes of 'rheumatism' at 38.6%, reported in 31.9% of

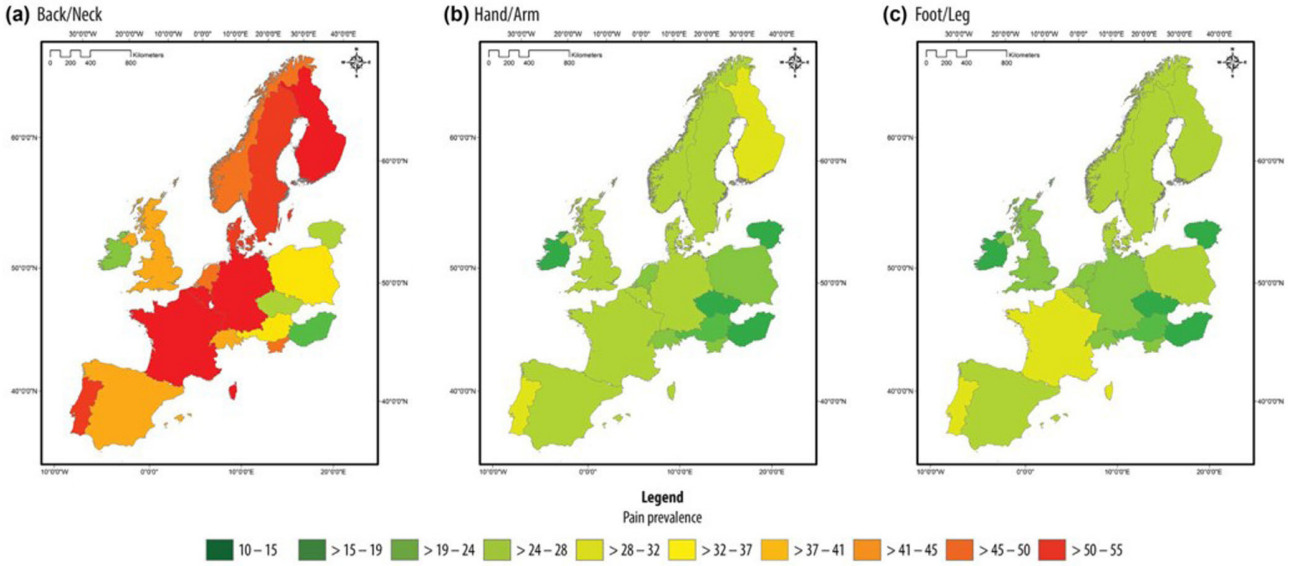


Figure 7. A map illustrating the prevalence of back/neck pain, hand/arm pain and foot/leg pain across Europe.
Source: Todd et al. European Journal of Pain 2019; 23(8):1425-36.

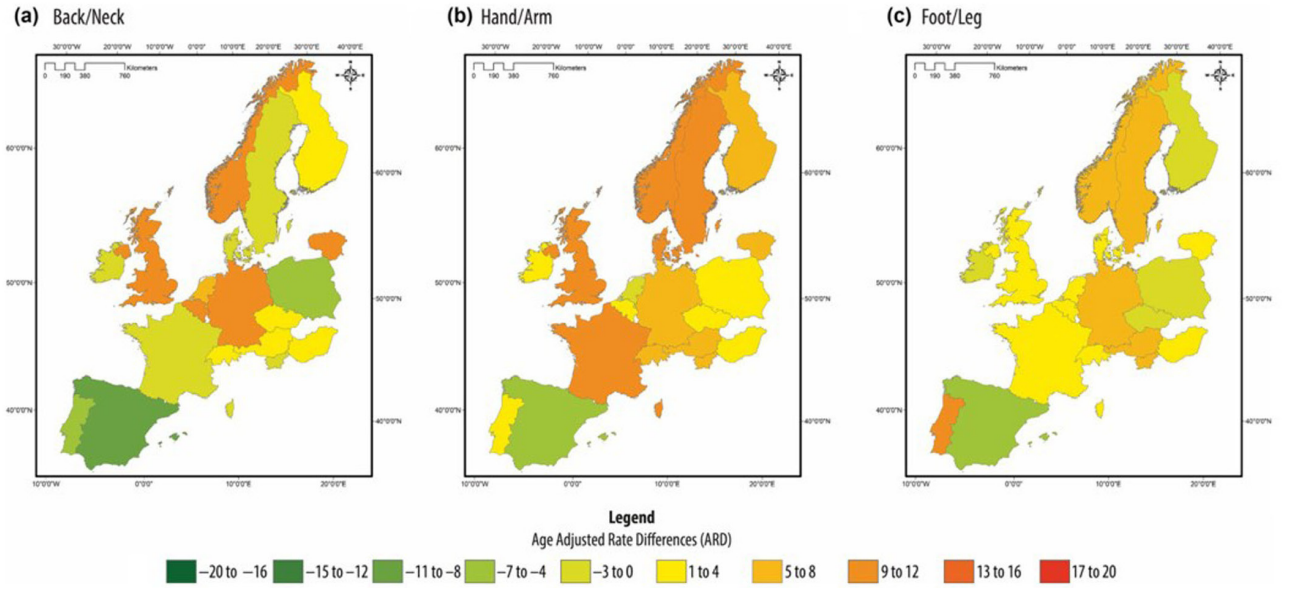


Figure 8. A map illustrating age-adjusted rate differences in pain between low education and high levels across Europe.
Source: Todd et al. European Journal of Pain 2019; 23(8):1425-36.

men and 42.6% of women (Cimas et al. 2017) (Table 2). A further analysis of SHARE 1-7 demonstrated that the prevalence has further increased since then with an annual average of 2.2% between 2004 and 2011 rising later to 5.8% (Zimmer et al. 2020).

7. Disability

In 2014 almost one third (32.3 %) of people aged 75 years or more in the EU27 reported severe difficulty walking, while more than one tenth (10.5 %) of people aged 65-74 years also faced this limitation (Figure 9). There were 10 EU Member States where the proportion of people aged 75 years or above who faced difficulties walking was within the range of 40.0-50.0 %; the highest rates were documented in Croatia, Bulgaria and Hungary (Eurostat 2020).

The most striking difference between the sexes in this age group was in terms of the share of older people who had severe difficulty in walking. One quarter (25.0 %) of all older women in the EU-27 reported severe difficulty in walking, while the corresponding figure for older men was much lower at 15.3 %. (Figure 10) (Eurostat 2020).

In 2019, Europe is the continent reporting the highest proportion of DALYs and YLDs due to MSCs: 7.6% and 18.8%, respectively. In the European Union MSCs are responsible for nearly 10% of all DALYs. MSCs represents the category associated with the third most DALYs following neoplasm and cardiovascular diseases, but with more DALYs than neurological and mental disorders and all other non-communicable and communicable disease categories (Figure 11).

In 2019, MSCs were the leading causes of disability and restricted function in the EU expressed by YLD. Approximately one-fifth of Europe YLDs are due to MSCs (19.9%, overall, 15.9% in Slovakia to 24.3 % in Denmark) while at the same time YLLs remain much lower (0.3%). (Figure 12)

Table 2. Chronic joint and/or back pain characteristics, treatments and prevalence of pain-related diseases

Source: Cimas et al. Chronic musculoskeletal pain in European older adults: cross-national and gender differences. Eur J Pain 2018; 22(2): 333- 45.

	Men		Women		Total	
	%	95% CI	%	95% CI	%	95% CI
Location						
Back	63.1	60.8-65.4	66.2	64.6-67.9	65.1	63.7-66.4
Hip	20.9	19.2-22.8	26.2	24.7-27.8	24.3	23.1-25.5
Knee	41.5	39.2-43.8	47.6	45.8-49.5	45.3	43.9-46.8
Other joints	36.9	34.6-39.2	42.4	40.6-44.2	40.3	38.9-41.7
Multisite (3 or more)	15.6	14.1-17.3	22.2	20.7-23.7	19.7	18.6-20.9
Intensity						
Mild	22.1	20.3-24.1	17.8	16.4-19.2	19.4	18.3-20.5
Moderate	54.4	52.0-56.8	53.0	51.2-54.8	53.6	52.1-55.0
Severe	23.4	21.6-25.4	29.1	27.5-30.8	27.0	25.7-28.3
Treatment (at least once a week) for						
Joint pain	34.3	32.1-36.5	42.2	40.4-44.0	39.2	37.8-40.6
Other pain (including back pain)	18.0	16.3-19.8	24.7	23.0-26.4	22.2	20.9-23.4
Sleep problems	7.4	6.3-8.7	14.8	13.5-16.2	12.0	11.1-13.0
Anxiety or depression	5.4	4.5-6.4	12.7	11.6-13.8	9.9	9.1-10.7
None	15.4	13.7-17.4	10.5	9.2-11.8	9.8	8.8-10.9
Pain-related diseases						
Hip fractures	2.2	1.8-2.8	3.1	2.6-3.7	2.8	2.4-3.2
Other fractures	9.6	8.4-11.1	8.8	7.8-9.9	9.1	8.3-10.0
Rheumatoid arthritis	13.8	12.3-15.4	21.6	20.0-23.1	18.6	17.5-19.8
Osteoarthritis/other rheumatism	31.9	29.6-34.3	42.6	40.9-44.4	38.6	37.2-40.1

Note: Prevalence´s were weighted using EES post-stratification weights and adjusted to the standard European population in accordance with the European Standard population (ESP) of 2013.

Source: European Social Survey (2014).

Low back pain was the single leading cause of YLD in the EU (10.31% overall, from 8.17% in Spain to 11.96% in Romania). Osteoarthritis and neck pain caused also relevant disability in 3.41% and 3.23% respectively. Having a long-term condition can reduce quality of life, and in the UK in 2016/17 those with a long-term MSK condition had an average EQ-5D (a standardised instrument for measuring health status) score of 0.58 compared with those without a long-term condition who had a score of 0.92 (Figure 14).

According to the GBD 2010 study, ischaemic heart disease and back pain caused the largest number of DALYs lost (2.5 million and 2.1 million, respectively). Over the period of the study the absolute number of DALYs due to ischemic heart disease dropped by 33%, while the number of DALYs due to low back pain rose by 11%. The most important disease groups were cardiovascular and circulatory diseases (19.4%), malignant neoplasms (17.9%), musculoskeletal disorders (15.8%) and mental and behavioural disorders (11.4%). Stratification by sex shows that the leading cause of lost healthy years (DALYs) in women is not cardiovascular disease but musculoskeletal disorders. Ischaemic heart disease (men) and low back pain (women) were identified as by far the most common causes of lost healthy years (Plass 2014)

8. Work

MSDs are the most prevalent work-related health problems at the EU level. Millions of European workers are affected at their work and MSD are a major occupational health issue (EU-OHA 2019). Roughly three out of every five workers in the EU-28 report MSK complaints. The most common types of MSK reported by workers are backache and muscular pains in the upper limbs (Figure 15).

Of all workers in the EU with a work-related health problem, 60 % identify MSD's as their most serious issue (Figure 16). One out of five people in the EU-27 suffered from a chronic back or neck disorder in the past year. The proportions of workers reporting MSDs vary considerably between member states (Figure 17).

The prevalence rates of MSDs are higher for female workers than for male workers. The likelihood of reporting MSDs increases significantly with age. The difference between age groups applies to all types of MSD. Workers with only pre-primary or primary education are more likely to report muscular pains in the upper limbs, lower limbs and/or back, and are more likely to report chronic MSDs.

Musculoskeletal injuries account for 38% of all reported fatal and non-fatal serious accidents at work. In particular, dislocation, sprains and strains are the second most common group of work-related injuries in the EU27 (after wounds and superficial injuries), accounting for 27% of all fatal and non-fatal work-related injuries. Bone fractures are lower, at 11%.

More than half of the workers with MSDs and other health problems were absent from work for at least 1 day, while around

Note: the figure is ranked on the share of the population aged ≥15 years self-reporting severe limitations with walking. Belgium and the Netherlands: not available.

(1) Low reliability.
(2) People aged ≥75 years: low reliability.

Figure 9. Self-reported severe physical functioning limitations by age class 2014.

Source: Eurostat Ageing Europe — looking at the lives of older people in the EU — 2020 edition, p. 68. Available from https://ec.europa.eu/eurostat/de/web/products-statistical-books/-/ks-02-20-655. Accessed September 2021.

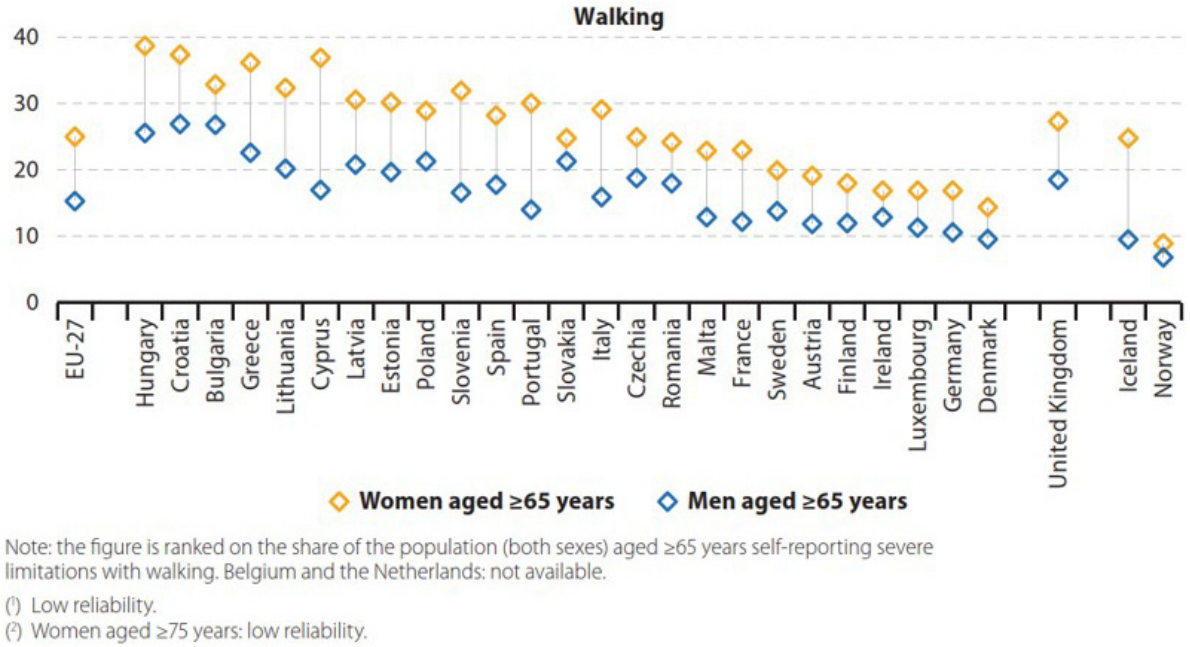


Figure 10. Self-reported severe physical functioning limitations of people aged 65 and over, by sex 2014.

Source: Eurostat Ageing Europe – looking at the lives of older people in the EU – 2020 edition, p. 69. Available from https://ec.europa.eu/eurostat/de/web/products-statistical-books/-/ks-02-20-655. Accessed September 2021.

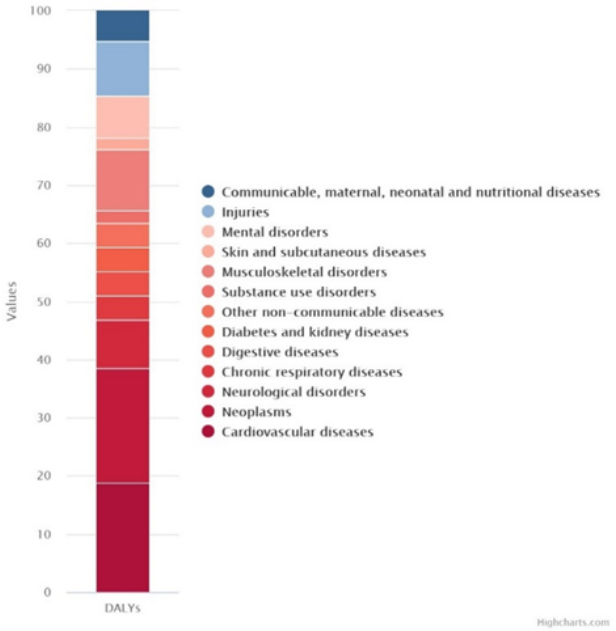


Figure 11. DALYs in the EU, 2019.

Source: Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2020. Available from https://vizhub.healthdata.org/gbd-compare/. http://ihmeuw.org/5hcx. Accessed September 2021.

23 % were absent for at least 10 days. For workers with non-MSK health problems and workers with no health problems, these proportions are lower. This shows that workers with MSDs tend to be absent from work more often than others.

At the level of individual member states, some studies have been identified that demonstrate the impact of MSDs in economic terms (loss of productivity and higher social expenses). In Germany for example, musculoskeletal and connective tissue disorders accounted for EUR 17.2 billion of lost productivity (production loss costs based on labour costs) in 2016 and EUR 30.4 billion in loss of gross value added (loss of labour productivity). This represents 0.5 % and 1.0 % of Germany's gross domestic product, respectively.

Utilisation of health care

Musculoskeletal problems consume large quantities of healthcare resources in the inpatient and outpatient sectors. Due to the diversity of health care systems across European countries a wide variety of treatment options and priorities exist. Additionally, different reporting systems and definitions applied to patients and procedures between countries complicate direct comparisons between national statistics in tables such as EUROSTAT and OECD.

Outpatient services

In Germany, every third German contacted a GP or specialist doctor at least once a year for back pain, 22% for joint problems and 13% for soft tissue disorders and shoulder problems. One in four Germans have at least one contact annually with an orthopaedic surgeon, rising to one third in the over 60 years age group. In the German GP consulting room every third patient is there to report MSK problems (Dreinhöfer 2017). A German patient with the diagnosis of osteoarthritis or osteoporosis consults a doctor on average 12 times a year, and on average 3 different physicians a year.

In England, one in five people consult a GP about an MSD problem annually. There are 1.7 million Rheumatology outpatient attendances annually and 7.6 million outpatient attendances at the trauma and orthopaedic clinics (Ingram 2018) (Figure 18).

In Norway primary health care services reimbursed for musculoskeletal disorders were used by 37% of women and 30% of men in one year. Of these, 32% (women) and 26% (men) were physician contacts and between 5 and 9% with a physiotherapist, chiropractor or combined contact. Corresponding figures for specialist services were 5% in men and 7% in women, where the majority were

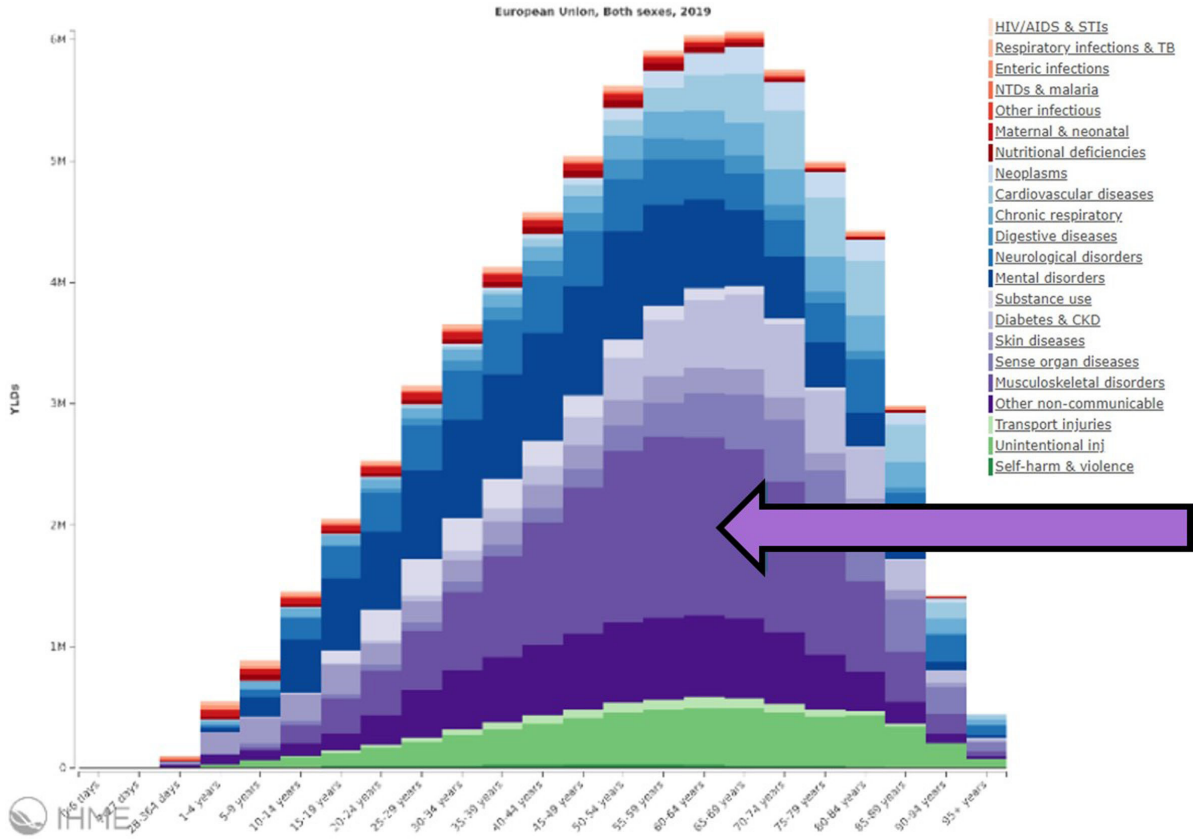


Figure 12. Years lived with Disease (YLD) in Europe by age groups.

Source: Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2020. Available from https://vizhub.healthdata.org/gbd-compare/. http://ihmeuw.org/5hcx. Accessed September 2021.

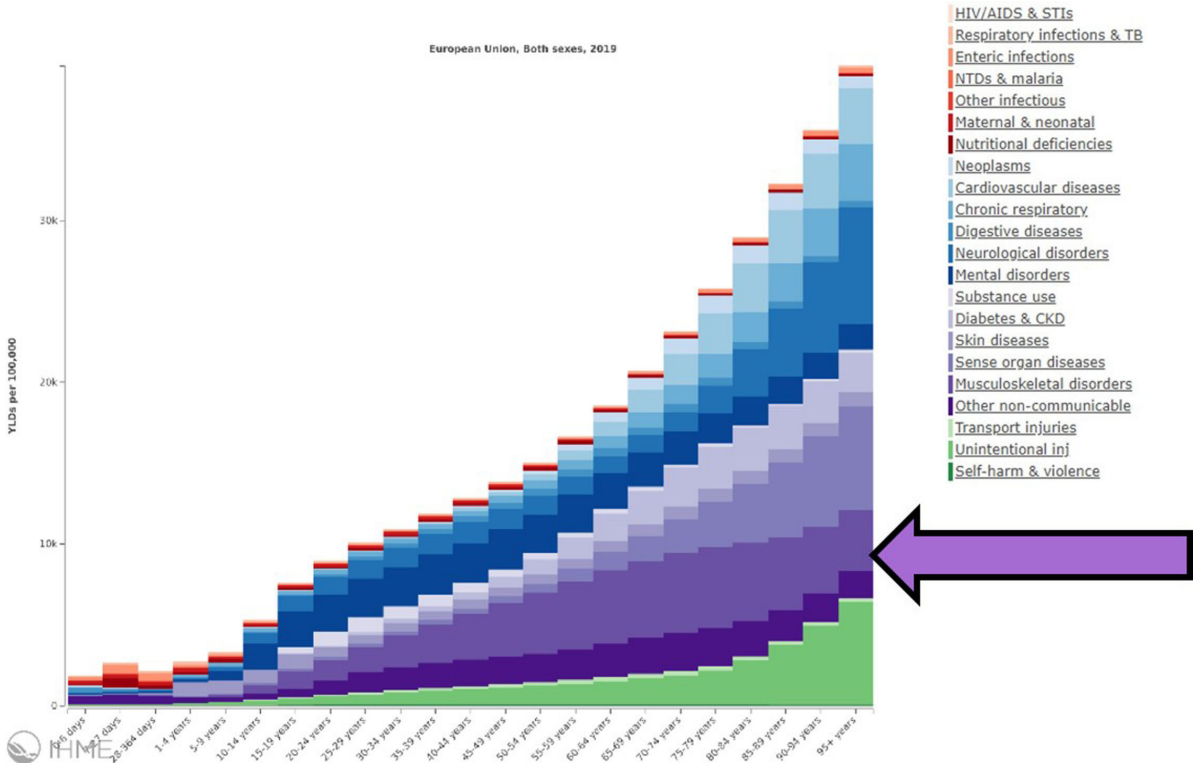


Figure 13. Years lived with Disease (YLD) in Europe by age groups, rate per 100.000.

Source: Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2020. Available from https://vizhub.healthdata.org/gbd-compare/. http://ihmeuw.org/5hcx. Accessed September 2021.

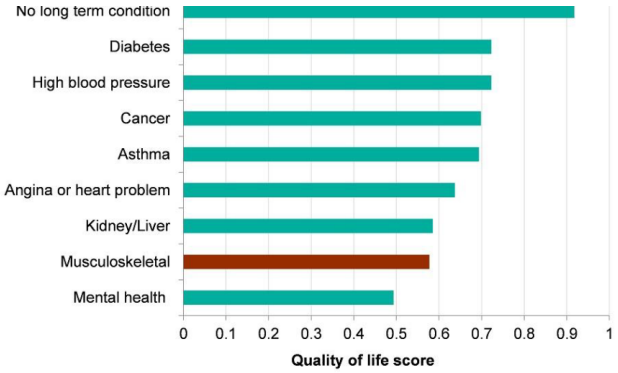


Figure 14. Average quality of life score for adults who live with a self-reported long-term condition, England, 2016/17.

Source: PHE Analysis of General Practitioner Patient Survey (GPPS)

Public Health England. Health Profile for England 2018 Chapter 3: trends in morbidity and risk factors. 11 September 2018. Online. Available: https://www.gov.uk/government/publications/health-profile-for-england-2018/chapter-3-trends-in-morbidity-and-risk-factors . Accessed March 2021.

outpatient consultations. Low back and neck pain were the most common reasons for health care utilization (Kinge 2015).

Combining primary and secondary care, the annual consultation prevalence for any MSK conditions (2,143 vs 1610/10,000) and low back pain (587 vs 294/10,000) were higher in England than in Sweden, but higher for RA, spondylarthritis and psoriatic arthritis in Sweden. Annual primary care prevalence figures for OA (176 vs 196/10,000), RA (25 vs 26/10,000), spondylarthritis (both 8/10,000) and psoriatic arthritis (5 vs 3/10,000) were similar in England and Sweden. The increased prevalence of MSK disorders in elderly people was also reflected in their utilisation rates (Jordan 2014) (Figure 19).

Each year, approximately 31.6 million prescriptions (single items on a prescription form) are dispensed for musculoskeletal and joint diseases, including drugs affecting bone metabolism, in England and Wales, at a cost of approximately £195.3 million (Ingram 2018).

Inpatient services

In England in 2015 there were just fewer than 160,000 inpatient episodes in rheumatology and 1.2 million in orthopaedics and trauma (7.9 % of all admissions). 234,000 joint replacement procedures were carried out in 2017: 114,000 hip and 120,000 knee arthroplasties (NJR 2018). The National Health Service funded just over 145,000 major hip and knee procedures; a large proportion of these were joint replacements (Ingram 2018).

In the same year in Germany 1.8 million people were treated in the hospital for orthopaedic disorders and another 1.5 million for injuries. These were 9% and 8% respectively of all inpatient cases, together forming by far the largest disease group. The overall increase in inpatients between 2000 and 2015 was 15%, whilst the number of patients treated for musculoskeletal disorders increased by 42% (Dreinhöfer 2017).

Nearly every third surgical procedure was performed for musculoskeletal problems, a total of 4.6 million operations. The most frequent of these were joint replacements (hip 240,000, knee 190,000), spine surgery (53,000), osteosynthesis of long bone fractures (230,000) and arthroscopies (560,000) (Dreinhöfer 2017).

In Germany, a specialised rehabilitation service provides both inpatient and outpatient treatment for people with chronic disabilities and following major surgery or sudden medical events, funded mainly by the German Pension Fund (DRV), with the aim of keeping people in the employed workforce for as long as possible. 1.5 million people in Germany received such treatment in specialized hospitals in 2015, one third because of musculoskeletal disorders and injuries (Dreinhöfer 2017).

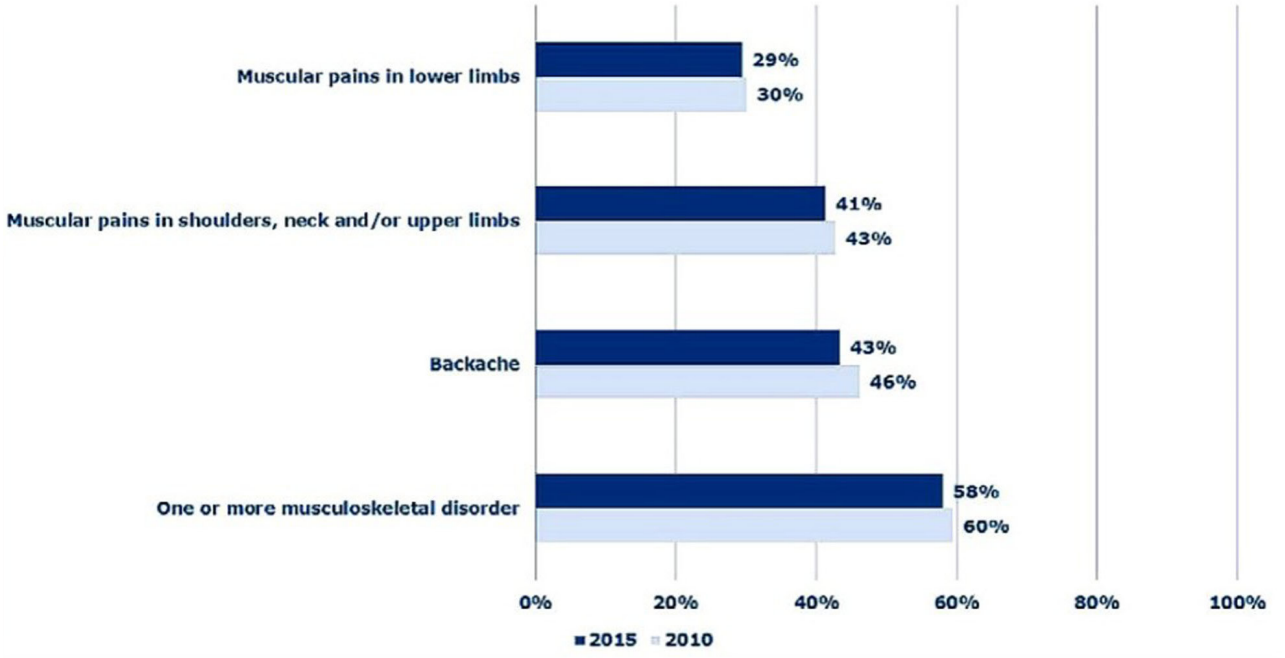


Figure 15. Percentage of workers reporting different musculoskeletal disorders in the past 12 months, EU-28, 2010 and 2015.

Source: Panteia based on the fifth (2010) and sixth (2015) waves of the European Working Conditions Survey (EWCS)

In: European Agency for Safety and Health at Work - EU-OSHA. Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU, 2019. Available from https://osha.europa.eu/es/publications/summary-msds-facts-and-figures-overview-prevalence-costs-and-demographics-msds-europe/view. Accessed September 2021.

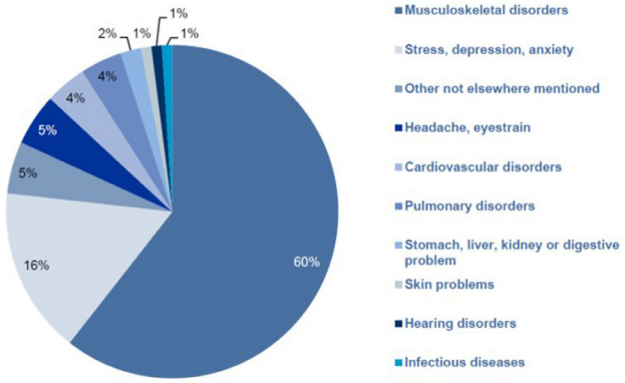


Figure 16. Percentage of workers reporting a work-related health problem, by type of problem, EU-27, 2013.

Source: Panteia based on the fifth (2010) and sixth (2015) waves of the European Working Conditions Survey (EWCS)

In: European Agency for Safety and Health at Work - EU-OSHA. Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU, 2019. Available from https://osha.europa.eu/es/publications/summary-msds-facts-and-figures-overview-prevalence-costs-and-demographics-msds-europe/view. Accessed September 2021.

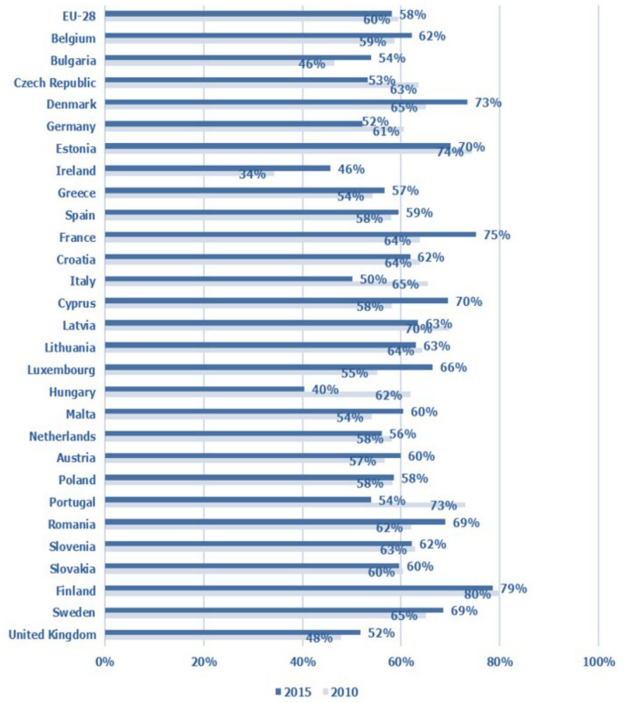


Figure 17. Percentage of workers reporting that they suffered from one or more musculoskeletal disorders in the past 12 months, by Member State, 2010 and 2015.

Source: Panteia based on the fifth (2010) and sixth (2015) waves of the European Working Conditions Survey (EWCS)

In: European Agency for Safety and Health at Work - EU-OSHA. Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU, 2019. Available from https://osha.europa.eu/es/publications/summary-msds-facts-and-figures-overview-prevalence-costs-and-demographics-msds-europe/view. Accessed September 2021.

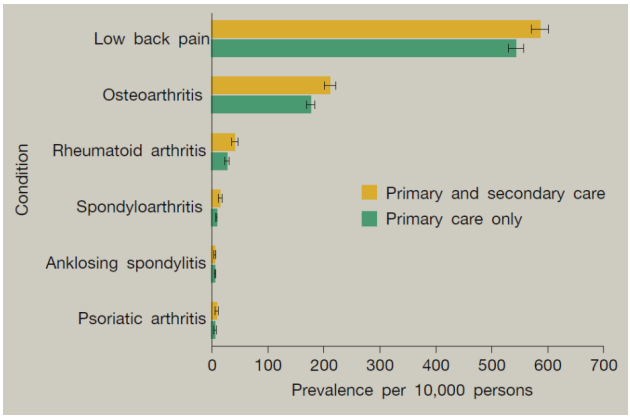


Figure 18: Annual consultation prevalence of musculoskeletal conditions, North Staffordshire, England 2010

Source: Ingram et al. Medicine 2018;46(3):152-5.

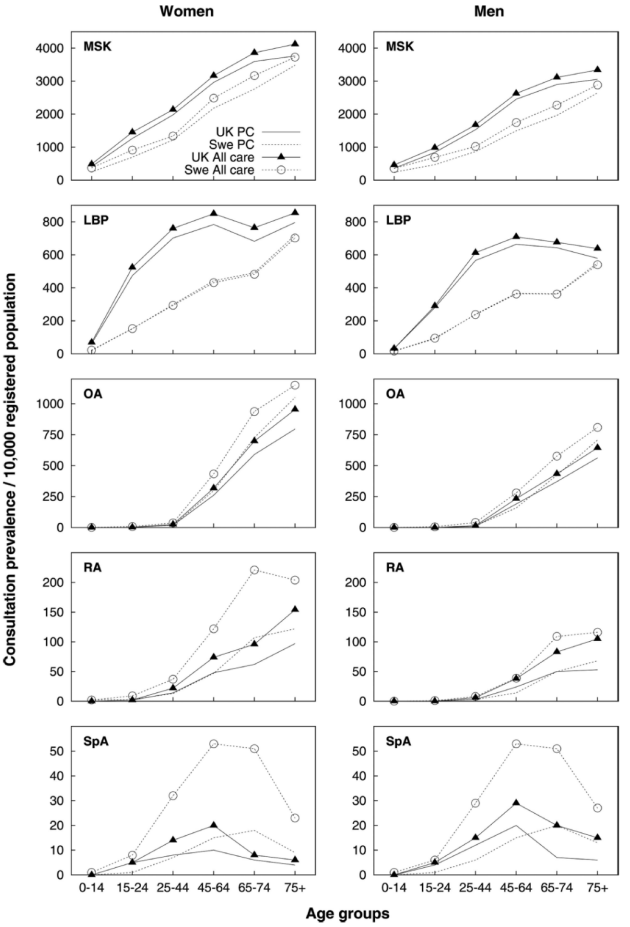


Figure 19: Annual consultation prevalence of musculoskeletal conditions by age and sex in 2020 in Sweden and the UK. All care includes primary and secondary care. LBP, low back pain; MSK, musculoskeletal; OA, osteoarthritis; PC, primary care; RA, rheumatoid arthritis; SpA, spondylarthritis. (Jorden et al. Annals of the Rheumatic Diseases 2014;73:212-8.).

There is a wide variation in the volume of reported MSC and inpatient trauma care in Europe (Table 3). While in Bulgaria MSC accounts only for 5,3% of inpatient treatments, in Hungary it accounts for 20,9%.

Table 3: Volume of inpatient care in 2013 (%)

Source: EUROSTAT: HEDIC – health expenditures by diseases and conditions 2016. Available at: https://ec.europa.eu/eurostat/web/products-statistical-working-papers/-/ks-tc-16-008. Accessed September 2021

ICD10	Description	BG	CZ	DE	EE	LV	LT	HU	AT	SI	SE[1]
		case	day	case	case	day	case	day	case	case	Case
I	Infectious	2.2	2.5	2.8	4.0	6.3	3.8	1.5	2.2	3.6	3.0
II	Neoplasms	7.1	7.4	9.8	11.9	9.3	9.5	8.6	15.1	10.2	7.7
III	Blood	0.8	0.5	0.7	0.9	0.5	0.7	0.7	0.8	1.4	0.9
IV	Endocrine	3.4	2.5	2.5	2.0	1.6	1.5	4.7	2.2	2.2	2.2
V	Mental	2.4	16.8	8.0	6.4	26.7	5.0	5.1	4.8	3.0	7.4
VI	Nervous	3.6	4.6	3.8	3.6	2.6	3.5	2.4	4.2	2.9	3.0
VII	Eye	3.2	0.4	1.6	0.8	0.3	3.9	4.6	6.9	1.4	0.6
VIII	Ear	1.6	0.4	0.7	0.8	0.4	0.8	2.5	0.9	0.4	0.6
IX	Circulatory	14.1	16.5	14.8	18.2	13.8	18.9	9.3	11.2	12.0	14.7
X	Respiratory	10.2	6.5	6.2	8.9	8.0	9.8	5.4	5.6	8.5	7.0
XI	Digestive	8.7	5.9	8.9	8.4	5.1	8.7	3.8	8.6	7.9	7.7
XII	Skin	2.0	1.4	1.4	2.0	1.2	2.0	3.4	1.3	1.5	0.8
XIII	Musculoskeletal	5.3	6.6	10.6	6.5	8.3	7.1	20.9	9.9	6.5	6.0
XIV	Genitourinary	7.2	3.9	4.8	5.5	2.9	7.3	7.9	6.0	7.0	4.8
XV	Pregnancy	6.2	3.2	4.4	8.8	4.1	6.4	2.2	4.4	9.0	8.7
XVI	Perinatal	1.0	0.9	0.8	1.5	1.0	1.6	0.4	0.5	1.3	1.0
XVII	Congenital	0.3	0.3	0.5	0.9	0.7	0.8	0.6	0.7	1.1	0.7
XVIII	Symptoms	0.7	2.5	4.9	1.1	0.1	0.7	5.1	4.1	4.9	9.8
XIX	Injury	0.0	8.4	9.4	6.8	6.8	6.3	10.8	9.8	9.2	9.8
XX	External	5.1	0.0	0.0	:	0.0	0.0	0.0	0.0	0.0	0.0
XXI	Factors	14.7	8.8	3.4	1.0	0.2	1.7	0.0	0.7	6.0	3.9
XXII	Special	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0	0.0	0.0
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(1) 2012 instead of 2013

(:) not available

Costs

Musculoskeletal Conditions have a huge economic impact. Direct costs borne by the healthcare services include drugs, physiotherapy, GP attendances, hospital referrals/admissions and surgery.

In England in 2013 MSCs accounted for the third largest segment of NHS spending at £4.7 billion. Treating osteoarthritis and rheumatoid arthritis is estimated to have cost the economy £10.2 billion in direct costs to the NHS and wider healthcare system in 2017. The hospital costs of hip fracture alone are estimated at £1.1 billion per year in the UK (Ingram 2018).

In Germany, direct costs in 2015 for musculoskeletal disorders were 34.1 billion € (men 12.5, women 21.6 billion €). This represents 10% of the overall health expenditure (338 billion €), placing MSC behind cardiovascular (13,7%), mental (13,1%) and digestive disorders (12,3%) in the fourth position of the most expensive disease categories. Considering that a further 18 billion € were spent treating injuries, the overall costs of 52 billion € add up to 15,4 % - by far the highest direct costs in Germany. At the level of individual diagnosis groupings the cost for spine problems was 10.9 billion €, for osteoarthritis 8.7 billion €, for hip fracture 2.3 billion €, for osteoporosis 1.9 billion € and for injuries of knee and lower leg 1.8 billion € (Dreinhöfer 2017).

In Europe, between 5,0% (Bulgaria) and 11,7% (Germany) of the Allocated Current Health Expenditure (ACHE) is spent on musculoskeletal conditions (Table 4).

Table 4: Health expenditures by disease as percentage of Allocated Current Health Expenditure in 2013 (%)

EUROSTAT: HEDIC – health expenditures by diseases and conditions 2016. Available at: https://ec.europa.eu/eurostat/web/products-statistical-working-papers/-/ks-tc-16-008. Accessed September 2021.

ICD10	Description	BG[1]	CZ[2]	DE	EL	LV	LT	HU	NL	SI	FI	SE[3]
I	Infectious	2.0	2.3	1.9	1.5	3.0	3.5	2.4	1.4	2.2	2.1	2.0
II	Neoplasms	8.4	10.0	8.4	12.5	8.0	9.7	13.1	7.7	9.3	11.9	7.4
III	Blood	0.6	1.1	0.8	1.9	1.1	1.2	2.0	0.7	1.1	1.0	0.7
IV	Endocrine	2.9	5.8	5.0	9.2	4.0	4.5	7.9	3.8	3.0	5.1	3.4
V	Mental	2.2	5.3	11.1	7.4	10.7	6.6	6.8	24.8	8.3	11.6	9.8
VI	Nervous	2.3	4.0	3.5	2.9	4.2	4.1	4.7	8.3	4.1	5.7	2.6
VII	Eye	3.0	3.5	1.8	2.4	5.4	3.8	2.1	:	4.4	1.8	1.9
VIII	Ear	1.1	0.6	1.3	0.4	2.3	1.2	1.1	:	0.9	0.9	1.1
IX	Circulatory	22.5	17.2	13.8	16.9	19.2	23.5	16.6	12.9	12.8	15.3	10.4
X	Respiratory	7.4	6.7	6.4	5.5	6.8	8.2	7.2	4.8	5.4	6.2	4.8
XI	Digestive	19.4	11.6	14.0	10.4	8.5	9.5	7.0	9.0	9.8	8.8	15.8
XII	Skin	1.6	1.5	1.4	0.6	1.4	2.2	1.8	1.6	1.6	1.4	1.9
XIII	Musculoskeletal	5.0	7.5	11.7	7.5	7.2	6.5	8.5	8.3	7.9	7.3	8.1
XIV	Genitourinary	8.1	6.4	4.2	6.5	5.2	4.4	4.7	4.1	5.4	4.0	3.4
XV	Pregnancy	3.1	1.1	1.8	3.4	3.3	2.7	1.6	2.7	1.8	2.4	2.2
XVI	Perinatal	0.4	0.9	0.3	0.9	0.7	1.1	0.7	0.2	0.5	1.1	1.0
XVII	Congenital	0.6	0.4	0.4	0.3	0.6	1.0	0.5	0.4	0.8	0.9	0.8
XVIII	Symptoms	0.6	3.8	5.1	4.2	0.2	0.8	3.0	5.8	4.5	3.5	6.2
XIX	Injury	:	4.3	4.4	2.9	6.5	5.3	3.8	3.6	6.8	6.1	6.8
XX	External	2.6	0.1	:	0.2	0.1	:	0.2	:	0.0	0.0	0.0
XXI	Factors	6.1	6.0	2.7	2.6	1.9	0.3	4.3	:	9.5	2.8	9.7
XXII	Special	0.0	0.0	0.0	0.0	2.6	0.8	2.1	:	0.0	0.0	0.0
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Not allocated	32.1	10.0	2.1	11.0	2.6	0.8	2.1	15.1	:	:	12.9

Ann.: The percentages are standardized on the sum of the allocated health expenditures in each country.

(1) structure refers to total inpatient and outpatient expenditures for 2013.

(2) expenditures for GPs and households-financed care were not completely allocated and are therefore

not fully included.

(3) 2012 instead of 2013

(:) not available

Costs to society also include disability pensions and incapacity benefits. Some societal costs, such as loss of employment, productivity or early retirement, are indirect and difficult to quantify. Finally, there is the cost to the individual, their friends and their families. This includes time spent attending appointments and providing informal care as well as transport costs (Ingram 2018).

The combined costs of worklessness and sickness absence in the UK amount to around £100 billion annually. Musculoskeletal ill health results in significant costs for individuals, employers, the health service and the wider economy.

MSC are the most common causes of work-related illness and the second most common causes of loss of time from work in Great Britain. The labour force survey for the 2015/2016 financial year found that >2.3 million people in the UK reported having a MSC as their major health problem, and that 8.8 million working days were lost because of MSDs (Ingram 2018).

Back pain accounts for around 40% of all sickness absence in the UK and cost the economy an estimated £10 billion in indirect costs in 2000. The cost of working days lost due to osteoarthritis and rheumatoid arthritis was estimated at £2.58 billion in 2017.

In 2016, 13% of incapacity claims and 14% of claims for Employment and Support Allowance were for MSCs (Ingram 2018). The Personal Independence Payment (PIP) is available to individuals <65 years of age who have a long-term health condition or disability. In January 2017, people suffering from MSCs accounted for 35% of those receiving PIP payments. Among musculoskeletal claims, 18% were for inflammatory arthritis, including RA, 22% for OA, 19% for back pain and 14% for chronic pain syndromes (Ingram 2018).

In Norway in 2013, MSCs were responsible for the highest loss of production. Mental disorders were the costliest conditions, followed by MSCs. The total economic loss attributable to mental disorders was 82 billion NOK, followed by MSK at 68 billion NOK.

Mental disorders caused more disability pension claims than any other disease category, closely followed by MSC. MSC were responsible for more sick leave than any other disease category (Kinge 2017) (Figure 20).

In Germany, musculoskeletal conditions are responsible for 17% of sickness cases in 2015 and 26% of sick days, injuries accounting for another 5,8% and 8,6% respectively. Altogether 6.55 million sickness episodes (2.8 million women and 3.7 million men) were caused by MSCs. The average duration of sick leave was 19.5 days. Back pain was the single most frequent diagnosis, accounting for 7,3% of sickness episodes and 6,8% of sick days (Dreinhöfer 2017).

MSCs are also a frequent reason for early retirement in Germany, as reported in 12.6% of women and 11.8% of men. Only mental disorders (40%) are a significantly more frequent reason for early retirement (Dreinhöfer 2017).

The Federal Institute for Occupational Safety and Health in Germany calculates the production downtime costs (PDC) and the loss of gross value added (GVA) for the different disease categories. MSCs are responsible for 18.5 billion € of PDC (17,2%) and 31.7 billion€ GVA (30,5%), injuries 9.0 billion € (8,0%) and 15.4 bill € (14,2%) respectively – this adds up to an equivalent of 2,4% of the gross national income being required to fund the indirect costs of MSC and injuries. In addition, the 54 billion € direct costs are equivalent to another 1,5% of GNI.

9. List of Activities Needed

- Definition and implementation of standardized European item lists for routine data collection and surveys to document health status, health service utilization and expenses in comparable settings.
- Strengthening and expanding Health Service Research in musculoskeletal conditions and injuries to analyse actual and best practise patterns.
- Improving collaboration with public health officials, politicians and funders to increase awareness of the burden of musculoskeletal problems and the consequences of this for individuals, families, countries and economies.

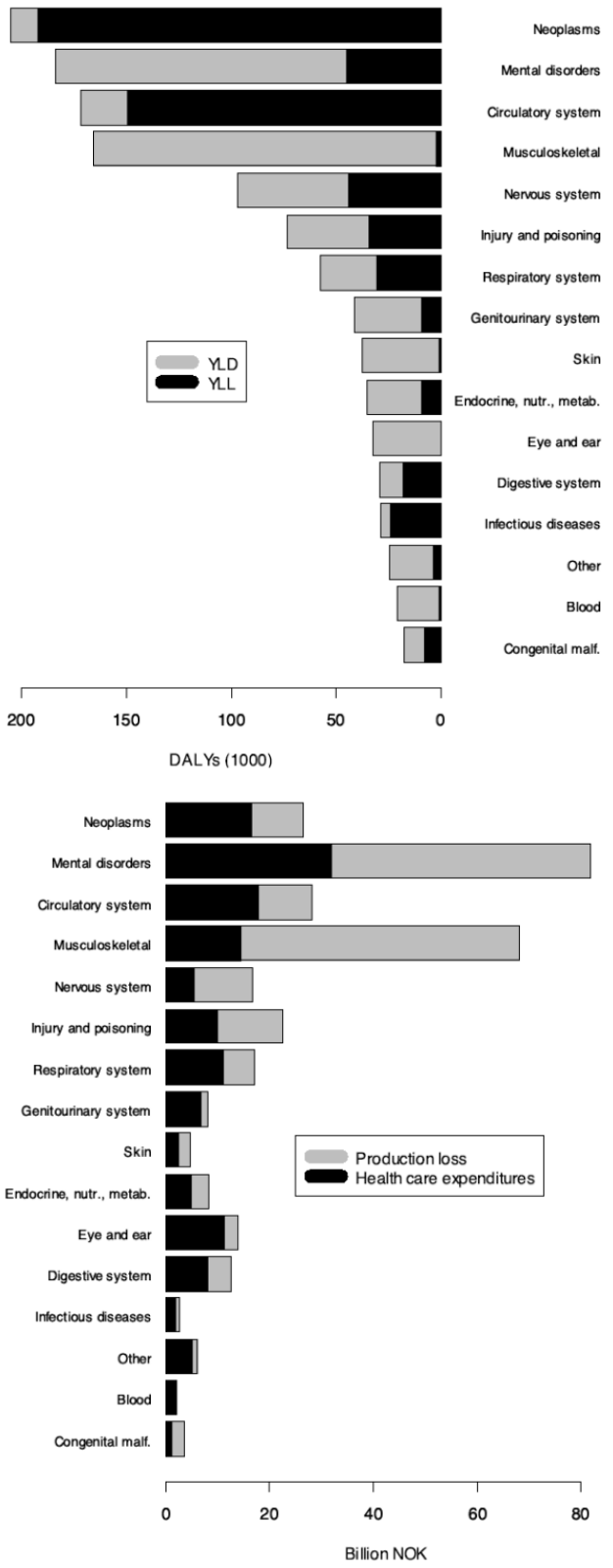


Figure 20. YLL, YLD, health care expenditure and production loss in Norway (Kinge et al BMC Musculoskelet Disord 2015; 16:75).

- A recent publication in the Bulletin of the World Health Organisation has addressed this issue and highlighted that policies, strategies and health programmes for noncommunicable diseases, as well as essential care packages for universal health coverage, must include musculoskeletal health as an integral component. Three priorities for action to reduce the burden have been defined (Briggs et al. 2018).
- Advocacy for, and integration of, musculoskeletal health and persistent pain into existing global and regional policy reform initiatives. The World Health Organization, the European Union and its Member States can help reduce the disability burden through an increased focus on musculoskeletal health within system-reform initiatives for noncommunicable diseases and healthy ageing policy agendas. For example, most activities in the non-communicable disease area focus on mortality associated with cardiovascular disease, cancer, diabetes and chronic respiratory disease, rather than on appropriate strategies, policies and service implementation to promote living with improved intrinsic capacity.
- Targets and monitoring for functional ability should be set as part of noncommunicable diseases global health surveillance and as part of the health SDG performance targets. Targets should also be set to reflect maintenance of mobility, participation and physical function as key components of functional ability and performance.
- Musculoskeletal health should be part of noncommunicable diseases national policy reform. So far, national system-level health policy and strategy responses to address musculoskeletal health as a component of noncommunicable diseases care remain disproportionate with the burden of disease.
- While health systems are now responding to the burden of noncommunicable diseases, there has been an almost exclusive focus on cancer, diabetes, chronic respiratory disease, cardiovascular disease and, more recently, mental health. While these foci are important, inadequate prioritization of musculoskeletal health and persistent pain as part of health reform initiatives targeting noncommunicable diseases does not align with contemporary evidence on global health, limiting opportunities for the development of appropriate integrated policy responses, workforce capacity building initiatives and their harnessing of capacity in society.
- System reform leadership in some high-, middle- and low-income regions is nonetheless encouraging. For example, the development of person-centred models of care for musculoskeletal health and persistent pain that consider multimorbidity and care integration across the health and social care systems are recognized to improve policy capacity, service delivery and cost-effectiveness. A global framework to develop, implement and evaluate such models has also been established. Further development and dissemination of effective models of care is needed to inform promotional, preventative, rehabilitative and curative essential packages for Universal Health Coverage, innovative service delivery options and strategies to build workforce capacity and consumer capacity to actively participate in care.

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Section 2

Major Musculoskeletal Conditions

Section 2

A | Spine Care in Europe

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1. Summary

The introduction to this chapter gives an overview of the burden of spinal disease in European countries in general, and is followed by general considerations on the affordability of spinal care in Europe. Subsequently, the authors shed light on topics relevant to spinal specialty groups, individual care providers and stakeholders alike: Education and certification; research; documentation of safety and effectiveness of spine care treatments and related technologies; importance of global networks for spine professionals; helping patients to make informed decisions and the future of spine care. Challenges emerging in the COVID-19 context are also addressed. Finally, the chapter is summarized by the bullet point consensus recommendations of SPINE 20 – an advocacy group founded in 2019 by EUROSPINE, the North American Spine Society, the German Spine Society and the Saudi Spine Society, in an effort to improve spinal care on a global level by harmonising recommendations on good practice policies to the G20 countries.

2. Introduction

Global Burden of Disease estimates show that low back pain is one of the most disabling conditions globally, with half a billion individuals suffering loss of function and disability worldwide (GBD 2019). In a recent publication, authors spotlight the effects of this disability and loss of function and focus on the need of rehabilitation to improve individuals´ lifestyle and wellbeing. The disease category with the greatest prevalence was musculoskeletal disease, affecting 1.71 billion people and causing 149 million Years of Life lived with Disability annually (YLDs). Among musculoskeletal disorders, low back pain was responsible for the greatest burden, with 568 million people affected and 64 million YLDs globally. In fact, low back pain was also the leading health condition contributing to the need for rehabilitation services in 134 of the 204 countries analysed (Cieza et al. 2019).

Table 1 shows the number of hospital discharges per 100.000 inhabitants in European countries. Austria, Germany, Hungary, Lithuania and Slovakia have the top five highest numbers of hospital discharges related to intervertebral disc disorders, spinal disease causing deformity, degenerative spinal disease spondylopathies and back pain combined, when calculated per 100.000 inhabitants, while Portugal, Italy, Ireland, Greece and the Netherlands have the lowest rates. These figures demonstrate that the percentage of spine related hospital discharges accounts for 0.8% - 4.3% of all hospital discharges and 14.2% - 45.6% of all discharges related to diseases of the musculoskeletal system in European countries (OECD 2018b). Intervertebral disc disorders alone accounted for 4.9% to 21.1% of all hospital discharges related to diseases of the musculoskeletal system in Europe.

Table 2 shows the average hospital length of stays per 100.000 inhabitants in European countries. These figures indicate that spine related diseases necessitate a higher average length of stay in most countries than the average of all causes together (OECD 2018a).

3.1 Affordable Spine Care

As mentioned in the chapter on health care resources and utilisation in Europe, most Europeans benefit of some form of health insurance coverage. When a European citizen's health is failing, they usually have access to good medical care without bringing on financial ruin and pushing their family into poverty. Thus, Europeans are highly privileged in this respect.

Table 1. Hospital discharges per 100.000 inhabitants in European countries

Source: OECD. Health Care Utilization: Hospital discharges by diagnostic categories, 2018. Available at https://stats.oecd.org/Index.aspx?DatasetCode=HEALTH_STAT. Accessed December 2020.

Country	All Causes	Diseases of the Musculoskeletal System & Connective Tissue	Intervertebral Disc Disorders	Deforming Dorsopathies & Spondylopathies	Dorsalgia
Austria	24,702	2,969	300	230	427
Belgium	16,833	1,472	212	154	39
Czechia	19,590	1,608	153	62	317
Denmark	14,492	788	88	119	60
Finland	16,386	1,207	78	156	123
France	18,553	1,118	77	110	79
Germany	25,478	2,775	272	325	358
Greece	13,805	528	53	32	55
Hungary	19,255	1,983	410	296	126
Iceland	11,453	780	38	92	60
Ireland	13,373	564	34	30	49
Italy	11,415	758	58	42	8
Latvia	16,353	950	84	321	28
Lithuania	22,236	1,959	414	189	42
Luxembourg	15,109	1,646	211	206	42
Netherlands	8,976	661	58	70	18
Norway	16,349	988	98	108	73
Poland	17,302	1,042	124	119	36
Portugal	8,319	329	28	31	4
Slovakia	19,094	1,496	257	82	296
Slovenia	17,495	1,082	75	117	84
Spain	10,471	767	73	51	25
Sweden	13,875	783	39	122	53
Switzerland	16,958	2,094	169	224	93
Turkey	16,588	743	143	34	62
UK	12,869	763	49	46	57

Denmark, Luxembourg 2016; Germany, Iceland 2017; Greece 2014; all other countries 2018 (OECD Data)

Spine-related disability, secondary to disease or trauma but mostly because of naturally occurring, age-related degenerative change, is a major socio-economic burden in Europe and beyond (Balagué et al. 2012). No country is spared, but the available financial resources for care and social support vary dramatically: worldwide many people are less fortunate and have no choice but to accept and live with their spine ailment.

Yet, those who are fortunate enough to have access to care are not out of trouble. In high-income countries, spine care-related costs have grown exponentially over the last three decades. Surgical procedures have gained in number and complexity, but global outcomes have not changed in a commensurate way, at least in respect of degenerative pathology, which represents by far the biggest proportion of spinal pathology consuming healthcare resources (Cherkin et al. 2019).

The population is ageing, and this ageing population often remains very active in advanced age, so becomes confronted by wearing-out of the joints and in particular of the most complex joint structure: the spine. While total joint replacement for hip, knee and shoulder has become remarkably effective at restoring a durable joint with almost normal function, we are still far from achieving these excellent results for the spine.

3.2 Where do costs lie in the management of spine ailments?

Loss of income and productivity, financial support or compensation and dependence on external help induce the largest financial burden

Table 2. Hospital average length of stays for all causes, diseases of musculoskeletal system & connective tissue and some spinal disorders per 100.000 inhabitants in European countries (days)

Source: OECD. Health Care Utilization: Hospital average length of stay by diagnostic categories, 2018. Available at: https://stats.oecd.org/Index.aspx?DatasetCode=HEALTH_STAT. Accessed December 2020.

Country	All Causes	Diseases of Musculoskeletal System & Connective Tissue	Intervertebral Disc Disorders	Deforming Dorsopathies & Spondylopathies	Dorsalgia
Austria	8.3	9.8	9.9	11.6	10.1
Belgium	6.2	5.7	4.2	7.7	5.6
Czechia	9.4	9.7	9.9	14	12
Denmark	5.4	3.4	2.4	5	3.3
Finland	7.7	5.1	3.2	6	5.9
France	8.8	5.4	4.2	7	4.9
Germany	8.9	10.9	10.7	12	11.3
Greece	7	5	4.0	6	5
Hungary	9.6	12.4	12.3	14.2	14.9
Iceland	6.1	5.4	2.8	8.4	7.3
Ireland	5.8	5.3	4.6	9.8	4.3
Italy	7.9	6.3	4.5	7.6	6.8
Latvia	8.4	8.4	8.7	8.5	8
Lithuania	7.2	7.4	8.4	10.8	7.5
Luxembourg	8.9	5.9	5.1	6.7	8.5
Netherlands	4.5	3.1	2.4	4.4	4.1
Norway	5.3	3.8	3.1	4.7	2.9
Poland	7	8.4	8.7	14.2	8.6
Portugal	7.9	6.5	4.3	9.9	6
Slovakia	7.1	7	7.3	9.2	7.6
Slovenia	7	6.1	5.1	9.3	6.7
Spain	8.3	5.2	5.1	8.4	6.2
Sweden	5.6	3.6	3.0	4.6	4.3
Switzerland	8.2	7.1	6.8	10.1	10.3
Turkey	4.2	5.2	5.9	8.1	2.8
UK	6.6	5.1	4.1	8.3	3.8

Denmark, Luxembourg 2016; Germany, Iceland 2017; Greece 2014; all other countries 2018 (OECD Data)

for society in most cases. Conservative management, if not overly prolonged, is cheap, often effective and has fewer complications than surgery. It is available almost anywhere and does not need much in the way of infrastructure to work. For common low back pain, there is Level 1 evidence proving the benefits of physical activity and the adverse effect of prolonged bed rest and interruption of activity. Yet this observation is not universally applied to clinical practice. Despite the lack of evidence of reliable effectiveness, surgery is still often proposed before the completion of an adequate cycle of conservative management (Maher et al. 2017).

Obviously, conservative management cannot solve all problems. Once surgery is performed, according to evidence-based indications, the immediate costs of care increase considerably. If successfully performed, rapid resumption of activities and functional restoration will result in a considerable reduction of the indirect costs to society mentioned above. If complications occur, however, both direct and indirect costs will increase dramatically because of various factors, which may include a lengthy hospital stay, further surgery or other interventions, medications, prolonged rehabilitation or persistent disability (Chotai et al. 2017).

The key for sustainable surgical spine care, anywhere in the world, for the rich and the poor, is first and foremost the appropriate observation of evidence-based indications for treatment, and in particular for surgery. Of course, a well-trained surgeon and surgical team with the appropriate infrastructure are essential in any healthcare system, but will never compensate for poor surgical indications.

The operating theatre in which the spine surgeon works has also seen dramatic changes over recent decades. This is true in relation to implants, surgical techniques, sophisticated imaging equipment and bio-active materials used to promote fusion, not to mention the immense progress in anesthesiology, neurological monitoring, blood sparing techniques and post-operative pain management.

The European spine surgery devices market is expected to reach the value of $3.46 billion by 2021. Spinal fusion and fixation accounts for the largest segment of this market in Europe, with a share of 66.5% in terms of overall value. It is also projected to grow at a Compound Annual Growth Rate of 6.2% during the forecast period. (SPINEMarket Group 2020). Among the factors driving the demand for spine surgery are the incidence of road accidents and an increasing incidence of diagnosis of spinal deformities and disc prolapse causing neurological compression. Amongst the ageing population, osteoporotic vertebral body fractures have a high impact: the prevalence of symptomatic vertebral fractures causing a change in vertebral shape among European women is highest in Scandinavia (26%) and lowest in Eastern Europe (18%). Rates in women ≥50 years in Latin America are lower overall than in Europe and North America (11–19%). The highest–lowest ratio between countries, within and across continents, varies from 1.4–2.6. Age-standardized rates in studies combining hospital and ambulatory vertebral fracture interventions are highest in South Korea, USA, and Hong Kong and lowest in the UK. Neither a North-South gradient nor a relationship to urbanization is evident. Conversely, the incidence of hospitalized vertebral fractures in European patients ≥50 years old shows a North-South gradient with 3–3.7-fold variability (Ballane et al. 2017).

The available tools aiming to allow safer, complex surgery, such as navigation, per-operative 3D imaging, minimally invasive and robotic surgery, are impressive. However, all these tools are associated with considerable costs, not only the capital cost to acquire them but also running and maintenance costs, which usually generate recurrent annual costs of 10% or more of their initial price.

3.3 Are there fashions and game changers?

When asked what they consider to be game changers in spine care over the past decades, European key opinion leaders answered as follows in this informal survey:

Technical field:

- Instrumentation for the correction of spinal deformity;
- Per-operative neurological monitoring;
- 3D intra-operative imaging and navigation;
- Minimally invasive techniques;
- Cement augmentation.

Knowledge domain:

- Outcome assessment by registers, systematic reviews, randomized controlled trials;
- Evidence-based medicine;
- Sagittal balance analysis;
- Cessation of bed rest, active rehabilitation and less surgery for low back pain.

Among the points cited, intraoperative 3D-imaging and navigation are expensive but are only needed in specific procedures. Cement augmentation may be carried out with a simple biopsy needle

and a syringe and does not demand expensive custom-made equipment. Less invasive surgery is a matter of training. Endoscopic surgery, however, carries significant extra costs in equipment and disposables. Last generation implants, such as total disc prostheses, interspinous implants, highly sophisticated fixation means, along with the applications of Bone Morphogenetic Proteins, were hardly cited in this survey.

In order to continue offering the best treatment available, spine professionals will need to continuously upskill themselves with the support of the national and international scientific societies and professional organisations, such as EFORT and EUROSPINE. Areas of focus to maintain and improve cost effective care may include the following:

4. Accessible Spine Education For All

Best-practice education programmes must offer innovative learning opportunities for spine specialists at all stages of their career. Professional societies should provide comprehensive programmes to diploma standard, taking advantage of developments in medical education such as e-learning modules, making spine education more accessible than ever before. Spine education must cover comprehensively the non-surgical treatment modalities, as exemplified by the EUROSPINE Diploma in Interprofessional Spine Care (EDISC). Educational offerings may be supplemented with online tools such as webinars that focus on updates and the highlights of spine care that can be disseminated to all spine care professionals.

4.1 Establishing a core curriculum through UEMS

Specialist Professional Societies must establish core curricula for spine surgery, and other orthopaedic subspecialties, with the European Union of Medical Specialists (UEMS). UEMS is an international non-profit organisation representing all National Associations of Medical Specialists in Europe, and has developed the educational event-accrediting body, EACCME. EUROSPINE has developed a draft of the UEMS-MJC Spine Surgery core curriculum which will now be formulated into the '*European Training Requirements in Spine Surgery*', to be presented, along with the proposals of other specialties, to the European Parliament.

4.2 Education and networking

Specialty Societies´ annual meetings are an ideal forum for sharing knowledge. They are recognised internationally as premier events and in the world of spine, are known for their top-level, well-balanced scientific content and educational sessions, animated debates, industry workshops and presentations on the latest technical innovations. Delegates have the opportunity to exchange ideas with the greatest minds in spine care today.

5. Excellence in Research: Vital For Patient Care

Societies representing spinal professionals should aim to facilitate the delivery of excellence in research, developing the very best care for spine patients. High priority should be placed on research and the stimulation of research; promotion of an active research community should be facilitated.

Some of the biggest developments in spinal research in recent years, and their impact on practice, include:

- A better understanding of the impact of psycho-social factors of the prognosis of spinal disorders;
- The importance of considering an interdisciplinary approach in the management of back and neck pain;
- Understanding that most clinical treatments have very little effect on the recovery of patients with common spinal pathological conditions;
- The demonstration that for common low back pain (LBP), spinal surgery and other invasive interventions do not provide more benefits than conservative care;
- A better understanding of the chronic recurrent course of back and neck pain; and
- Understanding that LBP is the one of the leading causes of disability in the world.

The key areas of current focus for researchers into spinal disorders include:

- Interaction between spinal pain and comorbidities (especially mental health);
- Understanding the impact of the environment (work, family, social life, policies) on the development of spine-related disability;
- The aetiology of back and neck pain in children; and
- The prognosis of back and neck pain in the elderly.

6. Top-Quality Care For Patients

Certification of institutions providing spine-related health care should be prioritised. The recently created accreditation programme of EUROSPINE, 'Surgical Spine Centres of Excellence' (SSCoE), aims to assist in promoting excellence in spine care around Europe. The purpose is to certify spine centres that meet strict quality standards in the provision of patient care, spine surgery and education, among other criteria. SSCoE certification provides a guarantee to patients that they will receive a high-quality standard of care in any such approved clinic in Europe.

6.1 Documenting safety and effectiveness of spine care treatments and technologies

Spine registry platforms (such as Spine Tango) can offer comprehensive implant databases and feedback services to clinicians, hospitals, and medical device manufacturers. The data collected provides clear evidence on prevention, treatment effectiveness, patient safety and best practice, supporting spine-related learning and research.

6.2 Establishing global networks of spine professionals

National spine societies should aim for a communication platform, where they can meet and connect on a regular basis as equal partners – defining common goals, identifying and addressing challenges and helping to locate the brightest minds in spine. EUROSPINE has called into life the European Spine Societies Advisory Board (EuSSAB). EuSSAB's network, with wide geographical distribution and precise local knowledge, enables sharing of minds and includes an effective and successful tool to find and identify new talent. Table 3 shows the number of individual members of EuSSAB´s national spine societies (EUROSPINE Database 2020).

Table 3. Number of Individual Members of National Spine Societies in European Countries as Declared to EUROSPINE

Source: EUROSPINE Database. The number of individual members of EuSSAB´s national spine societies. Accessed December 2020.

Country	Number of Individual Members	Last Update Received
Austria	175	2020
Belgium	276	2020
Croatia (2 societies)	225	2019
Czechia	missing information	2018
Denmark	82	2019
Finland	88	2020
France	470	2020
Germany	2373	2020
Greece	220	2019
Hungary	130	2020
Ireland	missing information	2018
Israel	60	2020
Italy	300	2020
Netherlands	missing information	2018
Norway	missing information	2018
Poland	325	2020
Portugal	128	2019
Romania	60	2018
Russian Federation	390	2019
Slovakia	83	2018
Slovenia	69	2019
Spain (2 societies)	461	2020
Sweden	300	2020
Switzerland	120	2019
Turkey	388	2020
United Kingdom	875	2020

6.3 Helping patients make informed decisions

In addition to digital platforms for medical professionals, societies should also offer platforms to empower patients to learn about their condition. EUROSPINE´s 'Patient Line', for example, provides reliable information in 14 languages to help patients understand and discuss treatment options with their healthcare provider and is considered one of the best information sources in Europe for patients with spine ailments.

6.4 Challenges in the COVID-19 context

The most noticeable effects of the COVID 19 pandemic on spinal care can be attributed to factors such as the reallocation of hospital resources (e.g. nurses and intensive care beds) away from spinal care to care for patients with the coronavirus, resulting in the cancellation of elective surgery both practically, due to staffing shortages, and to reduce the risk of the virus spreading in the hospital environment. The combination of these two factors led to drastic changes in the daily routine not only of spinal surgeons, but also of other professional groups involved in spinal as well as other specialist care. In order to ensure adequate care of COVID-19 patients, non-urgent operations were scaled back or stopped due to government recommendations. As a result, the majority of surgeons could only perform emergency surgery for a prolonged period. For the patient, the delay in receiving elective care can lead to physical (decline of skeletal muscle tissue with age, frailty etc.) and psychological (depression; pain management strategies such as pain medication abuse, etc.) stress, adding to their burden and making a good outcome more difficult to achieve.

7. The Future Of Spine Care

With demographic changes and changing lifestyles, the world is witnessing more spinal problems than ever before. With technological, biological, medical and surgical advances, the future is bright for improved standards of care in spine-related disorders. In a scenario reaching beyond individual nations´ needs, it is necessary to develop strategies to improve access to affordable and quality spine care. Professional Societies should aim to prioritise most urgent aspects of future developments in spine care, such as:

- Identifying and understanding the most promising advances in spine care which could help improve access to quality spine care; and
- Strengthening strategies on improving global access to advances in spine care including telemedicine, day care spine centres, virtual reality and robotics in spine therapy.

8. List Of Activities Needed

SPINE20 is an advocacy group founded in 2019 by EUROSPINE, the North American Spine Society, the German Spine Society and the Saudi Spine Society, in an effort to improve spinal care on a global level through recommending policies to the G20 countries and beyond. The aim is to alleviate the burden of spine disease and the impact of spinal injuries through various means, including stimulating better spine health, advancing spinal research, enhancing spine innovation pathways, improving spine care and enhancing public health and education through policies and support from governments.

The following consensus recommendations were deemed to be the most urgent recommendations to influence health policy and decision makers to promote spine health and mitigate disability and loss of function from spine disorders and injuries (AlEissa et al. 2021):

- Develop policies and support systems to mitigate the increasing burden of spinal disability on health care, the economy and social security systems;
- Define global standards for continuing education and training curricula for spine care practitioners that promote inter-professional collaboration and patient-centred care;
- Examine and adopt prevention strategies to limit spine problems, including exercise incentive programs to cultivate healthy populations;
- Recognize that lower back pain is the leading cause of years lived with disability and loss of function in the world. Create low-cost models to ensure the right care is delivered at the right time;
- Promote global access to comprehensive healthcare for individuals with spinal cord injury to facilitate community inclusion, return to the work force and improve quality-of-life;
- Create global awareness for the prevention of spinal cord injury;
- Encourage and support osteoporosis preventive strategies and early detection measures, particularly in the older population at risk of developing osteoporotic fractures;
- Support projects that improve access to quality spine care for the pediatric population, particularly in areas with limited resources;

- Promote balanced nutrition in the young population, to ensure full access to vitamins and nutrients throughout childhood;
- Implement the principles of Valued-based Health Care in spine practice to optimize spine care in the global community;
- Recognize the need to address patient safety which requires appropriate training and teamwork in spine care;
- Create national/global big data collections in the form of registries or other modalities so future care is based on reliable and valid outcome data.

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Section 2

B | Degenerative and Inflammatory Joint Diseases

Table of Contents

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1. Summary

Musculoskeletal (MSK) conditions, such as osteoarthritis and inflammatory arthritis (e.g. Rheumatoid Arthritis), are the most common cause of severe long-term pain and disability in the world. They have a high impact on healthcare and are a major cause of work absence and incapacity. 40% of people over the age of 70 years suffer from osteoarthritis (OA) of the knee. 80% of people with OA have some limitation of movement and 25% cannot perform routine daily activities.

Across the EU there is a lack of awareness of musculoskeletal disease and associated disability, which increases with age, obesity and lack of physical activity. Several degenerative and inflammatory diseases will be considered and treatment options discussed.

2. Introduction

Joints are essential for all our complex movements and activities. Therefore, all joint diseases have a significant impact on our functioning and quality of life.

There are many different joint diseases, which can be divided into degenerative and inflammatory joint diseases. Rheumatoid Arthritis (RA) and related disorders are inflammatory joint diseases caused by autoimmune processes. The immune system attacks healthy tissue. Osteoarthritis, which is much more frequently found than inflammatory joint diseases, is not caused by an autoimmune reaction. It is related to ageing, injury and a range of other factors and is often described as "wear and tear" disease. However, in osteoarthritis the destruction of the cartilage layer of the joint leads secondarily to inflammation, and many signs and symptoms of osteoarthritis are related to this inflammation. Consequently, although their origin is different, both types of joint disease have inflammation as a common factor.

Some joints are more prone to specific diseases. The small joints of hands and feet are more often involved in RA, while OA is more prominent in hip, knee and shoulder, although the basal joint of the thumb and great toe are also frequently involved.

The impact of joint disease is high. Lidgren et al. (2014) summarized the burden of OA on the society and the individual. 40% of people over the age of 70 years suffer from OA of the knee. 80% of people with OA have some limitation of movement and 25% cannot perform routine daily activities.

3. Definition and Description

3.1 Degenerative joint disease

Osteoarthritis

Osteoarthritis is characterized by joint pain after loading, stiffness of the joint and restriction of movement. If the cause of OA is not obvious, one speaks of primary or idiopathic OA. The condition can also arise from a distinct cause (infection or trauma) and is then defined as secondary OA. Joint injuries are a risk factor for OA, but most cases of OA occur without any specific history of injury. Obesity is also a risk factor for knee OA and, to a lesser extent, for hip and hand OA. Osteoarthritis is diagnosed on the history and clinical examination and is confirmed by X-rays showing the loss of cartilage and other associated radiographic abnormalities. It is a slowly progressive disease. Disease-modifying treatment is not yet available.

Osteoarthritis is a leading cause of disability in older adults. Globally, as of 2010, approximately 250 million people had OA of the knee (3.6% of the world population). Hip OA affects about 0.85% of the population. In 2005, 26.9 million US adults were estimated to have OA (OARSI White Book – 2016). As of 2004, OA globally causes moderate to severe disability in 43.4 million people. Together, knee and hip OA rank globally for disability as 11th of 291 disease conditions assessed (Cross et al 2014).

A Swedish registry data study counted the proportion of people aged 45 years and older with any form of physician-diagnosed OA (knee, hip, hand, or other locations except the spine), and found the result to be 26·6%. In the Dutch population the prevalence of physician-diagnosed OA (hip, knee, hand, or feet) is projected to increase from 7% in 2011, to 12% in 2040. The prevalence is generally highest around the age of 75 years (prevalence of 4–5% for hand OA, 6% for hip OA, and 16–17% for knee OA). The coming decades will witness an increase in the prevalence of OA, making it become one of the most frequent diseases. Knee OA is ranked 15th in Western Europe for year's life lost due to disability (IHM 2015). (Figure 1).

Pain is the predominant symptom in OA and is a major driver of clinical decision making and health costs. With pain-modifying treatment the majority of patients can be managed well, but when this is unsuccessful and the patient is significantly disabled, joint replacement may be a good option. Joint replacement surgery is a clinically appropriate and cost-effective treatment for end-stage OA of the knee and hip. The prevention of OA is in its infancy, but joint injury, obesity and impaired muscle function are modifiable risk factors amenable to primary and secondary prevention strategies, including lifestyle change (reduction of body weight and increased exercise, such as walking and riding a bike) (Roos and Arden 2016).

3.2 Inflammatory joint disease

a- Rheumatoid arthritis

Rheumatoid arthritis (RA) is a chronic autoimmune disease that causes pain, stiffness and swelling in multiple joints, especially the hands. The disease may also affect other organ systems of the body. The cause of RA is still not clear. It is believed to involve a combination of genetic and environmental factors. The incidence of RA is 20–300 per 100000 subjects per year, whilst that of the juvenile form of RA is 20–50 per 100000 subjects per year (WHO TRS 919). The prevalence of RA in most industrialized countries varies between 0.3% and 1%.

The goals of treatment of RA are to reduce pain, decrease inflammation and improve a person's overall functioning. This may be facilitated by balancing rest and exercise, the use of splints and braces, or the use of assistive devices. Pain medications and steroids are frequently used to reduce symptoms. Disease-modifying antirheumatic drugs (DMARDs), such as hydroxychloroquine and methotrexate, may be used to try to slow progression of disease. Biological DMARDs may be used when disease does not respond to other treatments. Biological DMARD agents used to treat rheumatoid arthritis include: tumor necrosis factor alpha (TNFα) blockers such as infliximab; interleukin 1 blockers such as anakinra, monoclonal antibodies against B cells such as rituximab, and tocilizumab, and T-cell co-stimulation blockers such as abatacept.

However, these drugs may be more likely to cause adverse effects and are rather expensive. Surgery to repair, replace, or fuse joints may help patients with significant damage in a joint with severe symptoms. Over recent years the need for surgery has decreased because of effective and early drug treatment of RA.

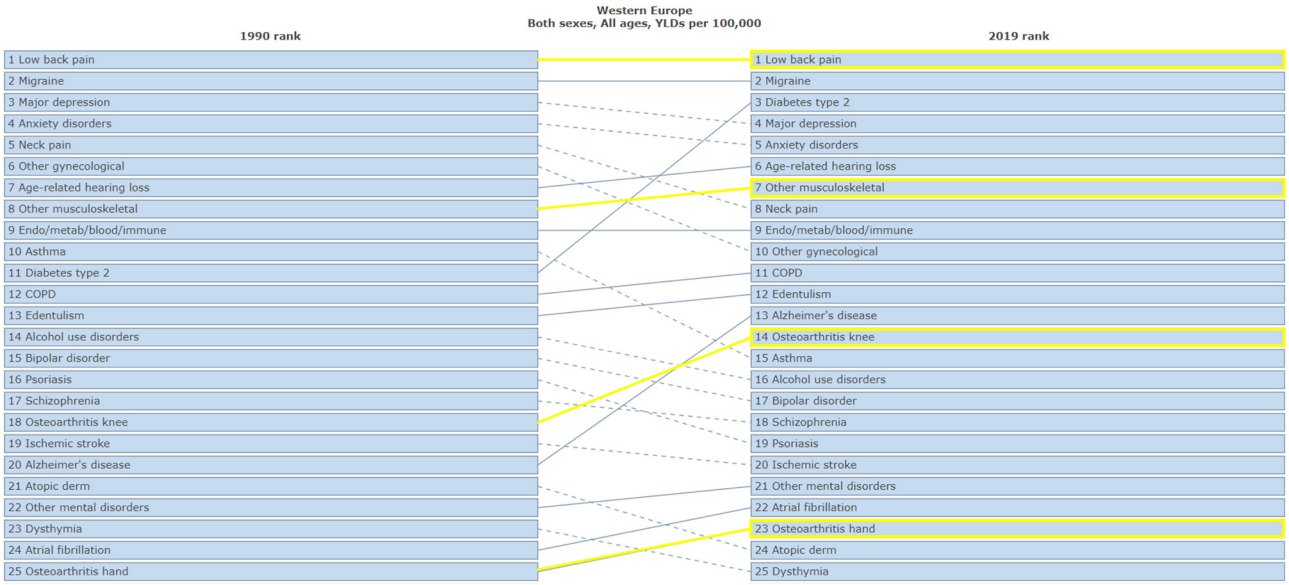

Figure 1. Ranking of conditions on basis of Years of life disabled (YLD).
Osteoarthritis of the knee ranked 14th in 2019 compared to 18th in1990. Available at: https://vizhub.healthdata.org/gbd-compare/. Assessed September 2021.

b- Juvenile arthritis

Arthritis and other rheumatic conditions are relatively uncommon in children. Juvenile (disease onset before age 16 years) idiopathic arthritis (JIA) is the most common, chronic rheumatic disease of childhood, affecting approximately one per 1000 children. JIA is an autoimmune, noninfective, inflammatory joint disease. It is differs significantly from the RA commonly seen in adults.

c- Spondyloarthropathies

Spondyloarthropathies are a cluster of overlapping and interrelated chronic inflammatory rheumatic disorders, in which joint disease also affects the vertebral column. Examples include ankylosing spondylitis, reactive arthritis, psoriatic arthritis, enteropathic arthritis (associated with ulcerative colitis or Crohn's disease) and juvenile spondylarthritis. They have an increased incidence of HLA-B27, as well as being negative for rheumatoid factor and antinucleic antibodies.

d- Gout and other crystal arthropathies

Gout is a disease caused by an excess uric acid in the body. Urate crystals are deposited in some joints leading to an inflammatory reaction. Gout most often affects the joint of the great toe and is characterized by recurrent attacks of painful, red, tender, warm, and swollen joints. It is more common in men, in whom it is the most common cause of inflammatory arthritis and affects almost as many subjects as RA. Gout occurs frequently in patients with metabolic syndromes (patients who also have diabetes, hypertension, and obesity).

Other crystal arthropathies can be caused by deposits of calcium pyrophosphate dihydrate (CPPD) crystals in the joints and have symptoms similar to gout. CPPD deposition disease is less common than gout, although radiographic chondrocalcinosis is common in older adults.

e- Fibromyalgia

Fibromyalgia is a syndrome of widespread musculoskeletal pain and tenderness. The diagnosis is difficult to make with certainty. Other symptoms are fatigue, sleep, memory and mood issues. Symptoms often begin after physical trauma, surgery, an infection or significant psychological stress. In other cases, symptoms gradually accumulate over time with no single triggering event. Women are more likely to develop fibromyalgia than are men. Many people who have fibromyalgia also have tension headaches, temporomandibular joint (TMJ) disorders, irritable bowel syndrome, anxiety and depression. There is no known specific cure for fibromyalgia. Exercise, relaxation and stress-reduction measures may help.

f- Systemic lupus erythematosus

Systemic lupus erythematosus (SLE) is an autoimmune disease in which the body's immune system turns upon its host and may attack many body systems, especially the skin, kidneys, and joints. Symptoms vary between people but may be severe. Common symptoms include painful and swollen joints, fever, chest pain, hair loss, mouth ulcers, swollen lymph nodes, feeling tired and a red rash, which is most commonly seen on the face. There are periods of illness and periods of remission, during which there are few symptoms. The cause of SLE is not clear. There is no known cure for SLE.

Treatments may include NSAIDs, corticosteroids, immunosuppressants, hydroxychloroquine and methotrexate. SLE significantly increases the risk of cardiovascular disease, this being the most common cause of death. The incidence of SLE varies between countries, from 20 to 70 per 100000.

g- Systemic sclerosis

Systemic sclerosis, or scleroderma, is an autoimmune disease that primarily affects the skin but can affect any organ system. It is characterized by diffuse fibrosis and vascular abnormalities affecting the skin, joints, and internal organs. Specific treatments are difficult to identify, and the emphasis is often on the treatment of complications.

h- Primary Sjögren's Syndrome

Primary Sjögren's Syndrome is a syndrome of dry eyes, dry mouth, and arthritis. Secondary Sjogrens syndrome can occur in association with other rheumatologic diseases such as RA and lupus. Sjögren's syndrome can affect various exocrine glands or other organs. Treatment is usually symptomatic.

i- Polymyalgia rheumatica and giant cell (temporal) arteritis

Polymyalgia rheumatica (PMR) is a syndrome of rapid onset of aching and stiffness, usually in the neck, shoulders, upper arms, and hips, in older adults. It responds to treatment with anti-inflammatory medications (e.g., corticosteroids). Most people with PMR wake up in the morning with muscle pains. Giant cell arteritis (GCA), which often occurs with PMR, is a type of vasculitis that affects medium-size arteries and results in headache, vision loss, and other symptoms.

j- Soft tissue disorders (excluding back pain)

These are a variety of problems of the tendons, bursae, muscles, ligaments and fascia that cause pain and dysfunction. The prevalence of soft tissue disorders is difficult to determine due to the variety of conditions included.

k- Tendinopathy

Tendinopathy is a type of tendon disorder that can cause pain, swelling, and impaired function. The pain is related to movement. Frequent locations are the shoulder (rotator cuff tendinitis, biceps tendinitis), elbow (tennis elbow, golfer's elbow), wrist, hip, knee (jumper's knee, popliteus tendinopathy), and ankle (Achilles tendinitis). It may be rendered symptomatic by an injury or repetitive activity. Treatment may include rest, NSAIDs, splinting, and physiotherapy. Tendinopathy occurs relatively frequently. Older people are more commonly affected.

4. Non-Surgical Treatment

Non-surgical treatment is often called conservative therapy. Its aims are to reduce pain, decrease inflammation and improve a person's overall level of function. This may be realised by exercise, the use of splints and braces, or the use of assistive devices. Pain medications and steroids are frequently used to reduce symptoms. Physiotherapy is important to stimulate exercise and instruct on technique. Lifestyle improvement is also an important element of non-surgical treatment (McAlindon et al. 2014).

5. Surgical Treatment

Depending on the severity of the (radiological) OA, the following orthopaedic surgical interventions are possible (Verhaar and Van Mourik 2021).

a- Arthroscopic lavage and debridement

In an arthroscopic procedure, damaged cartilage or bone is removed and the joint is rinsed to remove any debris from the affected joint. The aims are on the one hand anti-inflammatory (dilution of the inflammatory enzymes) and on the other hand mechanical (smoothing of cartilage irregularities). After years of research, including placebo-controlled trials, it has become evident that there are hardly any indications for arthroscopic debridement procedures. In placebo-controlled trials, the surgical treatment fares no better than the natural course of the condition (placebo treatment). Only in the case of locking of the knee due to a loose body is there a clear indication for arthroscopy in OA.

b- Osteotomy

The aim of an osteotomy is to relieve the overloaded compartment of the knee or to transfer load to a relatively unaffected part of the joint. Severe OA of all compartments of the knee, as occurs in RA, is a contraindication for osteotomy. Eight out of 10 young patients undergoing osteotomy can postpone an arthroplasty procedure (total or unicompartmental knee arthroplasty) by at least 10 years.

c- Arthrodesis

An arthrodesis fuses the two bones forming the joint, abolishing the joint and all of its movement. The aim of an arthrodesis is to take away joint pain by preventing movement. An arthrodesis can be performed on any joint and, depending on the location, leads to excellent pain relief and functional gains (through increased use). Examples of joints commonly fused are the wrist and ankle. However, as there is no movement in the joint any more, arthrodesis of the knee and elbow joint leads to considerably disability even though pain disappears.

d- Joint replacement prosthesis:

Joint implants have been developed for almost all joints. The best long-term results are achieved with hip and knee replacements. Although this surgical therapy for hip and knee OA gives predictable results (85-90 % average prosthesis survival after 15 years in people older than 65 years at the time of implantation), there are also disadvantages. Wear will occur on the bearing surfaces (polyethylene, metal or ceramics or a combination), which eventually may have to be replaced. In addition, the wear particles produced by joint activity are phagocytized ('eaten') by macrophages, which are activated to initiate a chain of events that ultimately may induce prosthetic loosening.

While joint replacement surgery is mainly carried out among people aged 60 and over, it can also be performed on people at younger ages.

6. List of Activities Needed

- Degenerative and inflammatory joint diseases are highly prevalent in Europe leading to severe long-term pain and disability, in turn leading to reduction in the quality of life. The impact on cost of health care is large but economic costs are also high due to loss of working days and incapacity, as well as the reduced capacity to perform daily activities.
    - Increased awareness of these diseases is important in order to stimulate the organisation of a program of prevention, improved treatment and access to appropriate medical and surgical treatment.
- Joint injury, obesity and impaired muscle function are modifiable risk factors, amenable to primary and secondary prevention strategies including lifestyle changes.

    - Prevention programmes should be developed to reduce body weight, prevent injury of the joints and improve participation in activities such as walking and cycling.
- Several orthopaedic surgical procedures are very effective. There has been a large increase in the number of implantations of joint prostheses, with excellent results in terms of both the reduction of symptoms and in prosthesis survival. Further increases are expected because of ag ing of the population. However, there are differences in the rate of utilisation of procedures in the different European countries.
    - The quality of surgical procedures used for joint diseases should be standardized and access for the European population to obtain the correct procedure in a timely fashion should be guaranteed. Quality control of implants used should be improved. National and transparent implants registers are important and essential for quality improvement.

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Section 2

C | Musculoskeletal Infections

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1. Summary

Musculoskeletal infections represent the most burdensome and devastating of pathologies in orthopaedic surgery. Clinical manifestations vary from isolated, localized infection to severe, systemic infection. Prosthetic joint infection (PJI), osteomyelitis, infected non-unions, septic arthritis, spine infections and skin and soft tissue infections are the most common septic complications in orthopaedic clinical practice. These musculoskeletal infections result in patient morbidity, higher mortality and higher healthcare expenditure. Although some causes of musculoskeletal infection, such as tuberculosis, are becoming less common, others, such as prosthetic infections, continue to severely affect everyday orthopaedic practice and have a detrimental effect on patients' quality of life. In the paediatric population, osteomyelitis and septic arthritis are the most common forms of musculoskeletal infections. With a population with an increasing life expectancy, and well-meaning efforts to ameliorate the quality of life by offering joint replacements, the number of these prosthetic joint replacements is steadily increasing. In tandem, prosthetic joint infections are also increasing and they represent one of the most common reasons for arthroplasty revision. This imposes a considerable burden both on patients and indeed the whole healthcare system. The implications of PJI mean that awareness should be raised among physicians, the public, as well as research-funding agencies and policy-makers.

2. Introduction

Over recent decades, musculoskeletal infections have increased in incidence and severity. Death from infectious disease remains a substantial challenge for orthopaedic surgeons worldwide. Although overall mortality has decreased since the early 1900s, death due to antimicrobial-resistant organisms is increasing (Zalavras and Schmitt 2016). The mortality rate for patients with a periprosthetic joint infection (PJI) is higher than that of five of the most commonly diagnosed cancers (Berend et al. 2013, Zmistowski et al. 2013).

The clinical picture of musculoskeletal infection ranges from isolated osteomyelitis to multi-site infections with severe systemic complications. The most significant musculoskeletal infections that an orthopaedic surgeon has to cope with include osteomyelitis, septic arthritis, soft tissue infections (including myositis), periprosthetic joint infections and some more specific conditions such as Lyme disease and tuberculosis. Osteomyelitis, infected non-unions, infections of both native and prosthetic joints, spine infections and skin and soft tissue infections are the most common septic complications in orthopaedic clinical practice. It is of great importance to raise awareness about the socio-economic burden of musculoskeletal infections among physicians, the public as well as research-funding agencies and policy-makers.

As the population ages and more patients undergo orthopaedic procedures in advanced age, adverse events also increase. In addition, we face the threat of the emergence and spread of multi-drug-resistant bacteria and nosocomial infections, which increase morbidity and mortality rates. More than 2 million hospital-acquired infections are reported annually in the European Union, one-third being surgical site infections (SSIs). A report from the World Health Organization (WHO) reported a 3% to 21% prevalence of nosocomial infections; 5% to 34% of the total were SSI's leading to a substantial increase in costs; additionally, these patients have a mortality rate 2.2 times higher when compared to patients without infection.

Of great importance is the economic significance of orthopaedic infections. Besides mortality, musculoskeletal infections are also a leading cause of patient morbidity and higher healthcare expenditure. Additionally, musculoskeletal infection is a leading cause of chronic pain and physical disability. The incidence of musculoskeletal infection, including PJI, soft-tissue infection, septic arthritis and osteomyelitis is increasing in the context of an ageing population and increasing rates of diabetes and obesity. Reducing the cost of treating musculoskeletal infection also depends on incentivising innovations in infection prevention (Hackett et al. 2015). Postoperative orthopaedic infections result in substantial morbidity for patients, both physically and mentally. In addition, the cost of care is considerable, given the outlay on surgical, medical and social resources that is required. Costs associated with the management of musculoskeletal infections vary widely but are higher than those associated with the preceding interventions, such as elective joint arthroplasty or fracture treatment. Infections requiring surgical intervention, such as osteomyelitis and septic arthritis, have higher costs than those not requiring such intervention, such as bacteraemia and surgical site infection. The treatment of necrotising fasciitis can be particularly costly, with charges ranging from $20,000 to $866,000 per episode and an overall mortality rate of 10%.

3. Osteomyelitis and Septic Arthritis

Osteomyelitis is an inflammatory reaction of the bone due to infection, most often bacterial. Infection can involve the bone marrow, cortex, periosteum or surrounding soft tissue, leading to destruction of any, or all, of these anatomic structures. In the US, the overall incidence of osteomyelitis increased from 11.4 cases per 100,000 person-years in the period from 1969 to 1979 to 24.4 per 100,000 person-years in the period from 2000 to 2009 (Kolinsky and Liang 2018). There has been an increase in the rate of osteomyelitis, mainly in patients with comorbidities, the elderly, and type-B and C hosts (Edwards et al. 2008). During the last 40 years, osteomyelitis incidence rates almost tripled among the elderly, with the overall risk of death increasing at least 2.5-fold (Edwards et al. 2008). Amputation is more frequent in patients with diabetes-related osteomyelitis (60%) than in those with haematogenous osteomyelitis (6%) or in those with direct (contiguous) osteomyelitis (24%) (Winkley et al. 2007). Amputation can result in permanent handicap, depression and unemployment. Unfortunately, data about the socioeconomic impact of osteomyelitis remain scarce.

Osteomyelitis and septic arthritis are the most common forms of paediatric musculoskeletal infection and most commonly occur in the first decade of life in previously healthy children. Lyme disease is caused by a bite from a deer tick and is less common than osteomyelitis and septic arthritis. However, there is an overlapping clinical and laboratory manifestation of Lyme arthritis and septic arthritis. From an epidemiological viewpoint, it is more prevalent in the North-eastern and Midwestern regions of the United States and in North European countries (Willis et al. 2003). Most published data come from the US, and epidemiological studies have characterised Lyme disease and arthritis as a 'not so common' condition in most European countries (Schmid 1985, Stein 2019). Nevertheless, regarding its distribution in Europe, available data suggest that transmission is most acute in Central and North-eastern Europe (Mead 2015).

Tuberculosis (TB) has become much less common in the United States over the last few decades, but has increased in incidence in developing countries secondary to immunodeficiency and the emergence of multi-drug resistant variants (Rasool 2001). TB infections involve the musculoskeletal system in 2% to 5% of cases (Rasool 2001). Community-acquired Staphylococcus aureus is the most common infecting organism in paediatric musculoskeletal infections. Over the past decade methicillin-resistant Staphylococcus aureus (MRSA) has become more prevalent, and the disease course for patients with this infection is much more severe, with more profound systemic disease requiring multi-modal and multidisciplinary treatments involving medical, surgical and critical care (Copley 2009). Patients are often hospitalised for extended periods, and most require continued care with long-term antibiotic treatment after discharge. Over the 13-year period from1988 to 2000 in the U.S., there was a trend toward decreased healthcare utilisation in paediatric patients with pyogenic arthritis, but no decrease in costs. Complications of musculoskeletal infections in children include growth deformity, fractures and arthritis, along with long-term morbidity and dysfunction.

4. Biofilm Associated Implant Infections

Biofilm associated implant-related bone and joint infections are clinically important because of the extensive morbidity, cost of care and socio-economic burden that they cause (Lamagni 2014, Kapadia et al. 2016). A biofilm can be described as a complex and well-structured aggregation of microorganisms of single or multiple species. Biofilms are tolerant to antimicrobial agents and evade the host immune system. All materials used in orthopaedic implants are vulnerable to the attachment of biofilm-forming bacteria. As a result, research interest in biofilm has expanded over the past two decades; however, there are many gaps in our knowledge regarding these infections. Around two thirds of all human infections are believed to be biofilm-related. Bacterial attachment can occur intra-operatively, post-operatively, or even on a delayed basis. This attachment places implants at risk of surgical site infections. After attachment occurs, biofilm formation gradually leads to infection development. These biofilm-associated infections are among the most common causes of failure of orthopaedic implants. Clinically, biofilm-associated infections are characterised by a wide range of symptoms but with a paucity of symptoms and signs in the individual patient (Saeed et al. 2019).

PJI is the third most frequent reason for revision of total hip arthroplasty and one of the most frequent reasons for revision of total knee arthroplasty (14.8% and 25.2%, respectively). Revision procedures for infection are associated with longer operative time, more blood loss and a higher number of complications compared with revisions for aseptic loosening or primary total hip arthroplasty ($p < 0.02$) (Bozic and Ries 2005).

In terms of total knee arthroplasty, the Swedish Knee Arthroplasty Register reported that the number of primary total knee arthroplasties increased five-fold from 1990 to 2010, with a subsequent rise in the need for revisions for PJI. In particular, joint replacements in immuno-compromised patients account for PJI rates higher than 5%, and patients with revised total joint replacements have infection rates that may exceed 7%. In the 2012 report from the Swedish Hip Arthroplasty Register, PJIs were the second most common reason for revision surgery (Rolfson et al. 2012). According to the Swedish Knee Arthroplasty Register, which has followed patients for 20 years, the prevalence of PJIs increases the longer patients are followed-up (Robertsson et al. 2014). The rate of PJIs in the U.S. between 2000 and 2009 was 2.0% for total hip replacements, 2.4% for total knee replacements and increased over time. The annual cost to U.S. hospitals for revision of orthopaedic implants for infection increased from $320 million to $566 million during the study period and was projected to exceed $1.62 billion by 2020 (Kapadia et al. 2014). The rate of PJIs was 1.4% in 2005, and the rate is anticipated to reach 6.5% for total hip arthroplasty and 6.8% for total knee arthroplasty by the end of the next decade. This is expected to result in more hospitalisations, readmissions and clinic visits, thus requiring substantial health-care funds, which will be redirected to fewer patients. Furthermore, mortality after septic revision arthroplasty is 2.5 times higher than mortality after aseptic revision at 3 months (3.7% compared with 0.8%, respectively), at 1 year (10.6% compared with 2.0%, respectively), at 2 years (13.6% compared with 3.9%, respectively) and at 5 years (25.9% compared with 12.9%, respectively) (Zmistowski et al. 2013).

The National Joint Registry for England, Wales, Northern Ireland and the Isle of Man (NJR) reported that the prevalence of revision due to PJI in the three months following primary hip arthroplasty rose 2.3-fold between 2005 and 2013, and 3-fold following revision hip arthroplasty (Lenguerrand et al. 2017). In the part of the UK that the NJR covers, over 1000 procedures are performed annually as a consequence of hip PJI, an increase of 2.6-fold between 2005 and 2013. Respectively, for knee replacements in the same period, the prevalence of revision due to PJI in the first 3 months after primary procedures rose by 2.5-fold and 7.5-fold following revision procedures. Moreover, recent data from the UK registry shows that it is worth noting the difference in average cost of inpatient and day case admissions in the 5 years following primary THA, between patients revised for PJI and all other reasons (Garfield et al. 2020). This difference in cost was estimated to be around £33,452 per case.

It is well established nowadays that PJI has an important effect on quality of life (QoL). Helwig et al. demonstrated that QoL is substantially reduced after a prosthetic infection (Helwig et al. 2014). They compared patients' QoL data after PJI to that of the general population and found a significant difference on the physical scale but not the mental scale.

Regarding minimally invasive orthopaedic procedures, such as shoulder arthroscopy, infections are rare but present. A prevalence of 0.85% has been reported in large institutions performing together more than 3,000 arthroscopic rotator cuff repairs. Male sex, age >60 years, smoking and longer surgical duration are all associated with increased infection (Chen et al. 2017).

Bone and joint infections are a relatively rare cause of attendance at the Emergency Department. Atypical and nonspecific presentations can be misleading, and definitive diagnosis of infection is challenging, often requiring invasive and time-consuming procedures.

5. Prevention of Prosthetic Joint Infections

Various issues have been addressed in an attempt to reduce the burden posed by PJI. The best way to achieve this is to identify patients who are at risk of developing PJI and by modifying the associated risk factors in the pre-operative period, the intra-operative environment and the peri-operative period. However, despite these efforts, the burden of prosthetic joint infection remains considerable.

The predisposing factors that can truly contribute to a decrease in PJI are the modifiable ones. In particular, those most amenable to an impact are those that can be identified and altered or controlled during the pre-operative period. The most important patient-related factors include obesity, diabetes, malnutrition, smoking and comorbidities such as inflammatory arthropathies (Alamanda and Springer 2019). Furthermore, proper surgical site preparation, along with a sterile operating environment with limited theatre traffic, is of major importance. In terms of medications, the administration of optimal antibiotics as close to the moment the incision is made as possible, and avoidance of aggressive anticoagulation, are also of paramount importance.

Periprosthetic joint infection starts with bacterial colonization of the implant surface. The development and application of novel prosthetic coatings to inhibit antibacterial activity on implant surfaces has been under investigation during the last decade. Several approaches have been proposed for the prevention of bacterial adhesion, such as antiadhesive polymers, nano-patterned surfaces and hydrogels, as well as coatings with bactericidal properties utilizing silver, titanium dioxide, copper, selenium and coated or covalent antibiotics, antimicrobial peptides, cytokines and enzymes; multi-layered coatings, positive-charged polymers and multi-functional smart coatings with nanocontainers (Perry and Hanssen 2017). Also, recent advances in local antibiotic delivery platforms for preventing PJI include titanium nanotube arrays, synthetic polymers, resorbable hydrogels and cyclodextrin-based drug delivery options (Levack et al. 2018).

To summarise, life expectancy has increased over the last 2 decades; an ageing population and a growing demand for novel medical technology have added a significant burden to health-care budgets (Kurtz et al. 2012). The expanding use of orthopaedic implants, in addition to the increasing trend to perform operations on high-risk patients (advanced age, diabetes or other comorbidities), have an additional effect increasing rates of infection following joint replacement and increasing post-traumatic infections, with subsequent expanded costs, longer hospital stays and rehabilitation courses, and loss of productivity (Bozic et al. 2010). Orthopaedic Societies should raise awareness of this important issue among the public, governments and healthcare agencies, aiming at better diagnosis, prevention and treatment.

6. List of Activities Needed

- More than 2 million hospital-acquired infections annually are reported in the European Union, one-third being surgical site infections.
- Musculoskeletal infections are a leading cause of patient morbidity, mortality and higher healthcare expenditure.
- Costs associated with the management of musculoskeletal infections are higher than those associated with preceding interventions, such as elective joint arthroplasty or fracture treatment.
- Osteomyelitis and septic arthritis are the most common forms of paediatric musculoskeletal infections and most commonly occur in the first decade of life in previously healthy children.
- The mortality rate for patients with a periprosthetic joint infection is higher than that of five of the most commonly diagnosed cancers.
- Various issues related to pre-operative management, the intra-operative environment and post-operative follow-up can be addressed in an attempt to reduce the burden of musculoskeletal infections.

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Section 2
D | Injuries

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1. Summary

Musculoskeletal trauma refers to injuries of the spine, pelvis and extremities and is primarily managed by Orthopaedic Surgeons. Its burden to society is tremendous and involves both direct costs (related to the healthcare provided) and indirect costs, such as the long-lasting consequences of physical and psychological impairment to citizens, loss of income and employment and therefore reduced taxpayer contributions. Currently, there are scarce statistics to estimate the scale of the problem, which is huge. If the numbers are not known, then prompt actions that will save money and provide optimal health care cannot be implemented. One solution could be National Trauma Registries: these are databases that collect such information in a systematic way. The EuroTARN project was started in 2005 to enable EU Member States to create such registries and to combine them at a Federal Level. It has stalled and needs political support to complete.

The next step would be to incorporate into these registries information provided by the patients after they have been discharged from hospital, in the form of self-evaluation questionnaires, known as Patient Reported Outcome Measures (PROMs). The message here is that we need to know how patients are coping after trauma, what are their residual issues and limitations, and how to address them. This is crucial, as one needs to know what the long-term effects of trauma are as perceived by the patients themselves. When this is known we can implement strategies to improve their functional capacity, increase their chances of returning to work and as a by-product return them to being a productive taxpayer.

Within a State, there exist different hospitals that have different capabilities. When a patient is injured, they should go to the most appropriate hospital within the accessible region, according to the level of care they need. Throughout many EU Member States there is no organization of the hospitals, and patients receive almost random levels of care, which is frequently not the most appropriate for their specific injury. This is a waste of money and resources, often resulting in transfers to other hospitals. Therefore, hospitals that have different capabilities should organise into groups, within a specific region, which together can provide all care required and thus become a part of a "Regional Trauma Network". The right patient should reach the right hospital at the right time, therefore minimizing delays, prevent long-term disability, saving life and unnecessary costs. A strong political will is required, firstly at a European level, with Federal recommendations and guidance to be implemented across Europe. This guidance should include specific definitions of the standards of care required of each hospital that is a member of any of the EU Member States Regional Trauma Networks.

2. Introduction

The socioeconomic burden of trauma involving the spine, pelvis and extremities, also known as "musculoskeletal" or "orthopaedic" trauma, is incredibly onerous to the European Community. A recent systematic review and meta-analysis of the literature (which collects data from multiple studies available and is considered as one of the highest levels of evidence), confirmed that the impact to society and economic burden of orthopaedic trauma is huge. Among other important observations, it transpires that 13% of patients who sustain a fracture may lose their employment secondary to their injuries (O'Hara, Isaac 2020). The impact on the patient is immense (loss of productivity/income), as it is on the health care system, the tax payer and the society as a whole. Pain and associated physical impairment, as well as psychological distress, are very common long-lasting consequences of musculoskeletal injuries (Rosenbloom et al. 2013).

It is critical to describe the current situation with regard to the impact on the healthcare system of orthopaedic trauma, providing an assessment of the magnitude of the burden, and highlighting the most critical issues that are relevant for now and for the future of Europe. It is also important to identify what data we are currently not monitoring or are missing, and to provide specific recommendations that will hopefully address the issues identified and stimulate fruitful consultations and actions for the future.

3. Definition and Description

An *injury* is a general term that refers to an episode of damage caused to the body by any of many different causes, and can involve all possible parts of the body, including, for example, the brain and the internal organs. When an injury involves the bones and joints of the upper and lower extremities, spine, or pelvis, it is termed orthopaedic injury, and these are primarily managed by orthopaedic surgeons, although for the very minor ones, emergency room physicians and general practitioners may provide definitive care. On the other hand, rheumatologists deal with a group of painful conditions involving the spine and extremities, which are not caused by specific injuries, but usually by internal causes which involve faults within the immune system, and thus may also involve other tissues of the body, including the skin, eyes, nervous system and internal organs. In this chapter, we are focusing on orthopaedic injuries involving the upper and lower extremities in adults, and the terms "orthopaedic injury or trauma", "musculoskeletal injury or trauma" will be used interchangeably throughout. Of note, paediatric and spine injuries will be covered in their own separate chapters.

A definition of orthopaedic injuries:

There are different types of injuries:

I Fractures: These occur when a bone is broken. They can potentially involve any or every bone in the body, but in orthopaedic trauma we are mainly dealing with fractures of the long bones in the upper and lower extremities, the spine and pelvis. There are several types of fractures, which have different degrees of severity and require different treatments, including bone surgery.

II Dislocations: Two or more bones unite together at a point to form a *joint*, where they are closely associated together, and move relative to each other in order to produce the various movements of the joint, as seen for example at the shoulder. A *dislocation* happens when one of these bones disassociates from the other, the "ball is forced out of the socket", such as occurs in the example of a dislocated shoulder.

III Sprains and Strains: These terms refer to injuries that cause stretching or tearing of a structure. When a ligament is involved, it is called a "*sprain*", such as when the ankle is twisted (ankle sprain), and when a muscle suffers such an injury, it is called a muscle "*strain*".

IV Contusions: This is synonymous with a "*bruise*": Contusions result typically from blows that do not break through the skin, but damage the blood vessels beneath it, resulting in bleeding beneath the skin, changing its colour. Most are typically of minor

importance but sometimes they can be significant in orthopaedic trauma, causing extensive tearing and damage of the soft tissues beneath intact skin, a condition called "degloving". These bruises can also occur in the deep internal organs and even within the bones themselves.

V Traumatic Amputations: These refer to losing a body part, typically when a limb is traumatically detached from the body.

Various types and settings of injuries:

There are several different variables that can be used to further categories injuries:

- *Intentional* (versus unintentional)
- *Falls, road traffic injuries* (including pedestrians, bicycles, motorcycles and cars), *natural disasters, gunshot injuries*
- According to the setting: Workplace injuries, Sports injuries and military injuries

Major trauma:

The term "Major trauma" refers to an injury (or a combination of injuries) that have the potential to be life-threatening and life-changing, leading to long-term disability. In medical language it is defined by using the injury severity score (ISS) calculation with a score of ≥16 (Baker et al. 1974).

4. Epidemiology

Diseases are reported using the ICD system *(WHO 2021)* (International Statistical Classification of Diseases and Related Health Problems (ICD)) developed by the World Health Organization (WHO): this assigns a specific code for each component of injury. For example, a shoulder dislocation would be designated as "S43.015A", and this is submitted to health insurance companies, governmental authorities and registries, and is used to calculate epidemiological data. Readers must acknowledge sources of bias when interpreting the reported frequency of Musculoskeletal Disease (MSD), and their contribution to quality-adjusted life years (QALY), disability-adjusted life years (DALY), years of life lost (YLL) and other key indicators of global national and international health (WHO 2021). In our experience, in the public National Health Care System (NHS) system of the UK, the ICD codes are not accurately reported, the main reason being that the system is public and re-imbursement is fixed and not dependant on accurate coding. This however, creates problems because no one can truly accurately calculate the magnitudes of the various conditions and the burden they impose.

Epidemiology of injuries and fractures in Europe

a. Eurostat and European Section of the WHO

Accident and injury statistics across Europe can be derived from https://ec.europa.eu/eurostat/statistics-explained/index.php/Accidents_and_injuries_statistics and https://www.euro.who.int/en/health-topics/disease-prevention/violence-and-injuries/data-and-statistics, although most data appear *out of date* (most recent entries were made in 2017). Some statistics for musculoskeletal diseases are also found in the EUMUSC.NET project (www.eumusc.net), however this collects information on all diseases but omits orthopaedic trauma. Once more, none of these statistics is specific to the burden of orthopaedic trauma, as accidents comprise a variety of injuries including, for example head injuries, electric shock, drowning, etc. which are not managed by orthopaedic surgeons.

Musculoskeletal injuries, i.e. orthopaedic trauma, comprise a heterogeneous group of conditions ranging from fragility fractures of the spine, occurring without exterior impact, osteoporotic fractures of the proximal femur or distal radius, caused by minimal trauma, through to fractures of the healthy femur or tibial shaft caused by high-energy impact. These are not monitored/reported separately, at a European Federal level, which makes their quantification difficult. To illustrate this, just by looking at the European health report in 2018, there is no mention of the word "musculoskeletal".

b. Trauma registries

- What is a trauma registry? It is a *database* that has information collected in a systematic way about traumatic injury to patients and includes information about their acute hospital care and, rarely, some follow-up data collected after their discharge from the hospital (Turner et al. 2019).
- Why do we need a trauma registry? It has the capability of differentiating the different types of injuries and providing reliable statistics in order to be able to understand what is happening to injured patients to enable us to take the necessary measures to more efficiently provide services, by cutting unnecessary expenses and optimizing treatment.

The largest trauma registry in Europe is the *UK Trauma Audit and Research Network (TARN®)* (Turner et al. 2019). Other important registries exist, such as the German TraumaRegisterDGU®, the French Traumabase® and others.

An effort to create a European registry following the example of the UK has been named the "EuroTARN" initiative (https://ec.europa.eu/transport/road_safety/specialist/knowledge/postimpact/references_en#Ref_20_EuroTarn_2005) (European Commission 2021). However, one problem is that since this project was initiated as far back as 2005 by 14 participating countries, the majority of EU countries do not have their own national trauma registry and there is limited communication of data between individual countries and the European Commission. In contrast, major trauma registries such as the German TraumaRegisterDGU® (http://www.traumaregister-dgu.de/index.php?id=142) focus on immediately life-threatening injuries (e.g., head injuries, thoracic trauma, pelvic injuries with uncontrolled haemorrhage), but may lack detailed information on individual bone fractures. The prevalence of fractures in various cumulative reports of the TraumaRegisterDGU® is summarized in Table 1.

The *Swedish Fracture Register* (https://sfr.registercentrum.se/) may currently represent the only dedicated national data record system documenting all bone fractures regardless of their aetiology and cause.

Its annual report of 2019 (https://registercentrum.blob.core.windows.net/sfr/r/VGR0050_SFR_-rsrapport-2019_Digital-1-uppslag-BJI2qw9v38.pdf) lists the eight most frequent fracture sites stratified by gender, age (<60 years and ≥60 years) and treatment (surgical versus non-surgical). The source population remains uncertain however. Assuming all fractures occurred in the year 2018, given a total Swedish population of 10.12 million, their estimated incidence based on rough numbers derived from published bar charts is illustrated in Table 2. These estimates may be representative at least for North-Western Europe.

Table 1. Prevalence of fractures amongst patients with multiple trauma, compared to injuries of the major body cavities and or AIS regions.

Source: Data derived from various analyses of the German TraumaRegister DGU®. Point estimates with 95% CIs recalculated based on reported denominators and numerators. Accessed February 2021.

Anatomic site	Record year	Population size	No. of injuries	Prevalence (95% CI)
Head	2017 – 2019	98671	45572	46.2% (45.9 – 46.5%)
Face	2017 – 2019	98671	10861	11.0% (10.8 – 11.2%)
Neck	2017 – 2019	98671	1540	1.6% (1.5 – 1.6%)
Thorax	2017 – 2019	98671	44482	45.1% (44.8 – 45.4%)
Abdomen	2017 – 2019	98671	14173	14.4% (14.1 – 14.6%)
Spine	2017 – 2019	98671	29059	29.5% (29.2 – 29.7%)
Pelvic ring	2017 – 2019	98671	14902	15.1% (14.9 – 15.3%)
Hand and forearm	2007 – 2017	139931	50459	36.1% (35.8 – 36.3%)
Tibia, closed	2002 – 2013	39664	2000	5.0% (4.8 – 5.3%)
Tibia, open	2002 – 2013	39664	2940	7.4% (7.2 – 7.7%)
Foot	2002 – 2014	34091	2532	7.4% (7.2 – 7.7%)

Table 2. Estimated annual incidence of (traumatic) long bone fractures, regardless of gender, age, and treatment, and numbers in the Swedish Fracture Registry

Source: Svenska Frakturregistret. Årsrapport 2019. Available at: https://registercentrum.blob.core.windows.net/sfr/r/VGR0050_SFR_-rsrapport-2019_Digital-1-uppslag-BJl2qw9v38.pdf. Accessed February 2021.

Fracture site	Incidence / 10,000
Distal radius	21.2
Hand	16.4
Elbow	5.9
Proximal humerus	10.2
Clavicle	4.2
Humeral diaphysis	1.4
Forearm	1.0
Scapula	1.4

c. Patient Reported Outcome Measures (PROMs) (Rosenberg et al. 2018, Turner et al. 2019)

Although the development of registries tells us what has happened, for example what were the accidents, ages and genders of the patients, what were the injuries sustained and whether patients survived or not, the registries do not tell us how the quality of life of the patients that have been discharged from the hospital is affected. Therefore, measurement of health and well-being of all trauma patients from these registries should be monitored using what are called "patient reported outcome measures" *(or PROMs)*. These are self-evaluations by the trauma patients, using specifically designed questionnaires that report their own experience and assessment of their quality of life after trauma (Rosenberg et al. 2018, Turner et al. 2019). These represent "real world" data and tell us how the trauma patients function in their everyday lives. Currently this valuable set of tools is extremely underutilized. As far as the authors of this white book chapter are aware, only the UK has started pilot studies on following patients beyond their discharge and this is the case in our Institution in Leeds.

d. The socio-economic impact of orthopaedic trauma

The impact of injuries on society is also extremely high. A recent study, which gathered the available literature from 205 studies, showed that 13% of trauma patients have lost their employment 12 months after their injury and concluded that "orthopaedic injury can have a substantial impact on the patient's socioeconomic well-being, which may negatively affect a person's psychological wellbeing and happiness" (O'Hara et al. 2020).

Direct costs:

These are the costs related to healthcare, including: Prehospital care, emergency department visits, hospital stay, initial management in the emergency and operating room, diagnosis (laboratory, blood and radiological investigations, specialist consultations), treatment, such as medications, assistive devices, wound care, surgical operations, rehabilitation, psychological support, etc.

The data on the cost of orthopaedic trauma, or how these costs correlate with its burden, are limited. As alluded to earlier in relation to epidemiological data, discrete data are missing and therefore the magnitude of the problem is hard to assess. Research on costs of injury is scare in the literature (Geraerds et al. 2020).

A recent study in the Netherlands (Geraerds et al. 2020) of 3785 trauma participants showed that the mean patient cost was €12190 and this increased with injury severity. However, this is a sample from only 10 hospitals from one country.

Again, *trauma registries* would be valuable in estimating the true numbers and inform economic studies allowing analysis of the costs per injured patient, per EU member state.

Indirect costs:

These are the costs to Society overall.

- Orthopaedic trauma results in chronic pain and ongoing disability.
- This reduces the quality of life, but it has tremendous effects not only on patient psychological well-being but also to their job and income.
- The impact on society is tremendous, but at the same time unfortunately impossible to calculate with accuracy, as far as financial costs are concerned.
- In the US, these costs were estimated at about $406 billion for the year 2000, and loss of productive years at $326 billion (Seifert 2007).
- Crippled patients are unable to go back to work and a great proportion suffers from significant psychological distress (Kang et al. 2021).
- Certainly, the use of PROMs as described earlier, would enhance our understanding of the needs of those patients and help identify the obstacles they face after trauma and provide effective counter measures to reduce those indirect costs.

e. Major trauma

Annual lost economic output from major trauma consequences (deaths and serious injuries) ranges between 3.3 and 3.7 billion pounds in the UK, as described in the National Institute for Health and Care Excellent (NICE) survey published in 2010 (https://www.nice.org.uk/). Road traffic accidents occupy a significant portion and major trauma is the leading cause of disability in people aged under 40 years old. The level of care for major trauma depends on the location and time of day of the injury and therefore this is not efficient and results in considerable disparity and inequality in the EU. For these reasons, organized groups of services, i.e. trauma networks, have been implemented in some EU countries, including the UK, Germany, the Netherlands and Spain (Chesser et al. 2019), but are lacking in many EU member states. Their purpose is to coordinate and deliver, using a unified protocol, at the appropriate time and place, the expert care that is required to manage these complex cases.

In the UK, since 2013, the implementation of *different tiers of hospitals*, providing different levels of care according to the needs of the patient, gave rise to a National Trauma Network in England. The tiers include "Major Trauma Centres", "Trauma Units" and local emergency hospitals, and this approach has been very successful in improving patient outcomes, as the triage systems route the patients from the scene of injury directly to the appropriate unit depending on the level of needed care (Chesser et al. 2019).

5. List of Activities Needed

- Development of Trauma Registries in every EU Member State: National Trauma Registries must be implemented in all EU Countries and collect data systematically, in a uniform way, and communicate with each other to allow collection of reliable statistics and cut down costs (revival of the EuroTARN (European Commission 2021) project)
- Implementation of Patient Reported Outcome Measures (PROMs) for all trauma victims. Following successful previous activity, PROMs need to monitor the aftermath of the injuries. How patients are functioning after trauma, what are their issues and limitations and how to address them. The goal is to restore the patient back to being a productive taxpayer.
- Implementation of regional trauma networks (i.e. hospitals that have different capabilities of treating patients working together) across all EU member states. Trauma networks that are groups of regional hospitals with different care capabilities working in an integrated fashion and should be implemented in all EU member states, such that the right patient reaches the right hospital at the right time, thereby minimizing delays, preventing long-term disability, saving lives and avoiding unnecessary costs. A strong political will is required first of all at a European level.

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Section 2

E | Paediatric Orthopaedics

Table of Contents

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1. Abstract

Musculoskeletal (MSK) diseases in children may have an impact in adult life, causing deformities and impairment. They can arise from congenital disorders, developmental diseases, spine disorders, neuro-muscular diseases, infections and tumours, rare diseases affecting the MSK system, or they can be a consequence of trauma.

MSK diseases can also affect the growth of the child, often with an effect on the psychological development of the child manifest by difficulty in adaptation to the playground and in interaction with other children. If not properly treated they may also be responsible for chronic pain and disability, as well as the development of osteoarthritis in adult life.

Although ***Paediatric Orthopaedics*** is part of the training for the speciality of Orthopaedics, rare diseases affecting the skeleton of the growing child, infections and malignant tumours require specialized treatment centres able to provide the necessary multi-disciplinary contributions. To best meet the demands of Children's MSK problems requires harmonized education across Europe in Paediatric Orthopaedics and a specialized fellowship program. This will provide the specialized paediatric orthopaedic surgeons able to respond to the new challenges of the 21st century.

2. Introduction

When Nicolas Andry published, in 1741, his book "*L'orthopédie*" the emphasis was on the prevention and correction of skeletal deformities in children by different methods. Indeed, Andry explains in a long preface that he coined the title in question, which became the name of the specialty 'Orthopaedics', from two Greek words "*orthos*",which means straight or devoid of deformity, and "*paidos*", which means child (Kohler 2010).

The practice of Orthopaedics has been developing in the last century from a situation where all surgeons had a general practice to one where the majority have a specialized practice, most often oriented to the different MSK disorders that affect a particular anatomical region, such as Foot and Ankle surgery or Spinal surgery. However, when dealing with children (between 0 to 18 years accordingly to EU laws) orthopaedic surgeons will face different challenges to those seen in adults. Children suffer different pathologies (congenital or acquired) and characteristics that differ from adults with the same pathology, which may change according to age. The "growth" factor induces particularities in the choice of treatment, which are often more often conservative than in adults because of the possibility of bone remodelling during growth. Surgical treatments also differ, requiring specific surgical instruments and implants, as well as operating techniques adapted to the age group and even to the institution providing care.

This requires not only well-trained surgeons able to deal with diverse presentations, much different from adults, but also specialization of the institutions treating some of the more challenging cases.

The education in paediatric orthopaedics and traumatology is appropriately delivered by universities and teaching hospitals in Europe. Nevertheless, inconsistencies are observed between EU countries, due to the historical development of the specialty and the different 'ways of working' seen in different healthcare systems. In the majority of EU Countries, after completing training in Trauma and Orthopaedic surgery (or less frequently Paediatric General Surgery), specialist Paediatric Orthopaedic surgeons pursue their separate path in which residents are exposed to an obligatory training in Paediatric Orthopaedics of at least 6 months. Usually this training takes the form of a fellowship in Paediatric Orthopaedics, with variation in the form and length of training acquired, as there is no current widely recognised governance of such fellowship posts (EFORT 2021). Most national scientific societies of Paediatric Orthopaedics and Traumatology organise and recommend educational programs through seminars and courses, and publish monographs. However, European harmonization in training requirements has not yet occurred.

In 1955, Walter P. Blount (1955), in the introductory sentence of his classic textbook "Fractures in children" wrote: *'A book about fractures in children is needed by the general physician, the general surgeon and, I fear, many orthopaedists'*. We are still at a point were paediatric orthopaedic and trauma education needs to evolve and become more precisely organised and harmonised.

One goal of the EU community is to offer the same quality of care, independent of the geographic location of the citizen. The European Societies of Traumatology and Orthopaedics, including EPOS (*European Paediatric Society of Orthopaedics*), organize many meetings and high-level courses every year focussing on orthopaedics and traumatology in children, which are open to any young surgeon. In addition, EPOS widely supports education in European countries via its regular Regional Core Curriculum Course.

Another goal of the EU is to promote the diagnosis of all major MSK conditions at an earlier stage, to treat them properly and prevent or minimise their future impact. To this end, it would be wise to develop an accredited EU training fellowship program in paediatric orthopaedics, ensuring the harmonization of care of MSK conditions in children.

So what is the role of the Paediatric Orthopaedic Surgeon? Every general orthopaedic and trauma surgeon should be able to assess and diagnose most conditions affecting the musculoskeletal system of a child and treat the most common problems. However, there are specific conditions that require specialized care if a poorer outcome is to be avoided. As shown by Vinz et al. (2012), adverse sequelae after trauma treatment could be significantly reduced if affected children were treated in the first place by a specialized surgeon. Some congenital and rare diseases almost demand dedicated care. This means that it is crucial that the treating surgeon is sufficiently trained to be able to recognise whether he or she is able to manage a specific conditions, or if the outcome would be better if transferred to a specialised centre.

In research, European surgeons are very active and display a high level of talent. Most of the innovative and successful treatments used globally to treat fractures in children were first described in Europe: plaster casts, intramedullary rigid and elastic nails, plates and screws, spine fixation, external fixators and resorbable implants, for example. The support of research in paediatric traumatology should promote promising new treatments, such as new mini-invasive approaches that might minimise the after effects of trauma in later life.

3. Paediatric Orthopaedics

In order to understand the importance of orthopaedic conditions in the growing child, it is essential to recognize the different presentations and how the course of disease processes relates to the child's age. Remaining growth may have an impact on the evolution of the condition and also interfere with therapeutic

possibilities. The paediatric orthopaedic surgeon has to deal, in daily practice, with multiple conditions, including congenital deformities, development diseases, spine disorders, neuromuscular conditions, infections, syndromes, tumours and trauma. There follow some specific examples.

a. Congenital deformities

Congenital deformities involving the skeleton represent a major healthcare burden in the EU and EUROCAT has been monitoring particular cases, such as limb deficiency syndromes, clubfoot, hip dislocation and polydactyly / syndactyly.

Club foot – In a study "Congenital clubfoot in Europe: A population-based study" the prevalence of congenital clubfoot without chromosomal anomaly was found to be 1.08 per 1,000 births (95% CI 1.05-1.11) and the prevalence of isolated congenital clubfoot was 0.92 per 1,000 births (95% CI 0.90-0.95). Decreasing trends over time have been identified and there are large variations in prevalence, depending on the registry reporting. Cases of congenital clubfoot from 18 EUROCAT registries, covering more than 4.8 million births in 1995-2011, have been reported (Wang et al. 2019). According to the JRC-EUROCAT Report on the Statistical Monitoring of Congenital Anomalies (2006 - 2015), clubfoot has shown a tendency to increase in recent years (Figure 1), contrary to the earlier reported trend (Lanzoni et al. 2017)

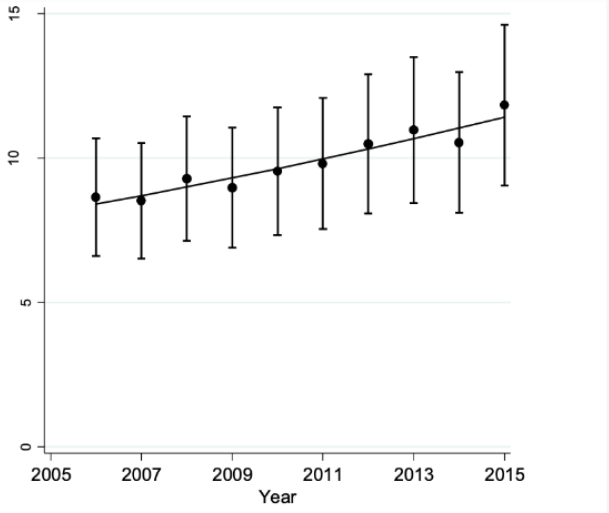

Figure 1. Club Foot talipes equinovarus – Prevalence and 95% confidence intervals for the registries included in the pan-Europe trend analysis

Source: Lanzoni et. Al. European Monitoring of Congenital Anomalies: JRC-EUROCAT Report on Statistical Monitoring of Congenital Anomalies (2006 – 2015) , EUR 29010 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-77305-1 (online),978-92-79-77304-4 (print), doi:10.2760/157556 (online),10.2760/955289 (print), JRC109868. Available at: https://publications.jrc.ec.europa.eu/repository/handle/JRC109868. Accessed August 2021

It is interesting to see how, over the years, treatment concepts have evolved from conservative approaches, to an aggressive surgical strategy, then to return to a more conservative approach, particularly in the last two decades, as illustrated by the Ponseti-method (Ponseti 2002, Böhm 2018). Only long term follow-up of the surgical patients revealed what, for some, were disastrous results of surgery.

Development dysplasia of the hip (DDH) – Although major advances have been made in recent decades in the screening / prevention of DDH, the incidence remains high in Europe, in particular in the Mediterranean countries and Eastern Europe (25,6 to 30,6 / 1000 births) (Loder and Skpelja 2011).

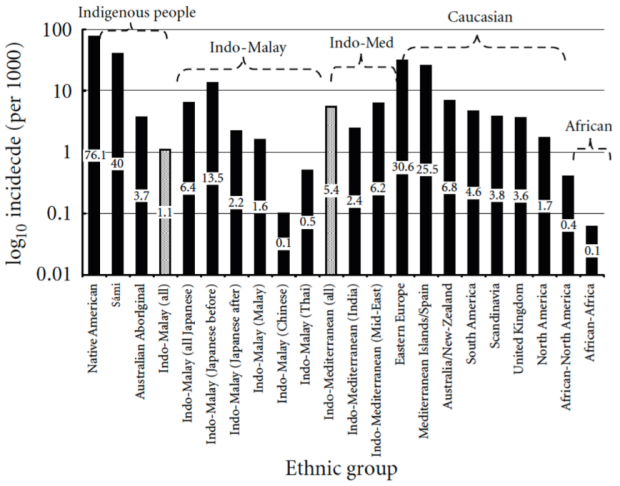

Figure 2. DDH incidence by ethnicity

Source: Loder and Skpelja. The epidemiology and demographics of hip dysplasia. ISRN Orthop 2011; 1-46

There is still a major concern regarding the impact of DDH in adult life as a consequence of late diagnosis or late treatment. According to the Norwegian Medical Birth Registry /Arthroplasty Registry (Engesaeter et al. 2008), observing more than 2 million newborns, there is an increased risk of 2.6x for total hip replacement (THR) being needed in later life in children born with DDH, when compared to the general population. In the analysis of 442 THR they found that 95 had undergone surgery for residual hip dysplasia but only 8 of these had DDH diagnosed at birth!

In order to save on the psychological and financial costs related to late diagnosis in DDH, many efforts have been made worldwide to foster the development of screening tools to promote early diagnosis. Unfortunately, there is no evidence that identifies the best screening tool (universal ultrasound vs selective ultrasound vs clinical screening alone) and a large scale prospective study would be fundamental to answer this important question. However, the Austrian experience of the long-term results of a nationwide ultrasound screening system for developmental disorders of the hip has shown a clear benefit for early diagnosis, with reduced rates of operative interventions and hospital admissions associated with the timely treatment of DDH (Thallinger et al. 2014).

b. Developmental diseases

Diseases like ***Legg Calvé Perthes Disease*** and ***Slipped Capital Femoral Epiphysis (SCFE)*** affect children during their growth and may be responsible for the development of osteoarthritis during adult life.

Legg-Calvé-Perthes' disease (Perthes' disease) is a childhood osteonecrosis of the hip. In a systematic review, including 21 studies describing 27 populations in 16 countries, with 124 million person-years of observation, the annual incidence among children under the age of 15 years ranged from 0.2 per 100,000 to 19.1 per

100,000. Race was a key determinant, with East Asians being least affected and Whites most affected, whilst latitude has also been shown to be a strong independent predictor of disease, even after adjustment for race (Perry et al. 2012).

Experienced surgeons with a practice dedicated to Paediatric Orthopaedics have become spectators of the different treatment approaches, observing the development and use of different orthoses and surgical approaches and techniques, to a new era of Pharmaceutical and Biological therapies. However, it is perhaps most important to take an overview and recall, for example, that it is better not to intervene in a Perthes' child where the outcome is likely to make the child a candidate for very early hip replacement, whereas most untreated Perthes' cases do not require intervention until the age of forty (Catterall 1971, Herring et al. 2004a and 2004b).

Regarding SCFE, the incidence varies from 0.33/100,000 to 24.58/100,000 in children age 8 to 15 years. There is relative racial variation in frequency; if the Caucasian incidence is taken as 1.0 the frequency in Polynesians is 5.6, 3.9 for Blacks and 2.5 for Hispanics (Hägglund et al. 1984). At 25 years follow-up, most of these patients present with signs of osteoarthritis, particularly those with severe slips, often leading to total hip replacement at a young age (Castañeda et al. 2013).

During normal growth, it is common to observe the development of ***angular deformities and leg length discrepancies*** that usually represent simple variations of normal development and they tend to resolve spontaneously. In specific conditions, particularly congenital, post-traumatic and metabolic, these deformities may become permanent and tend to increase with growth. Correction requires treatments such as growth arrest or leg lengthening, which is best delivered in specialized centres.

c. Spine disorders

Spine deformities are relatively common during growth. ***Scoliosis*** is prominent, particularly during adolescence, with an estimated incidence of 0.47–5.2 % according to current literature, rising ultimately to around 60% in adults, where its association with back pain is strongest (Konieczny et al. 2013). This can have a major impact on quality of life, since we know that back pain is one of the major causes of work absence. The estimated 32% not back at work at 1 month after the onset of back pain are at a crucial point for intervention if long-term work absence is to be prevented (Wynne-Jones et al. 2014).

Curve pattern and the prevalence of scoliosis are not only influenced by gender, but also by genetic factors and age of onset. There are several articles published with data from school screening programs, but the results have to be interpreted with caution. Methodological variation, cohort composition and diagnostic criteria differ substantially. We still therefore need data from studies with clear diagnostic criteria and study protocols that are comparable to each other.

In terms of treatment, significant progress has been made on stopping deformity progression in adolescent scoliosis and minimising its impact into adulthood. It was not until 2013 that a study from the US showed the importance of bracing, as it significantly decreased the progression of high-risk curves to the threshold for surgery in patients with adolescent idiopathic scoliosis. The benefit increased with longer hours of brace wearing but compliance remains a problem for such treatments (Weinstein et al. 2013).

d. Neuro-muscular diseases

Cerebral palsy (CP) is the term for a range of permanent movement disorders caused by a non-progressive injury to the immature brain. It is the most common cause of physical impairment in children. In addition, individuals with CP may also have epilepsy and difficulties in cognition, communication, feeding, vision and hearing, as well as secondary musculoskeletal problems (Rosenbaum et al. 2007). The overall prevalence of CP is around 2 per 1000 live births. CP is a life-long condition. In addition to the treatment costs, many of those with cerebral palsy require support with activities of daily living and have special educational needs. Additional costs relate to welfare support, housing adaptations, and the costs of informal care arrangements. A recent study from Australia estimated the economic impact of CP and found it to be one of the 5 most costly health conditions. No such estimate of the costs associated with CP in Europe has been completed. By bringing together health economists and CP professionals in a workshop, the costs associated with CP could be identified providing vital data for planning population healthcare, and a protocol for an EU-wide study looking at the economic impact of CP is under development.

From the database "*Surveillance of Cerebral Palsy in Europe*", looking at children born between 1990 and 2006, an "impairment index" was defined in order to characterize the severity of these impairments and their combinations. Amongst the 11015 children analysed, around 40% had a high impairment index (inability to walk and/or severe intellectual impairment +/- additional impairments). These were highest in dyskinetic CP (77%, n = 549) and bilateral spastic CP (54%, n = 2,680) (Horber et al. 2020). In 1994 a CP register and healthcare programme was established in southern Sweden, with the primary aim of preventing dislocation of the hip in affected children. A population-based hip surveillance programme enabled the early identification and the implementation of preventive treatment, which resulted in a significantly lower incidence of dislocation of the hip in children with CP (Hägglund et al. 2014). This programme showed how medical assistance can change the natural history of a disease by using preventive methods. These children need dedicated care by specialized professionals in order to prevent complications and MSK deformities in a later stage.

e. Infections and tumours

Osteoarticular infections in children, unless treated promptly and correctly, can result in limb impairment or life-threatening conditions. The estimated incidence in the EU is subject to regional differences and can vary from 1:100.000 to 1:20.000.

Malignant bone tumours in children are a rare group of tumours that account for 3–5% of paediatric cancers below 15 years of age, but the consequences of these tumours can be devastating.

These are special diseases requiring a specialized approach. Since there are such regional differences, it is important to collect European data that will allow a more comprehensive and population-based approach to optimise diagnostic and treatment modalities.

f. Rare diseases affecting the Musculoskeletal System

Despite the rarity of each individual "rare disease" (RD), the number that exist mean that it is always surprising for the public to discover that, according to a well-accepted estimation, "Rare

diseases currently affect 3.5% - 5.9% of the worldwide population, an estimated 30 million people in Europe", which means that 6% to 8% of the total EU population are rare disease patients. This figure is equivalent to the combined populations of the Netherlands, Belgium and Luxembourg (EURORDIS 2021).

Providing European support and cooperation, such as by ensuring that common policy guidelines are developed and shared throughout Europe in areas such as research, centres of expertise, access to information, orphan medicines, and screening, is a key point for the future. The implementation of RD registries may help us to better understand the natural course of these diseases, to distinguish which patient subgroups are at risk for poor outcomes, and to identify new targets for treatment (Forrest et al. 2011, Valkova et al. 2014).

The effort to coordinate the care of RD patients requires a national and supranational approach. The European Community has developed tools to provide a coherent framework for its members. One of the most relevant issues is the promotion of European Reference Networks (ERNs) dedicated to homogeneous groups of these diseases. The ERNs serve to share guidelines for disease diagnosis and treatment and standardize the approaches to RDs in the entire EC (Baldovino et al. 2016).

Here are some examples:

Skeletal dysplasias

Genetic disorders may have an impact on the skeletal development. Skeletal dysplasias, also known as osteochondrodysplasias, are a heterogeneous group of heritable disorders characterized by abnormalities of cartilage and bone growth, resulting in abnormal shapes and sizes of the skeleton and disproportion of the long bones, spine, and head. They differ in their unique natural histories, prognoses, inheritance patterns, and aetiopathogenetic mechanisms. Usually short stature is present (height that is three or more standard deviations below the mean height for age).

The molecular basis for a large majority of these disorders is now known. There are over 400 recognized types of dysplasia. They produce a wide variety of phenotypes, of which disproportionate short stature is the most common variety (Cole 2013). Each type of skeletal dysplasia is rare but, overall, the worldwide frequency is approximately 1/5000 births. The JRC-EUROCAT Central Registry performs annual cluster analysis using the most recent five years of data. In 2017, it detected a cluster of skeletal dysplasia in Wales, which was found to include a very heterogeneous group of conditions, many being of genetic origin (Figure 3). This appears as a cluster in time, but the heterogeneous diagnoses and geography suggest that it is in fact more apparent than real, and it is difficult to judge if this cluster in particular merits further investigation. However, this demonstrates how a Central Registry can help in detecting unusual patterns of disease (Lanzoni et al. 2017).

Osteogenesis imperfecta

Also known as brittle bone disease, Osteogenesis Imperfecta is a rare disease that affects 1 in 10,000 to 20,000 people worldwide. It is a genetic disease characterized by a disorder of collagen, a protein which forms the framework for bone structure. In OI the collagen may be of poor quality, or there just may not be enough to support the mineral structure of the bones and, as a consequence, the bones become fragile and break easily. This disease demands a specialized approach not only for diagnosis but also for treatment.

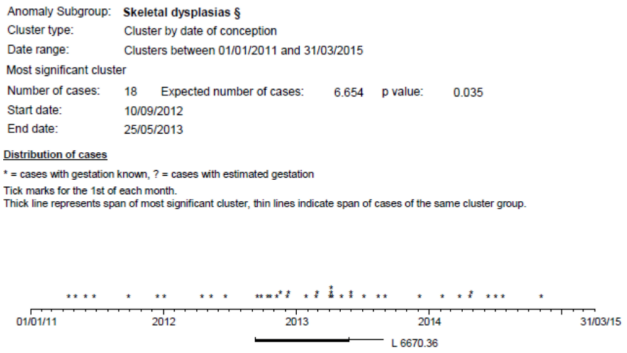

Figure 3. Cluster Skeletal dysplasia's

Source: Lanzoni et. Al. European Monitoring of Congenital Anomalies: JRC-EUROCAT Report on Statistical Monitoring of Congenital Anomalies (2006 – 2015), EUR 29010 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-77305-1 (online),978-92-79-77304-4 (print), doi:10.2760/157556 (online),10.2760/955289 (print), JRC109868. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC109868. Accessed August 2021

Mucopolysaccharidosis

Mucopolysaccharidosis (MPS) are a group of metabolic disorders caused by the absence, or malfunctioning, of lysosomal enzymes, which are needed to break down molecules called glycosaminoglycans (GAGs). These long chains of sugar-carbohydrates occur within the cells that help build bone, cartilage, tendons, cornea, skin and connective tissue. GAGs (formerly called mucopolysaccharides) are also found in the fluids that lubricate joints.

Type 1 mucopolysaccharidosis is a rare lysosomal storage disease belonging to this group. There are three variants, differing widely in their severity, with *Hurler syndrome* being the most severe, *Scheie syndrome* the mildest and *Hurler-Scheie syndrome* giving an intermediate phenotype, with a prevalence of 1 per 100.000 people.

Most of the children affected by MPS may present with restrictions in bone development and with deformities, including rigidity of the joints. It is important to make the diagnosis early and to implement an early treatment programme to prevent worsening of the deformities.

4. Paediatric Traumatology

a. Injuries in children and adolescents: epidemiology in Europe

Injuries include: 1- home, leisure, sport and school injuries, 2- road traffic injuries, 3- workplace injuries, and 4- suicide attempts.

26 countries in the European Community, between 2012 and 2014, reported the mean number of traumatic deaths in children per year as follows: around 1200 deaths in the age group 1-4 years mainly due to home injuries; 1420 deaths in the age group 5-14 years mainly due to school and sport injuries and 4500 deaths by injuries in the group of age 15-19 years mainly due to road traffic injuries (Eurosafe 2016).

In 2016, a study of the 51 WHO European countries observed around 21000 deaths yearly in children aged 5-14 years. Among them, 40% were due to any type kind of injuries, including drowning and burns, and 36% were exclusively due to traffic injuries (Kyu et al. 2018). Home injuries are the leading cause of trauma-related death in children under 5 years of age. Inequalities are found among the countries, with higher home injury rates in

European upper-middle-economy countries compared to high-income countries (Sengoelge et al. 2011).

Therefore, traumatic injury is the leading cause of death in children and adolescents. Although most isolated musculoskeletal injuries are not life threatening, they do account for approximately 20% of injuries in this age group. On average each European child will suffer at least one significant traumatic injury during its childhood. These injuries result in a very high number of hospitalizations, a large number of surgical procedures and a heavy cost, which also includes losses by the parents, who have to stop working to take care of their children.

b. Specific problems of children

Children are not small adults! (Wenger D et al. 2005). The major difference is the occurrence of growth: in the skeleton growth occurs in length, due to the cartilaginous growth plate (or physis) in the epiphysis-metaphyseal areas of the long bones, and growth in thickness is due to the thick periosteum. Any injury of the physis may lead to severe growth disturbance, including axial deviation of bone alignment if one side of the growth plate is more affected than the other, limb length discrepancies, severe functional disability and delayed degenerative arthritis.

After a displaced fracture, and in some other circumstances, physeal and periosteal growth may play a favourable role in helping to correct some post traumatic deformities. However, surgeons should be aware of the rules governing bone remodelling. For it to have an impact there needs to be: 1- a residual growth period of at least 3 years, 2- a fracture located close to an active physis (far from the elbow and close to the knee), and 3- a deformity in the plane of motion of the adjacent joint. Therefore, a post traumatic varus deformity of the distal humerus or tibia has almost no chance of spontaneous correction and has to be considered as permanent unless surgically corrected.

Overgrowth is a natural consequence of healing in some fractures as blood flow to the limb, and therefore growth plate, increases as healing progresses. Thereby, a fracture of the femur treated with the sort of "aggressive" osteosynthesis routinely used in adults, may result in a limb length discrepancy due to bone overgrowth of several centimetres. In contrast, slight shortening following conservative treatment (for example occurring after femoral shaft fracture treatment in a young child) will perfectly correct spontaneously over the next few months. In other cases, metaphyseal fractures close to the knee may induce an asymmetrical overgrowth growth and a progressive knee varus or valgus.

Finally fractures through the physis may be responsible for post- traumatic epiphysiodesis (growth arrest) leading to severe sequelae. In these conditions, achieving recovery of normal growth is a real challenge, requiring complex and recurrent surgical procedures, not always with complete success. The five most commonly fractured regions in children are 1- the forearm (48.1%), 2- shoulder and upper arm (14.1%), 3- lower leg including the ankle (11.3%), 4- wrist and hand (10.4%), and 5- the skull and face (9.0%) (Faris et al. 2020).

c. Treatment

In children, almost 50% of fractures overall can be successfully treated by conservative methods (Ömeroğlu and Cassiano-Neves 2020). Surgeons should be familiar with the reduction manoeuvres required to treat common fractures, techniques of effective immobilisation with casts and the rules of follow-up. About 20 to 30% have a degree of misalignment after treatment, and some of these are significant, whilst severe complications such as compartmental syndrome can occur. A second procedure, which could have been avoided with appropriate initial treatment, is then required.

Today, more and more fractures in children are treated by internal fixation of the bones in order to avoid the potential complications of conservative treatment, to allow rapid functional recovery, an early return to school and sport activities, as well as a decrease in hospital stay. Taking in account the activities of parents is also important to consider. Nowadays we strive to reduce the use of post-operative X-rays, and outpatient clinic follow-up is a modern goal. So, it is apparent that the reasons for the increasing tendency towards operative treatment are multifactorial and include patient-, parent- and surgeon-dependent factors. Furthermore, technological, economic, social, environmental and legal factors, seem to have an impact on this trend (Ömeroğlu and Cassiano-Neves 2020).

Specific bone fixation methods are adapted to children to avoid, as far as possible, any growth disturbance. Simple Kirschner wires can be allowed to traverse the physis, elastic nails are used in forearm fractures as well as fractures of the femur and the leg before adolescence, specific lateral trochanteric femoral nails are used in adolescents, resorbable screws are justified in some epiphysis-metaphyseal fractures, with no need for removal. The key words are: 1- mini-invasive surgery and percutaneous fixation; 2- protection of bone metabolism with respect, as far as possible. to the periosteum, which governs bone union.

d. Organization of trauma care in Europe

In Europe, the organization of trauma care in children may differ from country to country. Fractures may be treated by general surgeons, traumatologists or paediatric orthopaedic surgeons and/or traumatologists working in trauma centres with different levels of expertise. The role of emergency units is to sort cases and to transfer the most severe cases to the most appropriate centres, paying regard to the regional organization of medical care. Among children's injuries, elbow, spine and pelvic injuries, as well as polytrauma patients, need to be treated in the highest-level departments.

When some elbow fractures in children are not treated by the most qualified surgeons in paediatric traumatology, a great number of misdiagnosis and sequelae are observed (Vinz et al. 2012).

More than half of paediatric malpractice cases arise from treatment administered in emergency departments, primarily due to missed or delayed diagnoses. This is true also for many paediatric diseases including the recognition and management of child abuse (Edwards et al. 2020).

e. Rehabilitation and follow-up

Rehabilitation includes recovery of function of the injured limb, return to school and sporting activities. Whilst physiotherapy is rarely necessary in children, some conditions, including post-traumatic palsies and paraplegia, require management in specific medical centres dedicated to children. Follow-up also should be taken into consideration. If most fractures recover promptly, the diagnosis of growth disturbance should be made early, far before the development of progressive deformity and dysfunction. An early diagnosis allows adequate treatment and decreases the severity of sequelae.

f. Prevention of injuries

Prevention of injuries in children is a significant challenge. Its efficiency as a strategy has been demonstrated in a comparative study, with a significant 70% decrease in deaths observed between 1990 and 2016. More effort should focus not only on road traffic road accidents, but also on domestic, school and sport injuries (Kyu et al. 2018).

5. List of Activities Needed

In this chapter we have tried to point out the peculiarities of the speciality of Paediatric Orthopaedics, either elective Paediatrics or children's Trauma, and to highlight the differences between treating a child with a disease of the musculoskeletal system compared to treating an adult.

Present

- Paediatric Orthopaedics is part of the training for the speciality of Trauma and Orthopaedics; so every specialist should be familiar with most of the conditions that affect the growing child, and be capable of the diagnosis and treatment of most cases. Treatment of the population as a whole, however, also requires a highly specialized workforce of paediatric orthopaedic surgeons, able to manage complex and difficult cases and to respond to the new challenges of the XXIst century.
- In recent years, the treatment of children with MSK disorders has been changing in a dramatic way and, with reference to several orthopaedic and trauma diseases, the concept of non-operative treatment has evolved into a surgical approach. As is seen in adult care, day hospitalisation and fast track surgery are increasing.
- Rare diseases affecting the skeleton of the growing child, infections and malignant tumours require specialized treatment centres with a multi-disciplinary approach.

Future

- Need for harmonized education across European Paediatric Orthopaedics.
- Need for an accredited specialized fellowship programmes.
- Campaigns for preventing paediatric injuries should be implemented across Europe.

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Section 2

F | Musculoskeletal Oncology

Table of Contents

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1. Abstract

The impact of bone tumours on clinical practice remains as large today as it was at the turn of the century and as it is likely to remain so for several decades more. Bone and soft tissue cancers create challenges for patients that are not seen in most other malignancies, such as changes in gait, function, stability, strength, and appearance. Moreover, the economic burden can be great: the more advanced the disease at diagnosis, the worse the prognosis and, accordingly, the more expensive the treatments. This chapter of the White Book on Tumours aims to present an impartial review and a comprehensive overview of the current healthcare situation for patients with bone tumours in Europe.

2. Introduction

The economic burden of bone cancers can be great. The more advanced the disease at diagnosis, the worse the prognosis and, accordingly, the more expensive the treatments It is likely that early detection, and prevention if possible, could drastically reduce costs. A number of expensive treatments are currently deployed to address these tumours.

3. Epidemiology

3.1 Incidence

The impact of bone tumours on clinical practice remains as large today as it was at the turn of the century and as is likely to remain for several decades to come. Bone and connective tissue neoplasms, which include bone and joint sarcoma, myeloma and soft tissue sarcomas, are uncommon when compared with other cancers, and indeed with other musculoskeletal conditions. They accounted for about 2.2% of global annual cancer cases between 2006 and 2010 (approximately 43,000 cases). According to the Surveillance, Epidemiology, and End Results (SEER) Program of the National Institute of Health, the average annual incidence of bone cancers in U.S. between 2006 and 2010 was nine in one million, a rate that has remained constant for the last decade (https://seer.cancer.gov/statfacts/). The number of new cases of bone and joint cancers in a population is 0.9 per 100,000 people per year (Statista Research Department 2019).

In 2019, 550 males and 500 females were estimated to be newly diagnosed with primary bone cancer in Italy. Pertaining to a new diagnosis of metastatic bone disease among males, prostate cancer had the highest incidence (37,000). In both sexes combined, the highest incidence is seen in breast, colorectal and lung tumours, with 53,000, 49,000 and 42,500 new cases respectively (Statista Research Department 2019).

Sarcomas are a heterogeneous group of over 80 different tumours arising from mesenchymal or connective tissue. They make up less than 1.5% of all new cancer diagnoses. There were an estimated 1762450 new cancer diagnoses in 2019 in the United States, of which only 12750 cases were soft tissue sarcomas (STS), and 2970 cases were bone sarcomas. Sarcomas can be broadly categorized into soft tissue sarcomas, comprising approximately 1% of tumours in the UK and 2% of cancer deaths, and bone sarcomas, which, according to the figures from the Office of National Statistics, comprised 0.18% of all cancers and 0.21% of all cancer deaths in 2006 (Smith et al. 2011).

Annual population-based mortality rates due to cancers of bones and joints are low, averaging four deaths per one million people since the early 1990s in the U.S. as reported by the National Cancer Institute (https://seer.cancer.gov/statfacts/).

While the mortality rate from bone and joint cancer has dropped by approximately 50% since the late 1970s, no significant further improvement has been observed over the past 20 years (Figure 1). Although there are many histologic subtypes of bone and soft tissue sarcomas, the general principles of treatment remain the same, with surgical excision accompanied, at times, by adjuvant or neoadjuvant chemotherapy and sometimes by radiotherapy.

Almost all cancers have preferential sites to which they spread or metastasize, resulting in secondary cancers. Secondary deposits of cancer in bone are much more common than primary bone cancers, and result in great morbidity and pain overall. The skeleton is the most common organ affected by metastatic cancer, and the site of disease that produces the greatest morbidity. The most commonly encountered cancers that readily and frequently spread to bone are cancers of the breast, lung, kidney, prostate, gastrointestinal tract and thyroid gland. The prognosis of metastatic bone disease is dependent on the primary site, with breast and prostate cancers associated with a survival measured in years rather than the months typical of lung cancer. Timely diagnosis, followed by a combination of local and systemic treatments (surgery, radiation therapy, embolization, chemotherapy, bisphosphonates) represents the therapeutic strategy used to obtain an improvement in the quality of life, functional outcome and disease control. Survival rates for secondary bone cancer depend on patient factors such as age, overall health, treatment and response to treatment. However, metastatic disease has by definition already spread, therefore signifies advanced cancer, so survival rates are much lower than seen in primary cancer without such spread. The fundamental treatment for bone metastases arising from advanced cancer is disease control by systemic chemotherapy and radiation of the bone lesions. Prevention and treatment of bone metastases is highly dependent on an effective treatment being available for management of the primary cancer (Coleman 2006). As of today, there is increasing evidence that surgical resection of a solitary metastasis or oligometastases (2 to 4 distant metastases in the same anatomic region) is associated with a better prognosis in certain favourable tumour histiotypes (breast, prostate, kidney, bowel, thyroid cancer, or myeloma)(Cappellari et al. 2020).

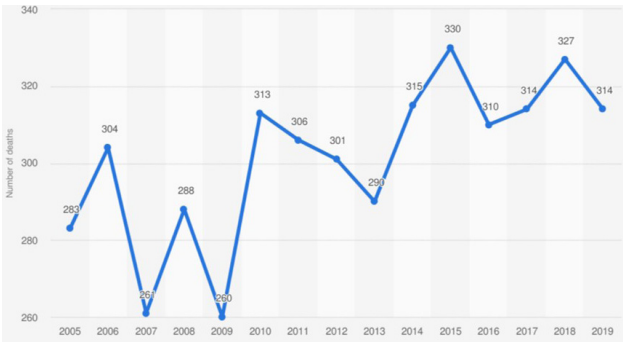

Figure 1. Total number of deaths due to a malignant tumour of bone and articular cartilage in Spain from 2005 to 2019.

Source: Statista. Annual number of deaths due to a malignant tumour of bone and articular cartilage in Spain from 2005 to 2019. Available at: https://www.statista.com/statistics/984704/number-of-deaths-due-to-malignat-tumour-of-bone-and-articular-cartilage-in-spain / Accessed March 2022

3.2 Prevalence

The median age at presentation for cancers of the bones and joints has risen slightly, to the age of 42 years, in recent years. Bone cancer remains the leading cause of cancer in young persons under the age of 20 years. More than one in four diagnoses of bone and joint cancer is in children and youths under the age of 20 years, with more than one-half (52%) of cases diagnosed in persons younger than 45 years.

3.3 Risk factors

The statement of Smith et al. (2011), that "early diagnosis of cancer has been topical for many years and has recently become a political imperative" is still true. Earlier diagnosis can improve outcomes both in terms of local control and overall survival (Smith et al. 2011).

Surgical excision of sarcomas is usually attempted with a limb salvaging technique, which is possible when local invasion is minimal and the tumour is of low volume. Patients who have small tumours or who are free of metastases at diagnosis have an increased survival rate and the chance of survival is increased with more rapid diagnosis (Mavrogenis et al. 2015). The prognosis for any individual is determined by a combination of many factors including the effectiveness of treatment and response to chemotherapy, when used. Other prognostic factors include grade, site and size of the tumour, along with the age of the patient. Of all of these factors, size is the only one that can be influenced significantly by earlier diagnosis. Earlier diagnosis should lead to smaller tumours at diagnosis, which in turn should result in a better prognosis and easier treatment (Mavrogenis et al. 2015). Smith et al (2011) reported an analysis of a total of 4,934 patients with newly diagnosed bone (2568 - 52.0%) and soft tissue sarcomas (2366 - 48.0%) from 1985 to 2009 in UK. In their analysis, they found that there is no difference in the symptom duration at presentation reported by men and women for either bone (p=0.154) or soft tissue sarcomas (p=0.416). Patients with superficial soft tissue sarcomas (n=615, 26%) had considerably smaller tumours at diagnosis (6cm) than those with deeper ones (11.2cm) (p<0.0001) but had a longer median duration of symptoms (45 weeks vs 26 weeks respectively, p<0.0001) (Figure 2).

3.4 Soft tissue tumours

Soft tissue sarcomas (STS) are a heterogeneous group of rare, malignant, mesenchymal tumours with an annual incidence of two to three per 100,000 population. It is estimated that one in every 200 to 300 lumps that people discover turn out to be a sarcoma. Given the rarity and diversity of these tumours, it is not surprising that excision is often carried out without the preoperative suspicion of a malignant tumour, without appropriate preoperative imaging, without a sufficient biopsy or staging, and without regard for adequate resection margins. Such procedures are known as unplanned excisions or "whoops" procedures. Unplanned excisions are often incomplete, with residual tumour reported in 35 to 74 % of patients and with a significant negative impact on prognosis.

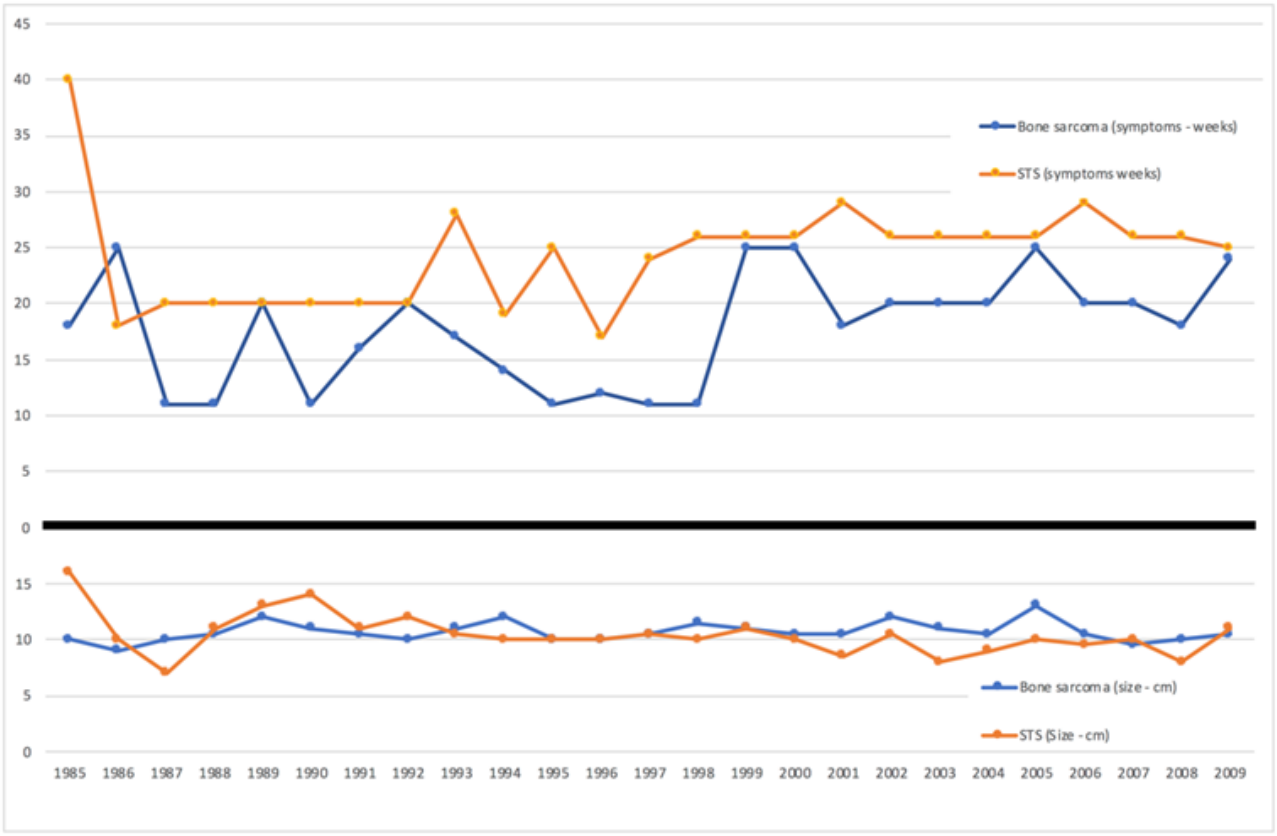

Figure 2. Mean duration of symptoms reported at presentation by patients (upper part of the graph) and mean tumour size at diagnosis (lower part of the graph) from a large series of bone and soft tissue sarcoma at the Royal Orthopaedic Hospital, Northfield (UK) (redrawn from the original publication)

Source: Smith et al. Trends in presentation of bone and soft tissue sarcomas over 25 years: little evidence of earlier diagnosis. Ann R Coll Surg Engl 2011 Oct;93(7):542-7.

4. Impact

4.1 Disability and pain

Bone and soft tissue cancer pose challenges to the patient that are not seen in many other malignancies, such as changes in gait, function, stability, strength, and appearance. These changes can make it difficult after treatment for patients to resume their pre-cancer lives, which can produce psychologic sequelae for years after remission is achieved (Tang at al. 2015). Additionally, high levels of depression and demoralization have been shown in patients with bone and soft tissue cancer (Tang et al. 2015). These psychological changes are widely known to increase suicide risk. Siracuse et al. (2017) reported a suicide incidence of 32 per 100000 person-years in US patients with bone and soft tissue sarcomas, with a standardized mortality ratios (SMR) of 2.43 (95% CI, 1.74–3.29; $p < 0.001$) compared with the matched US general population.

Depression, distress, and anxiety are frequently observed in the population with sarcoma (Tang et al. 2015). Patients with musculoskeletal malignancy who have any characteristics identified as having increased incidence of suicide should be screened for depression, distress and suicidal ideation, as there is a high correlation between these neuropsychological diagnoses and completed suicide.

The incidence of suicide in the population with cancer is known to be approximately twice than that of the general US population (Misono et al. 2008). According to this study, the suicide incidence specifically in the population with bone and soft tissue cancer has also been confirmed to be more than twice that of the general US population. Compared with subpopulations examined in other studies, the suicide rate among patients with bone and soft tissue cancer ranks below the incidence of suicide in patients with cancer of the lung and bronchus, stomach, oral cavity and pharynx, larynx, and ovary. If bone and soft tissue cancer had been included in that study, it would have ranked fifth in terms of linked suicide incidence. The patients with cancers that rank above it have in themselves very poor prognoses, high rates of depression and their own set of life-altering consequences of treatment.

Spinal tumours are associated with pain, limb weakness and numbness, as well as loss of bowel control. Bone metastasis can result in bone pain and other skeletal-related events (SREs). SREs include pain, pathological fracture, vertebral collapse and deformity, spinal cord compression and hypercalcemia of malignancy (increased concentration of calcium in the blood) (Coleman 2006). These complications result in impaired mobility and reduced quality of life and have a significantly negative impact on survival. Studies focused on patients with prostate cancer reported that more than half of the affected men experienced at least one SRE within 1.5 years of their bone metastasis diagnosis. A population-based study conducted in Denmark found that the 1-year cumulative incidence of SREs among patients with bone metastasis from prostate cancer is 46%. This study also showed that the 1-year survival rate was about 40% and the 5-year survival rate was less than 1% in those with both bone metastasis and SREs (Nørgaard et al 2010). The incidence of bone metastases in lung cancer patients is approximately 30% to 40% and the median survival time of patients with such metastases is 6 to 7 months (Cetin et al. 2014).

Metastatic disease may remain confined to the skeleton, with declining quality of life and eventually death almost entirely due to the skeletal complications and their treatment. However, new treatment strategies with targeted therapies, including antibodies and smart drugs, have dramatically changed the effects of bone metastases on quality of life, especially in certain histotypes (Cappellari et al. 2020).

4.2 Indirect costs

In addition to the direct medical costs, there are extensive indirect and social costs from lost work time and disability. From a societal perspective, indirect costs arise as patients with musculoskeletal tumours are unable to work and hence lose years of employment.

Approximately 30-66% of all patients with cancer suffer from psychosocial distress during the course of their disease, which constitutes in itself a relevant clinical and economic problem. This is particularly true in paediatric sarcoma survivors. Lenze et al. (2019) reported that patients with musculoskeletal malignancies are particularly vulnerable to psychosocial distress, with high distress levels occurring not only in the early stages of the disease but also during the follow-up period (even years after the operation) in some patients. Female patients and patients who underwent radiotherapy had significantly higher distress levels than males and patients without radiotherapy (Lenze et al. 2019). They therefore suggest that there is a need for psychosocial distress screening not only during active treatment but also throughout follow-up care. The high number of patients with sarcoma who suffer persistent psychosocial difficulties might also be at least partly explained by the surgical treatment regimen which, in some cases, involves restrictive or even mutilating operations (e.g. amputations) which might force life-role changes as well as producing physical impairment. This aspect is obviously correlated with a productivity loss in tumour survivors. These intangible costs cannot be directly calculated in terms of resource requirements or evaluated wholly in monetary terms

4.3 Direct costs (Healthcare costs, diagnosis, treatment, surgical/non-surgical costs)

There is an intense debate surrounding the cost of cancer treatment and the value of new therapies. However, there is limited data on the true cost of cancer in the European Union (EU) and how costs relate to the burden of disease. Direct health cost of cancer (DHCC) in the whole EU increased from €79 to €86 billion during the period 2005-2014 (in 2014 prices) (Jönsson et al. 2016). The cost of cancer drugs as a share of direct health costs increased from 12 to 22% during

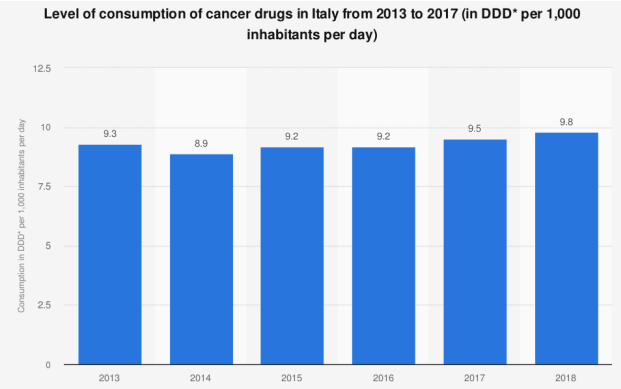

Figure 3. Level of consumption of cancer drugs in Italy from 2013 to 2017

Source: Statista. Level of consumption of cancer drugs in Italy from 2013 to 2017. Available at: https://www.statista.com/statistics/913085/consumption-of-cancer-drugs-in-italy/. Accessed July 2021

the same period. Other direct costs remained stable or decreased since 2005, probably linked to the shift from inpatient to outpatient care for many interventions (Jönsson et al. 2016).

The management of musculoskeletal tumours aims to improve patients' survival and quality of life. Direct costs of treatment for patients with musculoskeletal tumours include those incurred prior to diagnosis and surgical treatment (including chemotherapy regimens and adjuvant treatments), during any inpatient stay and over the course of the postoperative management. It is not easy to define the typical treatment pathway, because the correct management should be customized according to patient characteristics and tumour histotype. Combined wide excision and adjuvant therapy remains the standard treatment for local control without increased recurrence or mortality. The traditional treatment in patients with sarcomas of the upper or lower limb was amputation. Recently limb-sparing surgery has become the standard of treatment for soft tissue sarcoma (STS), as advances in adjuvant therapy enable adequate margins to be achieved without the need for amputation.

Summarizing, therefore, patients with primary bone tumours should be directed to a specialized centre if there is a suspicion that the diagnosis is tumour (based on a consultation with a primary-care physician or general orthopaedic surgeon/other specialist). Treatment usually includes preoperative chemotherapy and continues with the surgical management in a specialized hospital. After surgery, the patients undergo rehabilitation, further adjuvant treatments and, always, follow-up ambulatory care by the oncology team.

Therefore, healthcare providers who are directly involved in the treatment of a musculoskeletal tumour, from diagnosis to follow-up, also incur healthcare expenses. Beyond this, physicians prescribing medications, therapeutic products or medical technical aids also add to further healthcare expenditure as do prescriptions for other care providers (for example, physiotherapists, pain management etc.) in addition to material costs for equipment and consumables.

There are different direct costs based on the type of bone lesion (primary tumour vs metastatic bone disease), and the use of chemotherapeutic drugs is of course one of the most relevant direct costs incurred in oncology patients. The following graph (Figure 3) shows the trend of consumption of cancer drugs in Italy from 2013 to 2018. According to data, the level of consumption of medicines to treat cancer peaked in 2018, reaching a value of 9.8 defined daily dose per 1,000 inhabitants per day.

Whilst drug costs are relatively easy to identify, it is nevertheless really difficult to estimate the costs of reconstructive surgery, as there are different prosthetic designs for specific sites, different materials, variations in the length of reconstruction and emerging biologic options. These account for the differences observed between expenditure, with and without endoprosthetic replacements, in different hospitals. The costs for the replacement itself are to be considered as an estimate based on the lowest determined value, and this value is higher than the average expenditure for conventional arthroplasty, as it includes treatment costs related to tumour.

5. Sarcomas

Considering primary bone tumours, it has been observed that the most frequent initial treatments used vary widely in their rate of deployment, based on the histotype of sarcoma (Mavrogenis et al. 2015, Damron et al. 2007). Damron et al. (2007) reported that surgery alone was the most common initial treatment for chondrosarcomas (69%), whereas for Ewing sarcoma treatments were divided between surgery and chemotherapy (24% of cases), radiation and chemotherapy (23%), and chemotherapy alone in 18% . With osteosarcoma, where the initial treatment was known, the largest group received surgery and chemotherapy (46%). Surgery was reported as part of the initial treatment in 71% of osteosarcoma patients, 83% of chondrosarcoma patients and 47% of Ewing sarcoma patients. Multiple therapies may be needed later in the course of the patients' disease, especially in the more advanced cases. In the later stages of the disease, for those who have not been cured by surgery alone, significant costs will accumulate as these patients may develop pulmonary disease and ultimately die. Hormone therapy, immunotherapy and bone marrow transplant/endocrine treatments each accounted for 1% or less of initial treatments. However, in severely affected individuals in whom standard treatments fail, these alternative treatments may be tried more frequently (Mavrogenis et al. 2015). All of these treatments are costly to administer. Per-patient cost will vary widely depending on the treatments utilized, and the number and intensity of treatments. Overall, treatment for a bone and joint cancer can easily exceed $100,000 for a single patient based on the "The Burden of Musculoskeletal Disease in the United States" evaluation (United States Bone and Joint Initiative 2014). This is particularly true if that patient receives surgery, chemotherapy, and radiation therapy. If one includes the cost of bone-replacing endoprostheses or the costs of artificial limbs used in those cases that required amputations, the cost will be much higher.

6. Metastatic Bone Disease.

SREs may occur as frequently as every 3–6 months in someone with skeletal metastatic disease (Coleman 2006). As mobility and functional independence diminish with subsequent SREs, overall health-related quality of life also declines. Furthermore, patients with metastatic bone disease and an SRE have a poorer prognosis and increased risk of death compared with patients who are SRE naïve. With FDA approval of the use of bisphosphonate medications to reduce the risk of pathologic fractures in 1995, the incidence of fractures in treated patients with metastatic bone disease in the USA has significantly decreased. The fracture rates reported in cases of metastatic disease and myeloma have been demonstrated in multiple studies to diminish with a roughly a 50% reduction in fracture rates in many studies. Body et al. (2016) reported a multinational, before-and-after, retrospective study that enrolled patients from hospitals in Austria, the Czech Republic, Finland, Greece, Poland, Portugal, Sweden, and Switzerland. They strongly demonstrate that in real-world practice SREs are associated with substantial increases in health resource utilization across all countries investigated.

A retrospective analysis from the Netherlands (Ter Heine et al. 2017) estimated that the mean per-patient cost to treat SREs in individuals with prostate cancer and bone metastases was €6973 (range, €1187–€40948). Despite the differences in the healthcare systems in the Netherlands and the UK, similar values have been reported for patients in the UK (Body et al. 2016) with breast cancer and bone metastases, with an estimated mean lifetime SRE-associated cost of £11314–£19121 (€14029–€23710; 1 GBP = 1.24 EUR). Notably, total medical care costs are substantially higher for patients who have bone metastases and one or more SREs than for those with bone metastases and no SREs (estimated US$48173 [€37093; 1 US$ = 0.77 EUR] more per patient per 60 months in the USA). Some recent studies reported

the treatment patterns and health care costs in patients with prostate cancer and bone metastases. When the tumour progresses from localized or regional disease to metastatic disease, the 5-year relative survival rate drops from nearly 100% down to 29.3%. In mCRPC patients, 80%-90% present with bone metastases, which significantly lowers the 5-year survival rate to 3% versus 56% in patients without bone metastases. The presence of bone metastases has been strongly linked to increased resource utilization and costs (Yong et al 2014). In comparison with patients without bone metastases, those with prostate cancer bone metastases have increased use of skilled nursing facilities (22.3% vs. 8.1%), hospice care (20.0% vs. 4.8%) and hospitalization (60.9% vs. 43.1%) [Yong 2014]. Moreover, these patients have longer hospital stays (mean of 3 days longer). In fact, overall hospitalization costs of patients with bone metastases versus those without differed by more than US$2000 per visit between 2006 and 2010. A 2014 retrospective analysis of the linked SEER cancer registry and Medicare claims found that hospitalization rates among patients with prostate cancer without distant metastases was 43.1%, whereas the hospitalization rate among those patients with distant metastases was 60.9% at 1 year after diagnosis (Yong et al 2014). A study based on 342 patients with prostate cancer found that the average annual cost after the diagnosis of an SRE was about US$12500 (2006), ranging from $8484 to $26384 depending on the number of SREs that patients had experienced. Barlev et al. (2010) reported costs of inpatient treatment for each admission associated with different types of SREs. Among them, the cost of inpatient services for treating spinal cord compression (US$59788, 2009) was the highest, followed by pathologic fracture (US$22390, 2009) and surgery to the bone (US$42094, 2009). Hagiwara et al. (2013) measured costs of an SRE episode and found that the mean cost per episode was US$20984 (2010). Another study showed that the estimated lifetime SRE-related cost per patient suffering from metastatic lung cancer was US$11979, and that radiotherapy accounted for the greatest proportion of cost (61%) by SRE type.

In patients with metastatic spine tumours, overall complication rates range between 19% and 28%, whereas the incidence of surgical site infection and wound breakdown after surgery is 4%–20% (Demura et al. 2009). Crucially, the most common reason for reoperation after the resection of spinal metastases is surgical site infection, which commonly leads to wound breakdown. Spinal tumour resections are complicated by the fact that many patients have had previous radiotherapy or repeated surgeries, which diminish the capacity for wound healing following tumour resection. Reoperations in this cohort of patients with metastatic spine tumour are potentially devastating due to the potential risks of hardware exposure, delay in the administration of systemic treatments, increased costs, and prolonged hospitalizations.

7. Conclusions and List of Activities Needed

Overall, cancers that metastasise to bone cause significant pain and morbidity. Approximately 50% of patients with metastatic cancer of the lung, breast, prostate, and kidney develop bony metastases prior to death. Untreated, these metastases can lead to pathological fractures and cause great pain and disability. Thus, the elucidation of the biochemical steps involved in bone destruction and the development of drugs to target such steps are examples of tremendous scientific advancement and achievement, furthering the field of cancer research and treatment. Considering healthcare considerations, there is a need for even better collaboration between oncologists and other physicians and orthopaedic (oncology) surgeons in experienced centres in order to develop strategies to reduce the incidence of SREs, which are one of the main cost drivers in the management of musculoskeletal oncology patients.

The remuneration that a hospital receives for inpatient treatment constitutes the direct health insurance fund costs for the cases treated. Many European hospitals receive fees on a case-per-case basis (case fees) for individual inpatient stays (the case fees are also labelled Diagnosis Related Groups (DRGs)). The case fees reflect the average costs of treatment during a patient's stay in hospital. A major issue that deserves consideration is the inadequacy of DRGs in meeting the real-world costs of the management of oncologic patients: for example, the DRGs received for managing a case that requires a proximal femur resection or pelvic resection is the same as for a case that requires primary total hip arthroplasty or revision total hip arthroplasty, and does not consider the staggering difference in implant costs. A further problem is the futility of attempted specific statistical analysis of DRGs. As can be seen from the terms used to describe the DRGs, the fees usually cover several different types of interventions. Consequently, extracting data related to the average costs of a specific treatment separately is not possible. This is because the DRG system remunerates similar cases and treatments based on the average costs of a range of different interventions.

What is strategically/politically needed for European Union:
EFORT should promote initiatives which are of strategic importance in improving the outcomes of cancer patients, and in reinforcing the specialization of Orthopaedic Oncology:

1) Strategic aspects
Worldwide, cancer registries have been shown to be critical for the accurate determination of cancer burden, conduct of research, and in the planning and implementation of cancer control measures. Information from cancer registries is vital for monitoring the incidence, prevalence and mortality of cancer, the effectiveness of national cancer prevention and cancer control initiatives, resource allocation and public policy related to cancer control. In Europe there are a range of different treatment strategies related to National protocols. Even if these are evidence-based, particularly when considering rare tumours, there is a need for data sharing. We need to promote registries, both national and European.

2) Procedural aspects
Cancer research is constantly advancing. Evidence-based medicine helps to transfer the results of that research into new standards and methods for clinical practice. At present, most of the National Societies are involved in their own elaboration of a set of recommendations ("guidelines") for the best standards of cancer care. Unfortunately, in most of the cases, these guidelines are in the native language and are being developed specifically for the Country of origin. We recognize that musculoskeletal oncology requires a multidisciplinary team for optimal patient evaluation and management. A formal governing Board or Committee with representatives from National professional organizations, together with National and European Oncologic Societies, should be commissioned with the aim of defining agreed European guidelines dedicated to the improvement of the quality of care and monitoring of outcomes for patients with bone tumours.

3) Educational aspects

EFORT is very active in the field of education, with numerous projects and activities.

Courses co-organized by EFORT in collaboration with National Societies or European Societies related to oncologic diseases should be considered to be a great opportunity to share the knowledge of experienced Centres across the European community.

Moreover, multicentre research confers many distinct advantages over single-centre studies, including larger sample sizes and more generalizable findings, sharing resources amongst collaborative sites, and promoting networking. Well-executed multicentre studies are more likely to improve provider performance and/or have a positive impact on patient outcomes. We think that Europe should therefore promote and support European courses and multicentre studies, validated for quality by EFORT.

4) Specific aspects related to soft tissue tumours

The orthopaedic community should take care of most of the soft tissue tumours that arise in the extremities. Soft tissue sarcomas should be treated in tumour referral centres. Ideally, a patient should be referred to a tumour centre when a sarcoma is suspected and before undergoing a biopsy or excision. It is essential that a meticulous diagnostic and staging workup is performed and that a multidisciplinary tumour team draws up a management plan and considers the range of reconstructive surgery options. There is a need for wide-ranging activity in the education of all physicians and healthcare staff about the risk of underestimating general symptoms (swelling, pain etc.) that could lead to an early suspicion and diagnosis, with the consequent advantages of early treatment. Moreover, there is a need to educate physicians to avoid the inadequate treatment of STS. Europe should promote the awareness of these aspects through a range of media.

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Section 2

G | Osteoporosis and Fragility Fractures

Table of Contents

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1. Abstract

Osteoporosis is typically a "silent" disease, which can often progress without symptoms until its most severe consequence, a fragility fracture, is experienced. Osteoporosis is diagnosed based on the assessment of bone mineral density (BMD). Dual-energy X-ray absorptiometry (DXA) is the most widely used technique. Hip fractures accounted for the majority of the total cost of fragility fracture care (57%) but only for 20% of all fragility fractures. Fracture-related costs are projected to increase to €47.4 billion euro in 2030. Political actions are essential to reduce the burden by prevention (lifestyle) and early detection of osteoporosis and treatment if necessary.

2. Introduction

Osteoporosis is a systemic disease characterised by reduction in the density of bone tissues (low bone mass), which depends on bone development during childhood and adolescence and how quickly bone mass is lost through adulthood. Weakened bone tissues eventually lead to bone fragility and susceptibility to fracture. There are several factors that increase the risk of osteoporosis, most importantly age and sex. With advancing age, bone structures become weaker and bone mass decreases progressively; as a result, the proportion of people with osteoporosis increases (Table 1 and Table 2). Women are far more likely to develop osteoporosis than men, particularly with reduced oestrogen levels after the menopause. In addition, there are several modifiable risk factors that have a negative impact on bone health, such as insufficient physical activity, smoking, high alcohol consumption, low calcium intake and low body weight. Certain medications, such as steroids and breast cancer treatment, have also been associated with an increased risk of osteoporosis.

Table 1. Remaining lifetime probability of a major osteoporotic fracture at the age of 50 and 80 years in men and women

Source: Kanis et al. Long-term risk of osteoporotic fracture in Malmo. Osteoporos Int 2000;11:669–674 and Kanis et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int 2019;30:3–44

	At 50 years		At 80 years	
Site	Men	Women	Men	Women
Forearm	4.6	20.8	1.6	8.9
Hip	10.7	22.9	9.1	49.3
Spine	8.3	15.1	4.7	8.7
Humerus	4.1	12.9	2.5	7.7
Any of these	22.4	46.4	15.3	31.7

Table 2. Estimated number of men and women with osteoporosis (defined as a T-score of – 2.5 SD or less at the femoral neck) and prevalence in the population aged over 50 years in the EU27, 2010.

Source: Kanis et al. Long-term risk of osteoporotic fracture in Malmo. Osteoporos Int 2000;11:669–674 and Kanis et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int 2019;30:3–44

Age group (years)	Individuals with osteoporosis (000)			Population at risk (000)			Prevalence (%)		
	Women	Men	Total	Women	Men	Total	Women	Men	Total
50-54	1106	429	1535	17,556	17,152	34,708	6.3	2.5	4.4
55-59	1578	547	2125	16,434	15,637	32,071	9.6	3.5	6.6
60-64	2188	826	3014	15,302	14,242	29,544	14.3	5.8	10.2
65-69	2523	818	3341	12,489	11.054	23,543	20.2	7.4	14.2
70-74	3409	777	4186	12,217	9967	22,184	27.9	7.8	18.9
75-79	3876	768	4644	10,335	7459	17,794	37.5	10.3	26.1
80+	7350	1325	8675	15,573	7980	23,553	47.2	16.6	36.8
50+	22,029	5491	27,520	99,906	83,491	183,397	22.1	6.6	15.0

Osteoporosis is typically a "silent" disease which can often progress without symptoms until its most severe consequence, a fragility fracture, is experienced. Osteoporosis is diagnosed based on the assessment of bone mineral density (BMD). Dual-energy X-ray absorptiometry (DXA) is the most widely used technique. Osteoporosis is defined by a BMD that lies 2.5 or more standard deviations below the average peak bone mass of a 25 year old individual.

Fragility fractures are fractures which occur with often surprisingly modest stresses and impacts, that would not be expected to cause breakages in healthy bones. The most common fragility fractures are hip, vertebral, forearm and upper arm.

Osteoporosis is one of the main risk factors for sustaining a fragility fracture. The more the BMD value deviates from the standard, the higher the risk of fracture (Figure 1). A range of other factors also contribute to fracture risk: Advanced age, a history of fragility fractures (Figure 2) and low body mass index (BMI) are important risk factors for fragility fractures, independent of osteoporosis. In this context, falls and their associated risk factors such as reduced mobility and vision, cognitive impairments, psychotropic medications, fear of falling and environmental hazards significantly contribute to the likelihood of sustaining a fragility fracture. But genetic and environmental factors may also play a role;, there are major differences between the European countries (Figure 3).

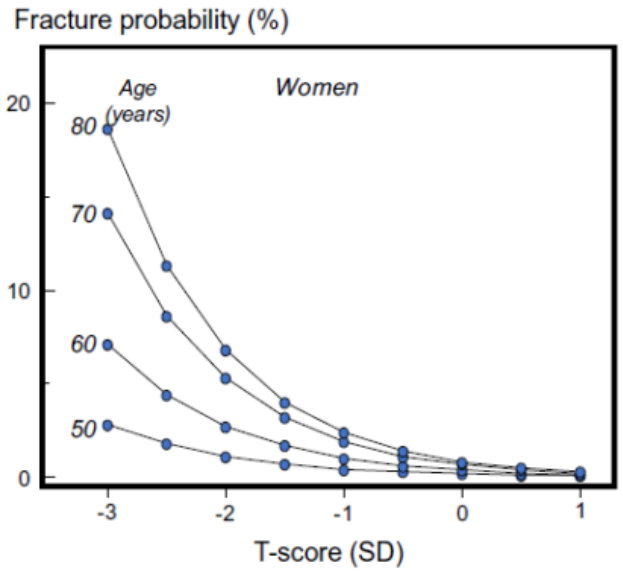

Figure 1. Ten-year probability of hip fracture in women from Sweden according to age and T-score for femoral neck BMD

Source: Kanis et al. Ten-year probabilities of osteoporotic fractures according to BMD and diagnostic thresholds. Osteoporos Int 2001;12:989–995 and Kanis et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporosis Int 2019; 30:3–44

Pain and limited mobility following a fragility fracture mean people are often at risk of losing their independence. The experience of a fracture can further cause anxiety due to a fear of falling, self-image issues and the limitations associated with carrying out day-to-day activities. Family and friends can suddenly find themselves becoming carers, with often limited support. National programmes are often insufficient or difficult to access, leaving people to manage the emotional and financial burden of becoming an informal carer without the support or guidance they need.

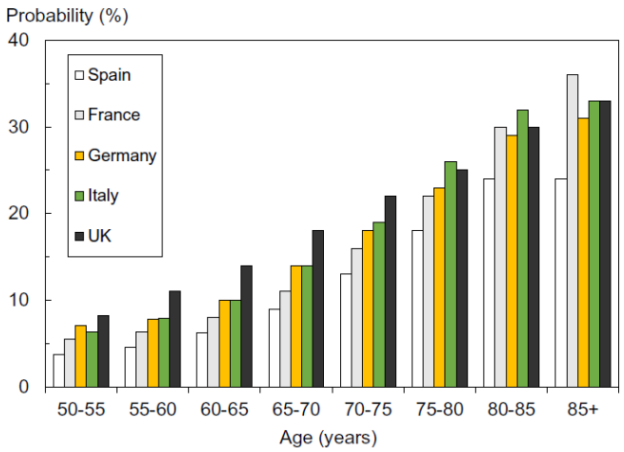

Figure 2. The 10-year probability of a major osteoporotic fracture by age in women with a prior fracture and no other clinical risk factors in the five major EU countries as determined with FRAX (version 3.5). Body mass index set to 24 kg/m2 without BMD.

Source: Kanis et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int 2019;30, 3–44

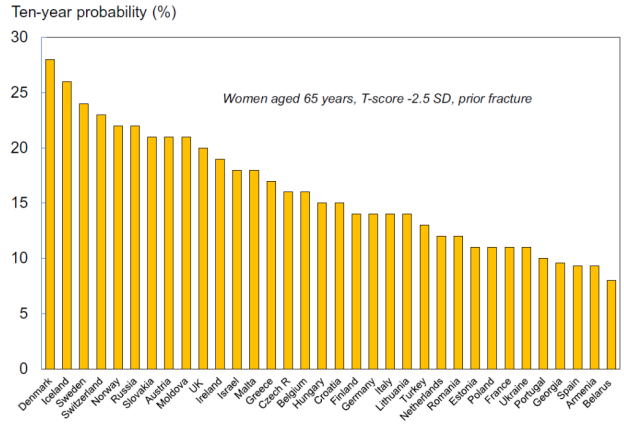

Figure 3. Ten-year probability (%) of a major osteoporotic fracture in women from different European countries. BMI set to 25 kg/m2

Source: Kanis et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int 2019; 30:3–44

3. Epidemiology

Prevalence of osteoporosis

The prevalence of osteoporosis at the age of 50 years or more is 22.5% in women and 6.8% in men.

About one-tenth of women age 60 years, one-fifth of women age 70, two-fifths of women age 80 and two thirds of women aged 90 years have osteoporosis and an increased risk of fragility fracture. In 2015, there were an estimated 20 million individuals with osteoporosis in the 6 most populous European countries (EU6).. Of these, 15.8 million were women and 4.2 million were men. The number of women with osteoporosis increased markedly with age (Figure 4) (Borgström et al. 2020).

Fracture incidence

There were estimated to be 2.7 million new fragility fractures in the EU6 in 2017—equivalent to 7332 fractures/day (Table 3). Almost twice as many fractures occurred in women (66%) compared to men. The total number of major osteoporotic fractures (MOF) was

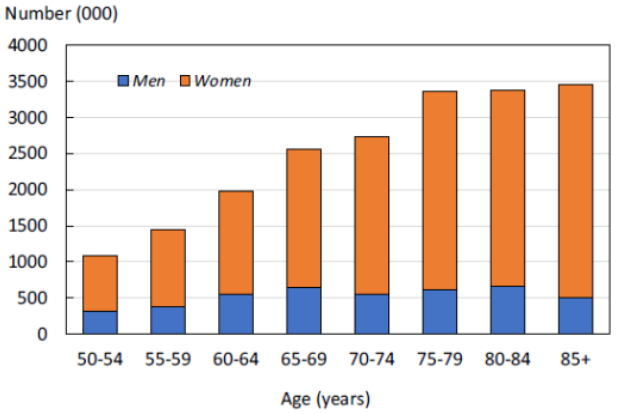

Figure 4. Prevalence of osteoporosis in the EU6 by age and sex

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Table 3. Estimated number of incident fragility fractures in the EU6 by site in 2017

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Fracture site	Women	Men	Men and women
Hip	381,732	144,738	526,470
Spine	267,194	148,089	415,283
Proximal humerus/distal forearm	303,021	175,020	478,041
Other	819,029	437,397	1,256,426
All	1,770,876	905,244	2,676,220

1.4 million. Hip, vertebral and distal forearm/proximal humerus fractures accounted for 19.6% (526.000), 15.5% (416.000) and 17.9% of all fractures, respectively. Other fragility fractures accounted for 49% of the fracture burden (Borgström et al. 2020). The highest number of fractures in both men and women occurred in Germany - approximately 765,000 incident fractures in total, reflecting the large population size and comparatively high fracture incidence (Figure 5) (Borgström et al. 2020). In relation to the population at risk, there was a greater than two-fold range in risk that varied from 15/1000 in France to 32/1000 in Sweden (Borgström et al. 2020). Around 120 000 proximal femoral fractures were treated surgically on an inpatient basis in Germany in 2018 (Rapp et al. 2019).

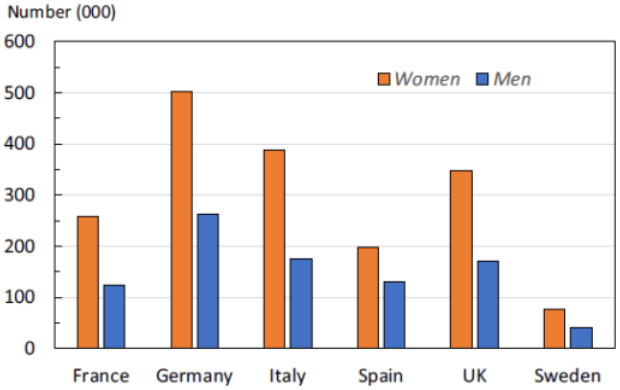

Figure 5 Number (thousands) of new fragility fractures by country in 2017

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Table 4. Number of new fragility fractures in 2017 in men and women by country, the population at risk (men and women aged 50 years or more) and the crude incidence (/1000 of the population)

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Country	New fractures (000)	Population at risk (000)	Rate/1000
France	381.6	24,672	15
Germany	764.9	33,399	23
Italy	563.4	26,282	21
Spain	327.6	16,510	20
UK	519.0	24,048	22
Sweden	119.7	3787	32
EU6	2676.2	128,699	21

Lifetime risk of fragility fracture

For MOF the remaining lifetime risk was highest in Sweden (46.3% for women and 28.7% for men (Figure 6). This lifetime risk of MOF was comparable to that of cardiovascular disease (CVD)(Borgström et al. 2020).

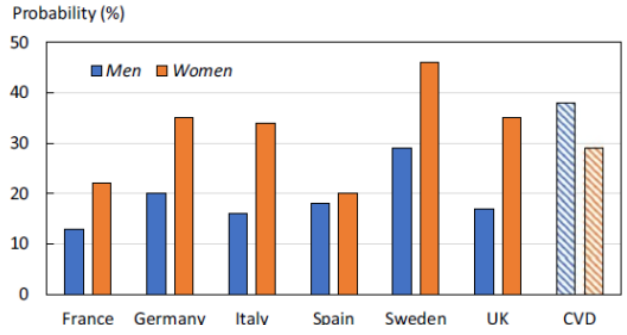

Figure 6. Lifetime risk of fragility fracture from the age of 50 years, by country and sex, and the equivalent risk for cardiovascular disease (CVD). Source: National fracture incidences and own calculations

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

For hip fracture the remaining lifetime probability was, for women at the age of 50 years, between 9.8% for Spain and 22.8% for Sweden (Figure 7). The corresponding risk range for men was 6.1% (France) to 13.7% (Sweden). The lifetime risk of hip fracture at age 50 years was comparable to the lifetime risk of a stroke in Europe for both women (20%) and men (14%) (Borgström et al. 2020).

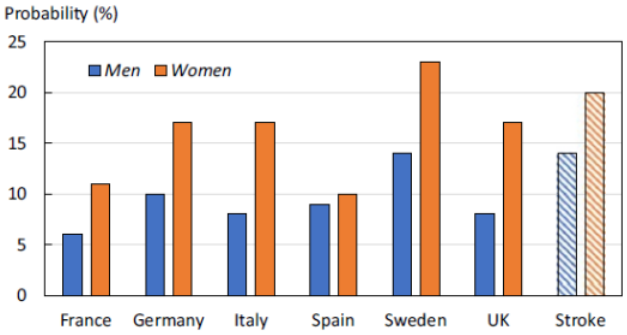

Figure 7. Lifetime risk of hip fracture from the age of 50 years, by country and sex, and the equivalent risk for stroke

Source: Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

There is a marked difference in the risk of fracture between countries. Northern European countries have the highest fracture rates observed worldwide. The reasons for the difference in fracture risk are unknown but cannot be explained by differences in bone density. Plausible factors include differences in body mass index, low calcium intake, reduced sunlight exposure and perhaps the most crucial factor, high socioeconomic status, which in turn may be related to low levels of physical activity (Borgström et al. 2020).

Fracture projections

Regardless of differences in fracture risk, the number of fractures in all countries is expected to increase due to an increasingly ageing population. To estimate the annual number of new fractures between 2017 and 2030, national data on fracture incidence by type and sex were combined with demographic projections over time.

The total number of all fragility fractures in the EU6 is projected to increase from 2.7 million in the year 2017 to 3.3 million in 2030; an increase of 23.3% (Figure 8). The total number of MOF is expected to increase by 24%. For hip fracture and clinical spine fracture the increases projected were 28% and 23%, respectively (Borgström et al. 2020).

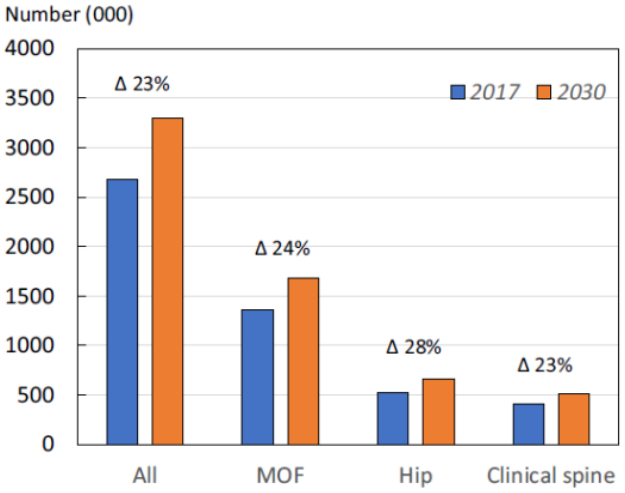

Figure 8. Estimated number of fragility fractures by fracture category in 2017 and 2030. Numbers denote the percentage change for all fragility fractures, major osteoporotic fractures (MOF), hip and clinical spine fractures

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Costs

Hip fractures accounted for the majority of the total cost of fragility fracture management (57%) but only for 20% of all fragility fractures (Figure 9) (Table 5). In 2010, fracture-related costs in the EU6 were estimated to total €29.6 billion. Fracture-related costs for the EU6 in 2017 were by then estimated to total €37.5 billion (an increase of 27% since 2010), and are projected to increase to €47.4 billion in 2030 (an increase of 27% since 2017) (Figure 10).

4. Diagnosis and Treatment

Measurement of bone density via DXA is done in the in- or outpatient sector in many countries by a radiologist, but in some also by bone experts with a primary specialisation in orthopaedics,

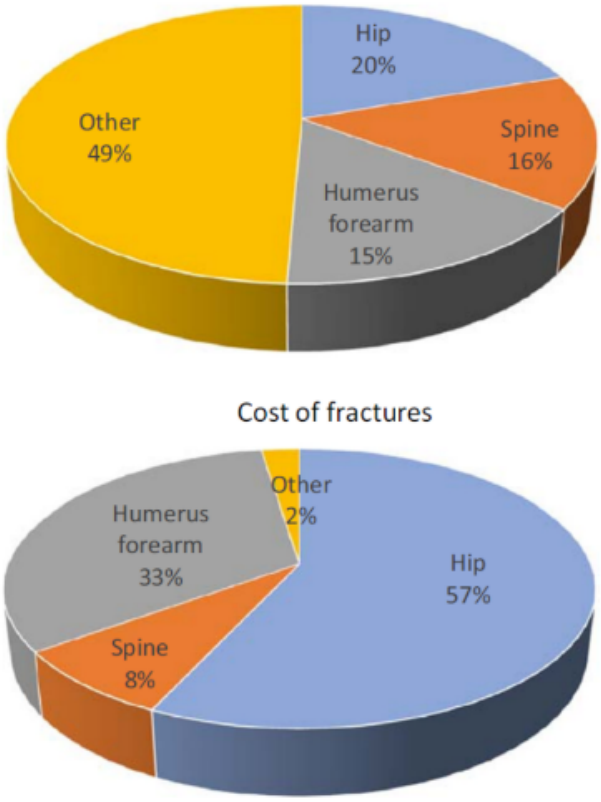

Figure 9. Number and cost of fragility fractures in the EU6 expressed as a percentage of the totals

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Table 5. Direct cost (million Euro) of fractures in 2017 (incident fractures), those arising from fractures before 2017 (prior fractures) and the cost of institutional care in each EU6 country

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Country	Incident fractures	Prior fractures	Institutional care	Total
France	3748	219	1404	5371
Germany	8176	414	2680	11,270
Italy	5951	299	3179	9429
Spain	2150	137	1915	4202
UK	2955	372	1919	5246
Sweden	1199	81	690	1970

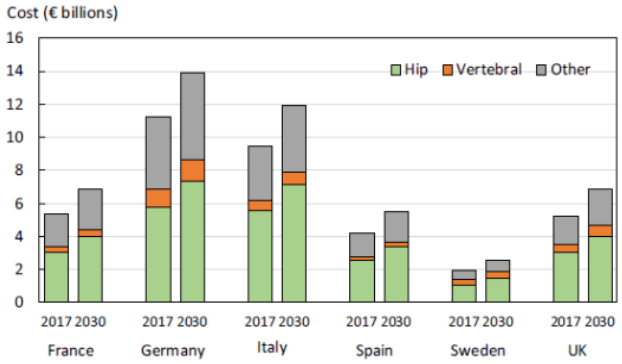

Figure 10. Cost of fragility fractures in 2017 and that expected in 2030 by country and fracture site

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

rheumatology, endocrinology, gynaecology or others. Further laboratory evaluation and prescription of drugs is performed mainly by the above named clinical specialities, as well as by GPs in the outpatient sector – again varying significantly between the countries (Dreinhöfer et al. 2004).

Primary prevention

The best effort to avoid osteoporosis consists of avoiding the relevant modifiable risk factors, such as smoking, alcohol consumption, unhealthy diets and lack of exercise. In addition, appropriate intake of Calcium and Vitamin D seems to be essential.

Secondary prevention

In cases of low bone mineral density indicating osteoporosis, secondary prevention of fragility fractures includes all of the above, as well as pharmacological agents, such antiresorptive and/or bone formation drugs. In addition, fall prevention is proven to be efficient.

Tertiary prevention

Following a fragility fracture the risk of sustaining further fractures is significantly increased, requiring all of the above and sometimes further medical interdisciplinary intervention.

Pharmacological treatment gap

The treatment gap has been estimated from the difference between the number of patients treated with any osteoporosis drug using IMS sales data and the number of patients in the population considered to be eligible for an osteoporosis treatment.

The average treatment gap (percent eligible patients not treated) in EU6 in year 2017 was 73% for women and 63% for men (Figure 11). The treatment gap varied between countries. The highest treatment gap for women was in Germany, whereas the UK had the smallest treatment gap (64%) in women and in men (43%). Compared to the analysis from year 2010, there was a marked increase in the treatment gap for the EU6 (17% and 16% points for women and men, respectively)(Borgström et al. 2020). In addition, there is a major adherence gap – many people (60-80%) stop the medication over the first 12 months since they do not perceive any beneficial effect and have limited information about the need.

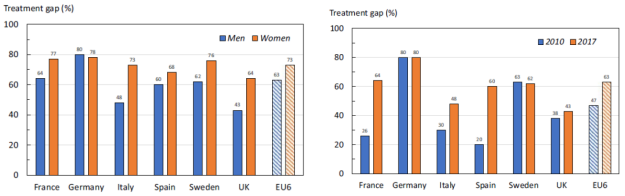

Figure 11. Treatment gap in men and women by country in 2017

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Post-fracture treatment gap

An alternative approach for assessing the treatment gap is to estimate the proportion of patients starting a pharmacological treatment after a fracture. With the exception of the UK, no more than 30% of women receive any treatment following a fracture. In the UK, the treatment gap was markedly lower after hip fracture (49%). (Figure. 12) (Borgström et al. 2020). Except for the UK, the treatment has not really improved compared to 2004 (Dreinhöfer et al. 2005).

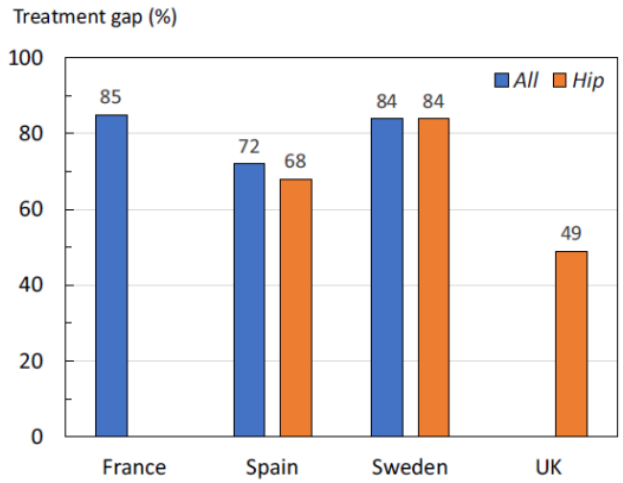

Figure 12. Percentage (%) of women (50 years and above) not treated within a year of an osteoporotic fracture or a hip fracture

Source: Borgström et al. Fragility fractures in Europe: burden, management and opportunities. Archives of Osteoporosis 2020; 15:59

Secondary and tertiary prevention activities have been proven to be very cost-efficient – but still they are seldom put in place. Different European societies have identified the insufficient and partly inappropriate prevention and treatment of patients with osteoporosis. Some have recently prepared National and European Guidelines on the prevention of fragility fractures. As an example, The European Union Geriatric Medicine Society (EUGMS) has released a statement on a comprehensive fracture prevention strategy in older adults (Blain et al. 2016). The International Osteoporosis Foundation (IOF) together with ESCEO published the European guidance for the diagnosis and management of osteoporosis in postmenopausal women (Kanis et al. 2019).

5. Treatment of Hip Fractures

The adequate care of elderly patients with femoral neck fractures is extremely important, since these injuries are associated with high mortality, significant loss of independence and high financial costs for the community. The general mortality rate following procedures of this kind is 10–15% within the first 30 days and 25–30% at 6 months. The excess mortality due to hip fractures is 8–36% at 12 months.

Orthogeriatric care

Many elderly patients with fractures have pre-existing chronic diseases, which affect not only the overall treatment situation, but also their long-term and short-term survival as well as their functional recovery. Preventing complications and, in particular, minimizing the risk of delirium, are treatment priorities. Adequate pain therapy, achieving fitness for surgery in the short-term and prompt, skilled surgical treatment are of central importance. Towards that goal it is increasingly recognised that people with fragility fractures should be managed in the context of a multidisciplinary clinical system, guaranteeing adequate and efficient preoperative assessment and preparation (Orthogeriatric Service - OGS) (Ranhoff et al. 2019). Older people with fragility fractures often have pre-existing chronic diseases impacting their general management, short-term and long-term survival rate and functional recovery. Minimising delirium and avoiding complications is critical for achieving good outcomes. Appropriate pain management, rapid optimisation of fitness for surgery and early surgery improve morbidity and mortality. Appropriate preoperative investigations should allow the identification and treatment of acute medical illness or exacerbations of chronic medical conditions.

Long-term rehabilitation

As many as half of older people who were independent prior to sustaining a hip fracture fail to recover their pre-fracture ability to walk and carry out usual activities required to remain autonomous. Strategies for long-term rehabilitation that address these functional limitations also need implementation beyond the acute recovery period; these too require management by multi-disciplinary care teams working with patients and their families. There is much evidence that long-term multi-professional rehabilitation programs are able to considerably improve patients' ability to resume active participation in everyday life (Dyer et al. 2016).

Secondary and tertiary prevention

Individuals who have suffered fragility fractures have a significantly higher risk of sustaining further fractures. Although the preventative effectiveness of pharmacological and non-pharmacological interventions has been unequivocally demonstrated, 80% of fracture patients currently remain undiagnosed and untreated for the underlying disease. The implementation of a treatment pathway (for example, a fracture liaison service) has led to significantly better care in many countries (Mitchel et al. 2019).

Already, in 2016, The European Federation of National Associations of Orthopaedics and Traumatology (EFORT) and the European League Against Rheumatism (EULAR) have recognised the importance of *optimal acute care for the patients aged 50 years and over with a recent fragility fracture and the prevention of subsequent fractures in high-risk patients* (Lems et al. 2017) and addressed these issues. This can be facilitated by close collaboration between orthopaedic surgeons and rheumatologists or other metabolic bone experts as well as geriatricians. Therefore, the aim was to establish for the first time collaborative recommendations for these patients (Table 6).

On a global level, the Fragility Fracture Network (FFN) recently released for the first time *A global call to action to improve the care of people with fragility fractures*. This was originated by six societies including EFORT and endorsed by more than 100 global, regional and national societies (Dreinhöfer et al. 2018). Improvements in the following three key areas are called for: multidisciplinary orthogeriatric acute care, post-acute rehabilitation and secondary prevention.

Great Britain started early on to work towards improving the quality of its care by optimizing structures and processes. To this end, a binding national interdisciplinary guideline was implemented, a registry was initiated (National Hip Fracture Database), and financial incentives were set up with the best practice tariff (BPT; a bonus of 1355 British pounds for every patient treated in accordance with the guideline). The BPT in particular, which is guided by structure and outcome criteria, appears to be the most significant measure, according to the available registry data, impacting on the reduction in 30-day mortality (Metcalfe et al. 2019).

In Germany, the orthopaedic/trauma surgery, geriatric, and osteological specialist medical societies have initiated a number of relevant measures in recent years: for example, the white paper on "Geriatric Traumatology" ("*Weissbuch Alterstraumatologie*") was jointly published by the German Societies for Trauma Surgery

Table 6. EFORT – EULAR Recommendations for patients with fragility fractures in patients aged 50 years and older

Source: Lems et al. EULAR/EFORT recommendations for management of patients older than 50 years with a fragility fracture and prevention of subsequent fractures. Ann Rheum Dis 2017; 76: 802–10.

1	Fragility fractures should be managed in the context of a multidisciplinary clinical system, guaranteeing adequate preoperative assessment and preparation of patients including adequate pain relief appropriate fluid management and surgery within 48 hours of injury
2	To improve functional outcome, and to reduce length of hospital stay and mortality, orthogeriatric co-management should be provided especially in elderly patients with hip fracture
3	Appropriate treatment of the fractures in these, often elderly and multimorbid, patients with frail bones requires a balanced approach with regard to operative vs non-operative treatment and careful selection of fixation devices and techniques
4	Each patient aged 50 years and over with a recent fracture should be evaluated systematically for the risk of subsequent fractures
5	Evaluation of the risk of subsequent fractures includes a review of clinical risk factors, DXA of the spine and hip imaging of the spine for vertebral fractures and evaluation of falls risk and the identification of secondary osteoporosis, which together predict subsequent fracture risk
6	Implementation requires a local responsible lead, that is, a person group that coordinates secondary fracture prevention based on guidelines, liaising between surgeons rheumatologists / endocrinologists, geriatricians in case of elderly with a hip or other major fracture, and general practitioners
7	An appropriate rehabilitation programme should consist of both early post-fracture introduction of physical training and muscle strengthening and the long-term continuation of balance training and multidimensional fall prevention
8	Patients should be educated about the burden of the disease, risk factors for fractures, follow-up and duration of therapy
9	Non-pharmacological treatment is important in the prevention of fractures in high-risk patients; it includes at least an adequate intake of calcium and vitamin D, stopping smoking and limitation of alcohol intake
10	Pharmacological treatment should preferably use drugs that have been demonstrated to reduce the risk of vertebral, non-vertebral and hip fractures, and should be regularly monitored for tolerance and adherence

(*Deutsche Gesellschaft für Unfallchirurgie, DGU*) and Geriatrics (*Deutsche Gesellschaft für Geriatrie, DGG*) (Liener et al. 2018). The paper highlights the most important steps in the optimal care of elderly patients with bone fractures in a multi-professional team. Furthermore, interdisciplinary centres can become certified (on a voluntary basis) as either a "Geriatric Trauma Centre DGU" or a "Geriatric Traumatology Centre DGG." Participation in the DGU Geriatric Trauma Registry is mandatory in order to become a Geriatric Trauma Centre and serves quality assurance and outcome analysis purposes.

In order to be able to deploy an adequate number of physicians with expertise in geriatric medicine, it is important to introduce a certificate of additional qualification in geriatrics. However, one should bear in mind here that there may be different treatment focuses; therefore, access to this type of continued medical education should be kept open to all relevant clinical specialties in order to be able to combine specialist medical skills with skills in geriatrics.

The "Global Call for Action" ended with:

To address this fragility fracture crisis in the "Decade of Healthy Ageing", the undersigned organisations pledge to intensify their current efforts to improve the current management of all fragility fractures, prevent subsequent fractures, and strive to restore functional abilities and quality of life. The time is now and it requires we acknowledge that the status quo is no longer acceptable and that the opportunity starts with the next fractured patient!

This is an ambitious goal that has so far only been addressed in a few countries.

To improve the system an interdisciplinary group of people developed under the leadership of the Health Policy Partnership the following recommendations in a policy toolkit.

- Building a system that works: Health system policies for scrutiny, accountability and investment
- Catching it early: detection and management in primary care
- Getting people back on track: Facilitating multidisciplinary care post-fracture
- Supporting quality of life as part of healthy and active ageing: prevention of falls and fractures in later life
- Engaging patients and public: awareness, activation and self-management

To ensure health systems in Europe are prepared to respond to the growing burden of fragility fractures, health and social services must be improved for people before and after they have had a fracture. This will require buy-in from stakeholders at all levels and a supportive policy environment in which osteoporosis is recognised as a priority.

6. List of Activities Needed

Three cross-cutting elements are required to ensure clinical care is optimised across the whole patient journey:

- Integrating osteoporosis and fragility fracture prevention into European and national policies and strategies: strategic leadership in policy development is key to ensuring longer-term investment and accountability, as is a clear vision of current and future demand on the healthcare system, and the setting of achievable and measurable targets in pursuit of justified long-term goals.
- Establishing comprehensive registries and audits: the availability of high-quality data on osteoporosis and fragility fractures is essential for effective scrutiny, performance management and planning, and can create vital feedback at the national and local level.
- Setting up reimbursement structures: adequate reimbursement needs to be in place to ensure access to best-practice care at all levels of service delivery. Where helpful, this should consider the wider costs of failing to prevent fractures across the whole pathway.

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Section 3

Orthopaedic and Trauma Management

Section 3

A | Non-Surgical Treatment

Table of Contents

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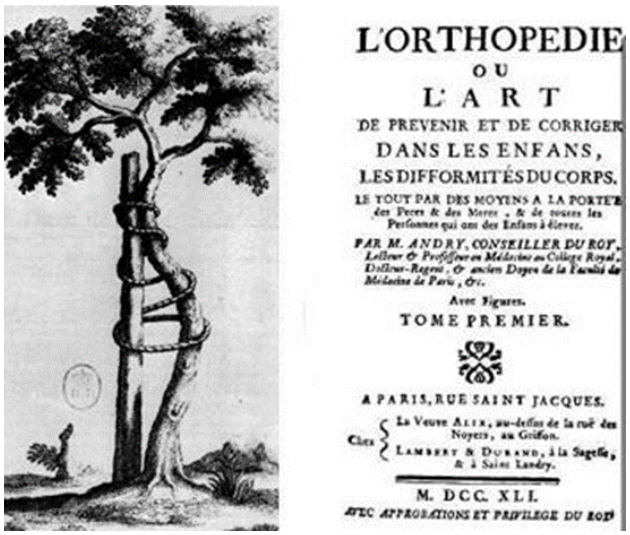
1. Summary

Non-surgical (conservative) treatment is an essential pillar in the management of all musculoskeletal disorders and injuries. It can be applied as a stand alone intervention or as an adjunctive therapy to surgical procedures. A large spectrum of conservative therapies of musculoskeletal disorders is practised in Europe, with differences both within and between countries. Adherence to published guidelines regarding conservative treatment in hip and knee osteoarthritis has to be improved. Whenever possible, patient-oriented treatment plans should be developed through interdisciplinary collaboration in order to achieve the best possible outcome. Necessary harmonisation of the provision of care in the future should be based on quantitative as well as qualitative indicators and benchmarks to facilitate comparison of national practices.

2. Introduction – Historical Roots of Orthopaedics and Traumatology

The term "orthopaedics" derives from the title of a famous textbook on the correction of childhood deformity, written by Nicolas Andry in 1741 (Andry 1741). The title page of the monograph (Figure 1), shows a picture of a hunched sapling, which is splinted with a stake, and this has become a symbol for many orthopaedic associations worldwide.



L'ORTHOPEDIE
OU
L'ART
DE PREVENIR ET DE CORRIGER
DANS LES ENFANS,
LES DIFFORMITÉS DU CORPS.
LE TOUT PAR DES MOYENS A LA PORTÉE
des Peres & des Meres, & de toutes les
Personnes qui ont des Enfans à élever.
PAR M. ANDRY, CONSEILLER DU ROY,
Lecteur & Professeur en Médecine au Collège Royal,
Docteur-Regent, & ancien Doyen de la Faculté de
Médecine de Paris, &c.
Avec Figures.
TOME PREMIER.
A PARIS, RUE SAINT JACQUES.
Chez { La Veuve ALIX, au-dessus de la rue des Noyers, au Griffon. / LAMBERT & DURAND, à la Sagesse, & à Saint Landry.
M. DCC. XLI.
AVEC APPROBATIONS ET PRIVILEGE DU ROY

Figure 1. The "splinted tree" symbolising the correction of childhood deformities on the cover of the historic monograph of Nicolas Andry

Source: Andry de Boisregard N. L'Orthopédie ou l'art de prévenir et de corriger dans les enfants les difformités du corps. Le tout par des moyens a la portée des peres & des meres, & des personnes qui ont des enfants à élever. Paris: Alix, 1741

Although non-surgical treatment of numerous musculoskeletal disorders has been practised for centuries, this historic monograph, elaborating on various options for non-surgical ("conservative") deformity correction, is the cornerstone of modern Orthopaedics. Even the treatment of fractures and dislocations started with conservative manipulations and splinting in the Egyptian era. Later on, the School of Hippocrates developed detailed techniques for traction, casting and bandaging. During the evolution of modern Orthopaedics and Traumatology, these non-surgical techniques have been further optimized and, even today, conservative treatment represents a valid alternative, or at least a necessary complement, to surgical care.

3. Conservative Treatment Principles in Musculoskeletal Disorders

Examples of the wide spectrum, as well as the impact, of conservative treatment modalities in the musculoskeletal field can be illustrated by considering osteoarthritis (OA), rheumatoid arthritis (RA), nonspecific low back pain, lumbar disc herniation, the application of prosthetics and orthotics, and musculoskeletal rehabilitation. These different fields highlight how various components of conservative therapy can be used in prevention, as a core treatment element alone, or even to improve results of surgery through pre-, peri- and post-operative rehabilitation.

Hip and knee osteoarthritis

Non-surgical management is the generally accepted core treatment of degenerative joint disorders. Especially for hip and knee OA, patient-focused treatment recommendations have been developed, which are based on numerous reviews of high-quality meta-analyses, which list interventions according to their supporting evidence (Bannuru et al. 2019). Patient education and land-based exercise programs (mainly aerobic and mind–body, strengthening and flexibility exercises (Goh 2019)) as well as non-steroidal anti-inflammatory drugs (NSAIDs), COX-2 inhibitors (depending on comorbidity or frailty) and analgesics belong to the core recommendations for all patients. In knee-OA, dietary weight management, topical non-steroidal anti-inflammatory drugs (NSAIDs), intra-articular corticosteroids and/or hyaluronic acid and aquatic exercise are additionally recommended. It is also well known that OA patients benefit additionally from multidisciplinary treatment beyond a traditional biomedical approach, utilising the biopsychosocial model of pain as a guiding framework to stimulate resilience (Bartley et al 2017): The effectiveness of structured programs, which support the implementation of guidelines for the non-surgical management of knee and hip OA, has been proven in regional and nationwide investigations. A recent German initiative concerning collaborative ambulatory orthopaedic care at a federal state level found a lower risk of OA-related hospitalization and joint replacement rates in more than 20000 enrolled patients when compared to a control group (Mueller et al, in review). In Denmark the nationwide implementation of guidelines within an initiative called "Good Life with osteoArthritis in Denmark (GLA:D®)" demonstrated a significant impact not only on patient symptoms and physical function, but also on the intake of pain medications and sick leave. These results are very important and will hopefully contribute to a wider acceptance of structured OA management programs based on established guidelines, which many patients still do not receive (Jacobs et al. 2020, Meiyappan et al. 2020). The best possible adherence to guidelines, however, is necessary to avoid inappropriately high utilization rates of arthroplasty, thereby increasing the burden for society (see chapter 3B).

Rheumatoid arthritis (RA)

Apart from the proven efficacy of glucocorticoids and various types of disease-modifying antirheumatic drugs (DMARDs) in RA, non-pharmacological conservative interventions are of great value for affected patients. Single exercise/physical activity interventions, psychosocial interventions and custom orthoses are effective in improving pain, functional disability and fatigue (Siegel et al 2017,

Santos et al. 2019). Non-pharmacologic management programs are increasingly available via the internet and mobile applications. Foot orthoses are also an important treatment option in patients with foot problems related to RA. Nevertheless, many different kinds of orthoses are prescribed but there is a definite lack of high quality RCTs evaluating the comparative (cost-) effectiveness of the treatment of foot problems encountered in RA (Tenten-Diepenmaat et al. 2019). Several recently published guidelines confirm that RA patients should be offered a global management program, including drug treatments, therapeutic patient education, psychological support, assistance with social and occupational issues, functional rehabilitation, and/or surgery if necessary (Daien et al. 2019). However, non-optimal adherence to these recommendations among patients and clinicians is frequent (Moe et al. 2014, Jacobs et al. 2019). The importance of early appropriate treatment to prevent chronicity and to reduce disability is still undervalued, and it is necessary to improve the equity of care for affected patients throughout Europe.

Nonspecific low back pain

As low back pain is one of the most disabling conditions globally, belonging to the group of leading indications for in-patient treatment as well as for medical rehabilitation (see chapter 2A), the appropriate application of non-surgical management is of utmost importance. Clinical practice guidelines exist in several European countries, which highlight the significance of different conservative treatment modalities (Oliveira et al. 2018). Whilst in the acute phase patients without "red flags" may require injections, thermo-therapy and analgesics to help them cope with symptoms. Active exercise therapy is mandatory in patients with symptoms of longer duration and has proven to be effective. Numerous high-quality studies have shown the beneficial effects of strength/resistance and coordination/stabilisation exercise programs over other interventions in the treatment of chronic low back pain (Searleet al. 2015). In patients with psychosocial risk factors, interdisciplinary and multi-modal treatment can be necessary, which includes specific medications and psychosocial interventions. Referral to a specialist is generally recommended in cases with symptoms or signs causing a suspicion of specific more sinister pathologies ('red flags") (Oliveira et al. 2018).

Lumbar disc herniation

The treatment of lumbar disc herniation with painful radiculopathy falls within the domain of conservative therapy when clinical symptoms occur for the first time. Spontaneous regression of herniated disc tissue definitely occurs in most patients, and approximately 60%–90% of patients with lumbar disc herniation can be treated successfully with conservative strategies (Chen et al. 2018). In the case of recurrent or refractory clinical symptoms, surgical therapy may be indicated. Good results can be achieved by surgery, especially with regard to rapid pain reduction, improved function and patient satisfaction. However, despite the faster improvement seen after surgery, in the medium and longer term there is an equalization of results and surgical complications mean there is no clear advantage over a conservative approach (Jacobs et al. 2011, Kim et al. 2021). Non-surgical management is therefore a good option in the shared decision-making process (Kim et al. 2021). As the number of patients undergoing spinal surgery is significantly rising (see chapter 3B), more high-quality studies are needed to evaluate which patients benefit more from surgery and which from conservative care.

Prosthetics and orthotics

Patients with a variety of disorders benefit from prosthetic and orthotic devices (e.g. congenital limb deformities, traumatic and non-traumatic amputations, neuro-orthopaedic disorders, poliomyelitis and other lower extremity palsies, vertebral column fractures and spinal deformities, degenerative disorders). In all of these disorders close collaboration between the orthopaedic surgeon and orthotic & prosthetic technician is essential to achieve the best possible treatment results. New developments in prosthetic attachment and component design, the application of advanced biomechanical principles and technological solutions embracing information technology and micro-processing, have contributed to substantial recent improvements in the field of prosthetics and orthotics. This is promoted and supported by an internationally growing industry, which provides a large variety of devices. Nevertheless, there remains a lack of high quality studies and suboptimal education and research in the field of orthopaedic technology that has to be improved (McDonald et al. 2020).

Musculoskeletal rehabilitation

Rehabilitation is a process of facilitating patients suffering from an illness, injury and/or have undergone surgical procedures, to regain maximum self-sufficiency, and is based on a variety of conservative treatment modalities. Physiotherapy is indispensable in the rehabilitation of patients with musculoskeletal disorders, as well as in preoperative and postoperative care. Systematic reviews reveal that accelerated physiotherapy regimens before and after hip and knee arthroplasty are effective in reducing the length of hospital stay. They also improve patient outcomes (Moyer et al. 2017, Henderson et al. 2018) and are of special relevance for the introduction of enhanced-recovery protocols (Papalia et al. 2020). There is an ongoing debate concerning the relative efficacy of in-patient versus out-patient rehabilitation. Most recently there is also discussion about the added value of technology-assisted rehabilitation, in particular virtual- or tele-rehabilitation, which can only be solved with more information from high quality studies.

4. Provision of Non-Surgical Treatment in Europe

Numerous professions and medical specialties are involved in the non-surgical treatment of patients, and responsibilities differ from country to country. Available information from UEMS-acknowledged specialist sections and divisions suggests that the following specialties are practising conservative therapy in musculoskeletal disorders:

- Orthopaedic Surgery
- Rheumatology
- Occupational Medicine
- Physical and Rehabilitation Medicine
- General Surgery
- Traumatology

Conservative therapy is an integral part of the "EFORT Core Curriculum in Orthopaedics and Traumatology" (EFORT 2016). The EFORT Core Curriculum has been approved by UEMS and forms guidance for orthopaedic resident education in Europe. Although the daily professional practice of certified Orthopaedic Surgeons revolves around surgical activity in many European countries,

training in non-surgical competencies is important in order to inform appropriate choices about the indications for surgery to plan post-operative rehabilitation. In Germany and some other countries (e.g. Austria) a significant number of Orthopaedic Surgeons perform conservative treatment as a major, or even exclusive, part of their practice. Some even subspecialize in Orthopaedic Rheumatology, providing sufficient care to patients with inflammatory disorders in regions where the number of Rheumatologists is limited.

The above-mentioned medical specialists, and some others (e.g. neurologists, ENT and other physicians) can qualify in manual medicine, which is neither a specialty nor a sub-specialty, but represents an additional competence that can be used to treat musculoskeletal disorders conservatively. In addition to physicians and medical specialists, many other health professionals (e.g. physical therapists and occupational therapists) as well as allied health professionals (e.g. chiropodists/podiatrists, chiropractors, dietitians, osteopaths, orthotic & prosthetic technicians) are involved in the non-surgical management of patients.

The development of the conservative treatment of musculoskeletal disorders originates from a range of medical specialties. In addition, the historical context of rehabilitation, manual medicine, physiotherapy, balneotherapy and many other conservative modalities is country-specific. The available resources result in differences in the delivery of non-surgical care, both within and between European countries. However, cross-border healthcare for European citizens and economic pressures will almost certainly require further harmonization of care provision in the future. This process should not be guided by lobbying of interested provider groups, but requires quantitative as well as qualitative indicators and benchmarks to facilitate comparison of best national practices.

5. List of Activities Needed

- Maintenance and strengthening of conservative treatment competencies in Orthopaedic Surgical education and training throughout Europe.
- Intensification of research activities to elucidate the efficiency and cost-effectiveness of non-surgical treatment.
- Improvement of adherence to published guidelines regarding conservative treatment in hip, knee osteoarthritis and back pain, but also in other orthopaedic conditions.
- Development of quantitative as well as qualitative indicators and benchmarks to facilitate the comparison of non-operative treatments of musculoskeletal disorders and injuries in health care systems throughout Europe, in order to improve the harmonization of the cross-border provision of care.

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Section 3

B | Surgical Treatment

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1. Summary

Due to their high prevalence and an ageing population, musculoskeletal disorders significantly contribute to the utilization of health services in European countries, and health policy must anticipate further growth. Total hip and total knee arthroplasty belong, together with arthroscopic surgery of the knee and spinal interventions, to the list of the most frequently performed, as well as the most successful, surgical procedures. Analysis of provision rates is difficult, as some inconsistencies impair the comparison of current data. Nevertheless, a significant variation in surgery rates, both between European countries and within individual countries, can be observed. Potential reasons are multifactorial and range from variability in the incidence of disorders, through differences in health care structure (e.g. number of orthopaedic specialists, hospitals and insurance systems) to nation-specific economic factors. Key measures are proposed to ensure appropriate and fair resource allocation in the future.

2. Introduction

Due to the high prevalence, and therefore burden, that musculoskeletal disorders and injuries impose, a significant number of surgical procedures end up being performed in this healthcare sector throughout Europe. Although surgery can be performed as an inpatient procedure or as a day case procedure with no associated hospital stay, most data currently available relates only to inpatient treatment, nearly all information in this chapter being derived from hospital discharge statistics. These are used widely as a measure of health service utilisation.

According to the Eurostat database (Eurostat 2020), on average around 1200 inpatients with diseases of the musculoskeletal system and connective tissue and 1300 with accidents and injuries per 100000 inhabitants were discharged from European hospitals in 2018. This amounts to a total of nearly 12 million inpatient treatments in 2018 for musculoskeletal disorders and injuries in Europe, and in most cases this treatment involved surgical procedures. These patients accounted for a range from 5% (Romania) to 10 % (Cyprus and Austria) of the total number of inpatient hospital discharges in Europe, which demonstrates the variable, but overall very high, impact of musculoskeletal conditions on national health systems. Relative to population size, Austria and Germany recorded the highest number of inpatient discharges of patients treated for musculoskeletal diseases (3197 and 2861 per 100 000 inhabitants respectively) as well as accidents and injuries (2981 and 2429), while the numbers were lowest for injuries in Turkey (618) and for musculoskeletal diseases in Portugal (377).

European comparisons of hospital discharge statistics are complicated because hospital activities are affected by several factors, such as the demand for hospital services, the capacity of hospitals to treat patients and the ability of primary care to prevent avoidable hospital admissions. In addition, differences between national health information systems as well as public and private insurance systems, also affect the collection of these statistics. Finally, numbers of inpatient treatments for what are mostly degenerative musculoskeletal diseases depend largely on the age structure of the population, and the life-expectancy in various European regions is still very different. Therefore, higher treatment numbers can be expected in middle and south European regions, which have older populations than eastern Europe.

Nevertheless, the high burden of musculoskeletal disorders and injuries, resulting in a significant amount of surgery throughout Europe, can be summarized with some key figures concerning the most frequently performed procedures, such as arthroplasty, spine surgery and arthroscopy. More information about surgical treatment of injuries is outlined in Chapter 2-E.

3. Reporting of Musculoskeletal Procedure Rates in Europe

Quality of published data and statistics

Surgical interventions for musculoskeletal disorders and injuries are amongst the most frequently performed therapeutic procedures in industrialized countries. Nevertheless, it is difficult to obtain valid numbers for the actual number of procedures performed. Several institutions (e.g. OECD, Eurostat, National Health Services, National Joint Replacement Registries) and scientific studies have declared procedure volumes, and even rates of procedures in the population, but the data often do not match when sources for the same population are compared (OECD 2019, Eurostat 2020, Pabinger et al 2014 and 2015).

An example is a survey of Total Hip Arthroplasty (THA) numbers performed for this White book, which clearly highlights the problem of inconsistent data sources. In table 1 numbers of primary THA performed in specified countries, obtained from health authorities (where available) or national implant registries, are listed.

Table 1. Annual total numbers of total hip arthroplasty (all THA) and arthroplasty for femoral neck fracture (THA Fx NOF) in selected European countries, according to various national data bases and arthroplasty registries

Source: (1) National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. Annual Report 2018. Available at: http://www.njrreports.org.uk/ . Accessed September 2021; (2) Swedish Hip Arthroplasty Register. Annual Report 2017. Available at: https://shpr.registercentrum.se/shar-in-english/the-swedish-hip-arthroplasty-register/p/ryouZwaoe . Accessed September 2020; (3) Statistisches Bundesamt. Fallpauschalenbezogene Krankenhausstatistik (DRG-Statistik). 2018. Available at: www.destatis.de. Accessed December 2020; (4) Danish Arthroplasty Register (LROI) 2019. Available at: www.ortopaedi.dk. Accessed October 2020; (5) ScanSante. Statistiques par groupe, diagnostic, acte 2018. Available at: https://www.scansante.fr/applications/statistiques-par-groupes-diagnostique-actes. Accessed June 2020; (6) Spanish National Health System, Spanish Ministry of Health, Instituto de Información Sanitaria (CMBD, Conjunto Mínimo Básico de Datos); (7) Dutch Arthroplasty Register (LROI) 2019. Available at: https://www.lroi.nl/. Accessed June 2020.

Country	origin of data	Procedures**	2012	2013	2014	2015	2016	2017	completeness (%)
UK* (1)	registry	all THA	78126	80226	87596	88845	91953	91698	95
		THA fx NOF	2444	3122	3757	4149	4621	4445	
Sweden (2)	registry	all THA	n.a.	16350	16563	16631	17263	18148	98
		THA fx NOF	n.a.	1436	1405	1526	1615	1643	
Germany (3)	national statistics	all THA	212304	210384	219325	227293	232746	238072	100
		THA fx NOF	48196	50328	51180	53645	53232	n.a.	
Denmark (4)	registry	all THA	9305	9404	9830	10127	10730	10691	98
		THA fx NOF	598	633	556	568	591	583	
France (5)	national statistics	all THA	132237	135228	138582	140160	141893	145364	100
		THA fx NOF	33944	35261	35157	36163	36488	37094	
Spain (6)	national statistics	all THA	25470	27236	27871	27771	n.a.	n.a.	80-90
		THA fx NOF	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Netherlands (7)	registry	elective THA	25388	26114	28174	28798	29662	29.937	95
		THA fx NOF	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	

** UK data covering England, Wales and Northern Ireland but not Scotland*
*** "all THA" includes elective total hip arthroplasty (THA) and THA for femoral neck fracture (THA Fx NOF)*
n.a. = not available; completeness = true percentage of cover of annually performed procedures in the country

Table 2 contains the figures for the number of THA procedures as published in the Eurostat-Database. There are obvious inconsistencies in the data:

Table 2. Surgical operations and procedures performed in hospitals by ICD-9-CM for primary total hip replacement.

Source: Eurostat. Surgical operations and procedures statistics (2020). Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Surgical_operations_and_procedures_statistics&oldid=502541. Accessed June 2020

	2012	2013	2014	2015	2016	2017
United Kingdom	112.929	117.173	119.882	118.798	122.917	119.512
Sweden	23.053	23.008	22.776	22.953	22.429	24.710
Germany	231.183	228.162	237.067	244.496	250.661	255.720
Denmark	12.683	12.836	13.214	13.448	14.202	14.224
France	151.592	155.153	158.124	160.267	162.061	165.810
Spain	47.497	49.652	51.849	52.002	51.975	55.808
Netherlands	37.840	37.980	38.670	39.420	37.290	38.090

When table 1 and table 2 are compared, differences between reported numbers are evident for several countries. An interesting example is Germany: for the year 2016 the German Federal Bureau of Statistics, which covers 100% of all performed procedures, reported an overall number of 238072 THA (Table 1), while Eurostat lists 255720 THA for the same year (Table 2).

There may be several reasons for these differences: THA can be performed in patients with osteoarthritis and also in patients with traumatic femoral neck fracture (NOF), but it is often unclear whether reported national figures include both. National coding and reporting systems may also be inconsistent and it is therefore unclear whether THA performed for indications other than hip osteoarthritis (e.g. THA for avascular necrosis or second stage THA after initial revision for periprosthetic joint infection) is counted separately in different countries. Furthermore, in several countries some, or all, patients from the private sector are excluded and do not therefore appear in the Eurostat-database. For these reasons, the data presented in the following sections must be interpreted with care but are most likely to be underestimates.

Annual numbers of frequently performed orthopaedic procedures in European countries

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) belong, together with arthroscopic surgery for the knee and spinal interventions, to the group of most frequently performed musculoskeletal surgical procedures. Surgical volumes are provided in various publications and databases, which range from procedure-specific surveys of regional arthroplasty registries to national and European statistical sources. OECD (2019) and Eurostat (2020) publish annually the overall numbers of several orthopaedic procedures performed in European countries. Although the veracity of the database must be questioned (see above), table 3 summarizes the numbers of arthroscopic meniscal surgery, discectomy and total knee arthroplasty (TKA) procedures performed in 2015 (the last year with close to complete numbers for these three indications) in certain European countries (Eurostat 2020).

A - Knee arthroscopy

As many knee arthroscopies are performed as day case (outpatient) procedures in an ambulatory setting, and not inpatient hospital facilities, the numbers seen in table 3 may be far short of the real procedure volume. In Germany, for example, more than 413000 knee arthroscopies were performed in 2015 but only about 25%

Table 3. Eurostat-Database of surgical operations and procedures performed in hospitals by ICD-9-CM for selected procedures in 2015

Source: Eurostat. Surgical operations and procedures statistics (2020). Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Surgical_operations_and_procedures_statistics&oldid=502541 . Accessed June 2020

	knee arthroscopy	discectomy	hip replacement	total knee replacement
Belgium	n.a.	n.a.	n.a.	n.a.
Bulgaria	n.a.	n.a.	n.a.	n.a.
Czechia	n.a.	n.a.	19.002	13.317
Denmark	11.873	9.518	13.448	9.529
Germany	108.708	113.822	244.496	168.141
Estonia	2.917	872	2.048	1.231
Ireland	633	1.521	6.121	2.437
Greece	n.a.	n.a.	n.a.	n.a.
Spain	52.992	20.292	52.002	54.969
France	n.a.	n.a.	160.267	106.561
Croatia	4.735	3.028	5.609	2.515
Italy	13.320	35.762	104.414	67.685
Cyprus	112	121	434	327
Latvia	n.a.	n.a.	n.a.	n.a.
Lithuania	2.349	2.016	5.683	2.420
Luxembourg	1.086	1.111	999	942
Hungary	10.693	4.629	13.590	8.522
Malta	380	129	341	727
Netherlands	n.a.	n.a.	39.420	25.180
Austria	n.a.	8.423	23.401	18.559
Poland	n.a.	6.359	42.417	15.143
Portugal	n.a.	n.a.	9.387	6.441
Romania	4.620	7.702	12.961	4.519
Slovenia	2.407	1.911	3.569	2.214
Slovakia	n.a.	n.a.	7.200	5.803
Finland	6.116	3.134	13.583	10.267
Sweden	13.250	10.138	22.953	12.118
United Kingdom	82.180	14.800	118.798	96.914
Iceland	n.a.	n.a.	495	n.a.
Liechtenstein	314	0	10	45
Norway	9.504	4.197	12.671	5.214
Switzerland	n.a.	n.a.	25.262	20.006
North Macedonia	422	338	1.161	244
Serbia	755	1.981	8.099	1.541
Turkey	n.a.	n.a.	n.a.	n.a.
Total number (2015)	**329.366**	**251.804**	**969.841**	**663.531**

n.a.=not addressed

of these patients were treated during an inpatient hospital stay. According to the Eurostat data at least, the number of inpatient arthroscopies has significantly decreased in recent years, most markedly in Denmark, Finland and Germany. There is probably an underlying compensatory increase in day case procedures, but as a consequence of attention to evidence-based guidelines introduced in recent years the overall number of procedures performed decreased, at least in certain countries. Mattila et al (2016) reported a decrease in the number of knee arthroscopies performed in Finland, as well as in Sweden, after the implementation of these guidelines, which clearly state that arthroscopy is not indicated for knee osteoarthritis alone. Nevertheless the indications for the arthroscopic treatment of traumatic meniscal tears are growing and there seem to be significant differences in country-specific rates; for example the incidence of knee arthroscopy due to traumatic meniscal tears per 100000 person-years was 97 in Finland and 13 in Sweden in the year 2012.

B - Spinal surgery

In spinal surgery, rapid advancements have been observed in recent years, which are due to novel technological innovations, safety improvements and an increased understanding of the pathophysiology of spinal conditions. Degenerative disorders of the lumbar and cervical spine are a worldwide and significant cause of disability, and the burden of vertebral fractures is also enormous.

It is therefore not surprising that several publications report an increasing trend, not only in the number of hospital admissions, but also in the volume of surgical procedures, throughout Europe in the first decade of this century (Sivasubramaniam et al 2015, Grotle et al 2019). According to the Eurostat database (Eurostat 2020), however, this increase has levelled out, at least for surgical discectomy, throughout Europe after 2010 in most regions. There is even a minor decrease in some large countries (e.g. France, Germany, Italy, UK). Due to a lack of comparable national data for other spinal procedures, particularly lumbar fusion, it is difficult to say if, overall, there is growth in the number of procedures performed. There is only one report from Germany (Tesch et al, in press), which shows a plateau being reached for all types of lumbar surgery between 2011 and 2016. In addition, this study highlights significant regional variations in the frequency of spine surgery.

C - Total hip and total knee replacement

Joint replacement is one to the most effective treatment options for advanced hip and knee osteoarthritis, disorders which themselves impose significant individual, as well as societal, burdens. In addition, hip replacement is an acknowledged treatment not only for end stage avascular necrosis of the hip but also for displaced fractures of the femoral neck, which affect an increasing number of elderly patients worldwide. Therefore large, and indeed increasing, numbers of THA and TKA are performed in industrialized countries every year and, despite their proven efficacy and cost-effectiveness, there is continuous debate about whether this growth is justified.

As outlined in tables 1 and 2, THA numbers increased steadily in many European countries from 2012 to 2017. Interpretation of this growth is difficult, as it is unclear in most countries the degree to which prosthetic replacement for femoral neck fractures accounts for part, or all, of this growth. According to reported data in national arthroplasty registries (Table 1) the percentage of THR for fracture treatment ranges from 5 % (Denmark and UK) to about 25 % (France and Germany). This variation probably reflects differences in the perceived indications for osteosynthesis versus joint replacement more than variation at a population level. Nevertheless, there is no single European country where THA numbers did not increase between 2010 and 2018 (Eurostat 2020) and most growth rates are around 10-15% per year, even more in some smaller countries.

A similar observation applies to TKA between 2010 and 2018, where numbers grew in all countries with reported data (Eurostat 2020): while the increase during this time is only moderate in Denmark (6%), Sweden (8%), Germany and Cyprus (8%), substantial growth was recorded in other countries such as Spain (30%), France (50%) and Slovenia (70%). Romania, Hungary and Slovakia, which began with smaller numbers, more than doubled their rates.

While moderate growth rates in THA and TKA may reflect growth in demand simply due to ageing of population, substantial increase is, except for the case of Spain and France, mostly observed in countries with lower arthroplasty rates in general. This probably therefore reflects a phenomenon of catching up with contemporary thresholds for intervention in economically weaker regions.

D - Shoulder arthroplasty

There are currently no procedure numbers for shoulder arthroplasty available in the Eurostat database. Nevertheless, this is a procedure that is being performed with increasing frequency in all European countries and it is therefore important to consider recent developments. Lübbeke et al (2017) have published an overview of international variation in shoulder arthroplasty rates, for which they included those countries or regions where shoulder arthroplasty is recorded in population-based arthroplasty registries (Norway, Sweden, New Zealand, Denmark, California, Australia, Emilia-Romagna in Italy, United Kingdom) or by a national statistical institute (Germany). The shoulder arthroplasty incidence rate in 2012 was 20 procedures per 100.000 inhabitants, with a 6-fold variation between the highest (Germany) and lowest (United Kingdom) country. Over the past decade the annual incidence rate has increased 2.8-fold and there is wide variation in major indications for the procedure (osteoarthritis, fracture, cuff-tear arthropathy) between registries. Recent data from those national arthroplasty registries included shows that the volume increase is continuing in most countries. In the UK and France, for example, the numbers rose from 2563 and 11404 shoulder arthroplasties per 100000 in 2012 to 6526 and 17952 arthroplasties per 100000 in 2017 (http://www.njrreports.org.uk/, https://www.scansante.fr/applications/statistiques-par-groupes-diagnostique-actes).

The overall increase in procedure volumes reflects improved surgical techniques and implants. Nevertheless, variations in procedure selection for the major indications, low average surgeon volumes, a substantial number of brands with small annual volume and large variations in outcomes reported have to be addressed in the future.

4. Rates of Surgical Procedures per Capita

Approximate numbers of surgical procedures (as summarized in tables 1-3) need further analysis in order to allow comparisons on a national level throughout Europe. As the overall size of the population varies between countries, it is primarily important to calculate surgical rates rather than crude numbers. Rates for frequent musculoskeletal procedures have been published for different European countries in several scientific articles as well as in public statistical reports (Eurostat 2020, OECD 2019)

Pabinger et al (2014, 2015) have analysed utilization rates for THA (2014) and TKA (2015) in OECD countries between 1990 and 2011. They calculated the absolute numbers of implantations and the compound annual growth rates per 100,000 population for patients in two age groups (65 years old and over versus 64 years and younger). They showed that national arthroplasty rates vary to a great extent not only throughout all OECD countries, but also between European countries. The rates for THA in 2011, for example, varied between 75/100000 (Poland) and 308/100000 (Switzerland). The rates for TKA in the same year varied from 22/100000 (Poland) to 218/100000 (Austria).

In the Eurostat database the most recent rates for THA and TKA have been published and compared with other surgical procedures throughout Europe (Eurostat 2020) and are outlined in table 4.

Rates of all selected procedures, including cataract surgery, coronary angioplasty, cholecystectomy, repair of inguinal hernia (data not shown) and appendectomy as well as tonsillectomy show significant variation throughout Europe similar to that seen in hip and knee arthroplasty. According to the database in 2018, THA was performed 311 times per 100000 inhabitants in Germany and between 275 and 300 times per 100000 inhabitants in Austria, Belgium and Finland. Countries with the lowest rate were Liechtenstein and Cyprus with 26 and 56 THA per 100000, respectively.

Table 4. Surgical operations and procedures performed in hospitals – selection of top 10 procedures 2018, displayed as rates per 100000 population

Source: Eurostat. Surgical operations and procedures statistics (2020). Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Surgical_operations_and_procedures_statistics&oldid=502541 . Accessed June 2020

	Hip replacement	Total knee replacement	Appendectomy	Tonsillectomy ([1])
Belgium	274,6	207,3	141,4	202,6
Bulgaria	117,7	31,5	77,6	60,8
Czechia	199,2	144,7	124,7	59,3
Denmark	241,4	181,2	123,5	71,5
Germany	310,6	222,8	149,5	110,0
Estonia	170,2	108,3	152,5	*355,4*
Ireland ([2])	123,3	47,5	141,1	77,7
Greece	n.a.	n.a.	n.a.	n.a.
Spain	121,5	132,2	105,4	55,5
France	248,6	181,8	107,5	87,3
Croatia	171,0	72,8	129,6	159,7
Italy	184,9	128,9	68,0	49,3
Cyprus ([2])	55,5	54,4	52,6	61,5
Latvia ([3])	180,4	103,9	126,6	n.a.
Lithuania	200,6	124,4	170,2	158,2
Luxembourg	181,6	182,1	91,1	123,5
Hungary	138,8	88,6	97,2	105,6
Malta ([4])	88,9	167,3	104,5	75,6
Netherlands ([2,4])	222,3	171,4	95,5	184,9
Austria	298,5	229,9	147,8	83,2
Poland	161,8	66,8	72,7	66,0
Portugal ([2,5])	90,6	62,2	92,0	81,6
Romania	71,4	24,7	131,5	96,6
Slovenia	187,7	132,8	120,3	62,3
Slovakia	129,0	105,9	100,9	n.a.
Finland	274,5	233,4	133,6	204,3
Sweden	242,0	130,6	127,0	122,3
United Kingdom ([2])	187,1	148,4	87,3	84,4
Iceland	217,2	n.a.	165,3	505,2
Liechtenstein	26,2	7,8	49,7	13,1
Norway	259,6	130,7	134,5	157,1
Switzerland	307,3	250,2	164,4	104,4
North Macedonia ([2])	61,1	15,1	75,3	81,7
Serbia	126,1	25,3	94,4	76,3

[1] also includes surgery performed on out-patients. [2] excludes some or all of the private sector. [3] in-patients only. [4] 2015. [5] 2017.

The frequency of TKA showed greater variation between the EU member States than did THA and the frequency of TKA is, with exceptions of Spain, Malta and Luxembourg, generally lower than the frequency of THA. In 2018 more than 200 knee replacements per 100000 inhabitants were performed in Finland, Austria, Germany and Belgium, compared with less than 50 per 100000 inhabitants in Ireland, Bulgaria and Romania.

As outlined above, a direct comparison of rates is difficult, as different numbers can be found in different databases. National coding and reporting systems differ; surgery within the private sector is not included in all reported numbers and it is unclear to which extent THA for femoral neck fractures is counted. A major source of disparity, especially in arthroplasty surgery, is the age structure of society, as these disorders show an age-dependant prevalence. Lohmander et al (2006) have described not only regional variations of THA rates within Nordic countries (Denmark, Finland, Iceland, Norway, Sweden) in the time period 1996–2000, but have also provided detailed data about the correlation with patient age (Figure 1).

In populations with a higher percentage of elderly, more patients with hip and knee osteoarthritis will be diagnosed and it is to be expected that this also may result in a higher number of joint replacements being performed in general. As a consequence, nation-specific arthroplasty rates should be adjusted for patient age. Unfortunately this important confounder is not integrated into Eurostat and OECD-calculations, which is why the published

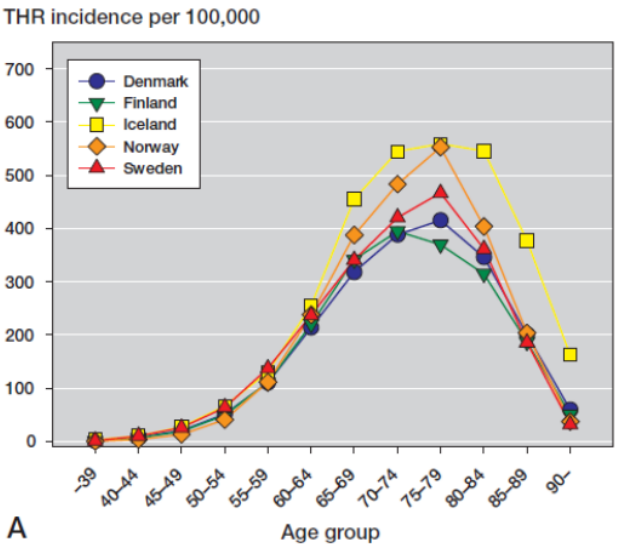

Figure 1. Average incidence rate of primary THR for primary hip OA per 100000 per year (1996–2000), for different age groups in Denmark, Finland, Iceland, Norway and Sweden.

Source: Lohmander Set al. Standardized incidence rates of total hip replacement for primary hip osteoarthritis in the 5 Nordic countries: similarities and differences. Acta Orthop Scand 2006;77(5):733-40.

rates may be somewhat misleading. The database "Managing Hospital Volumes" published by the OECD (2013), for example, did not adjust rates for age, which led to an incorrect statement that Germany performed the highest rate of hip replacements and the second highest rates of knee replacements within OECD countries. The median age of the German population in 2010 was 44.3 years, while median age of the populations in Switzerland and Norway, for example, was 41.3 years and 39.7 years respectively. Therefore, Finkenstädt and Niehaus (2015) re-analysed the OECD-data and performed age- as well as gender adjustment of the reported rates. This lead to substantial changes in the ranking of countries with regard to their procedure rates (Table 5):

Table 5. Difference in country specific ranking between published OECD-rates for THA/100000 inhabitants in 2012 (left column) and ranking after adjustment for age and gender (right column).

Source: Finkenstädt and Niehaus. Die Aussagekraft von Länderrankings im Gesundheitsbereich. Eine Analyse des Einflusses der Altersstruktur auf die OECD-Daten. Wissenschaftliches Institut der PKV Köln (2015). Available at: www.wip-pkv.de . Accessed January 2020

OECD-ranking 2012			Adjusted ranking (age and gender)		
rank	country	THA per 100000 inhabitants	rank	country	Difference to Germany
1	Switzerland	307.0	**1**	Switzerland	**+ 24.2 %**
2	Germany	287.4	**2**	Norway	**+ 12.0 %**
3	Austria	272.0	**3**	Austria	**+ 7.5 %**
4	Norway	250.0	**4**	Luxemburg	**+ 2.8 %**
5	Sweden	241.7	**5**	Germany	**0.0 %**
6	Finland	237.3	**6**	USA	**- 0.6 %**
7	Belgium	236.6	**7**	Sweden	**- 6.1 %**
8	France	230.3	**8**	Denmark	**- 6.3 %**
9	Denmark	226.8	**9**	Belgium	**- 6.8 %**
10	Luxemburg	216.7	**10**	Island	**- 8.3 %**

After adjustment for age and gender it becomes evident that the relative THA rates per 100000 inhabitants are higher in Switzerland, Norway, Austria and Luxemburg than in Germany. A similar observation is made in the case of TKA, where 7 countries

perform relatively more joint replacements than Germany (USA 48%, Switzerland 19 %, Australia and Austria 18 %, Luxemburg 12 %, Finland 6 %, Belgium 1 % more).

Despite the need for adjustments to published data a striking difference persists between the arthroplasty (as well as other surgical procedure) rates within EU countries. According to Merx et al (2003) and Pabinger et al (2015) the significant variation between individual countries cannot be explained by variations in the pathology for which THR is indicated (elective procedures for osteoarthritis only versus all other procedures including trauma care), different coding systems and country-specific differences in the healthcare system, but is probably to a large extent the result of economic and medical decision making in given surroundings. Countries with higher medical expenditure show significantly higher utilization rates, as outlined in Figure 3:

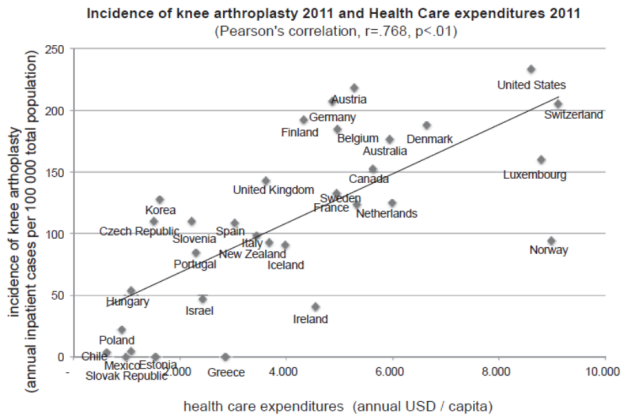

Figure 3: Correlation between economic data and utilization of knee implants. Source: Pabinger et al. Utilization rates of knee arthroplasty in OECD countries. Osteoarthritis and Cartilage 2015;23:1664-73.

5. Regional Variation in Surgery Rates

There is not only significant variation in surgery rates between European countries, but also within individual countries. Recently, detailed investigations have been performed in order to establish the regional distribution of THA and/or TKA rates in Finland, the UK, Spain and Germany.

In Finland Mäkelä et al (2010) have calculated incidence rates for THA within 21 hospital administrative regions between 1998 and 2005. The variation in rates of THA ranged from 1.9 to 3.0 fold during the study period. Neither average incomes nor morbidity were associated with the incidence of THA. There are other investigations of hip and knee provision rates from Spain (Padilla-Eguiluz et al 2014, Gomez-Barrena et al 2014), Germany (Schäfer et al 2013), the UK (Judge et al 2010) and recently also from Switzerland (Wertli et al 2020), where detailed analyses not only of the regional distribution of arthroplasty rates but also of potential influencing factors have been performed (Figure 4 a-d):

While the variation for THA is similar in Spain (1:2.9), Germany and the UK (1:2.8 each), the 1.9 fold variation in Switzerland is significantly lower. As Switzerland currently has the highest provision rates for THA, as well as TKA, among OECD-countries, Wertli et al (2020) conclude that the threshold to perform arthroplasty is uniformly low across regions. In other European countries, equity is obviously more challenged in the distribution of knee and hip arthroplasty . In the studies published the incidence of osteoarthritis, the number of orthopaedic specialists, social deprivation and urban/rural differences, as well as regional health budgets, were identified as influencing factors. Health inequalities caused by social and economic issues are a complex social and political issue. Nevertheless, it is necessary to provide an evidence base in order to inform the necessary political discussion.

6. Future Demand for Musculoskeletal Surgery

Over recent years, there has been an increase in utilization rates for several interventions directed at musculoskeletal disorders and injuries. The most marked growth has been observed in arthroplasty (hip, knee, shoulder), which is probably due to improved technology and implants as well as the increasing demands of an active, elderly population. A rising prevalence of obesity worldwide may also contribute to this situation, as body mass index is a clearly influence on the incidence of osteoarthritis, particularly in the lower extremities. Another important observation is the significant increase in the rate of THA and TKA utilization in younger patients (Pabinger et al 2014; 2015), which is justified by improved long-term treatment results.

Due to increasing life expectancy, the prevalence of obesity and the increasing use of arthroplasty in younger patients a further increase in the utilization rates not only for primary arthroplasty, but also revision procedures, can be expected in the future (Culliford et al 2015, Pabinger et al 2015, Yu et al 2019). Although several authors have tried to predict annual growth rates in Europe (Culliford 2015, Pilz et al 2018, Nemes et al 2014, Nemes et al 2015, Rupp et al 2016), it is difficult to provide valid estimates. The fact is, however, that future demographic changes leading to an older population, as well as an increasing proportion of obese patients, are more important reasons for the increasing numbers of arthroplasty procedures than a general increase in the frequency at which surgeons recommend an operation.

7. List of Activities Needed

Further analyses are needed to better understand the potential reasons for observed variation rates in musculoskeletal surgery between European countries as well as within individual countries

- To ensure appropriate, as well as fair, resource allocation in the future it is necessary to
  - improve existing, and develop new, databases which facilitate Europe-wide comparison of key indicators for the treatment of musculoskeletal disorders
  - develop clinical practice guidelines regarding the indications for high-volume procedures
  - implement quality improvement programs (i.e. arthroplasty registries and multi-centre databases)
- Considering the continuing ageing of the population, and the resulting increase of musculoskeletal disorders, additional approaches are needed to ensure appropriate care:
  - Enhanced implementation of effective prevention strategies in order to reduce the burden of musculoskeletal disorders
  - Improvement of training and working conditions for health care providers
  - Intensification of research programs directed towards improved treatment strategies

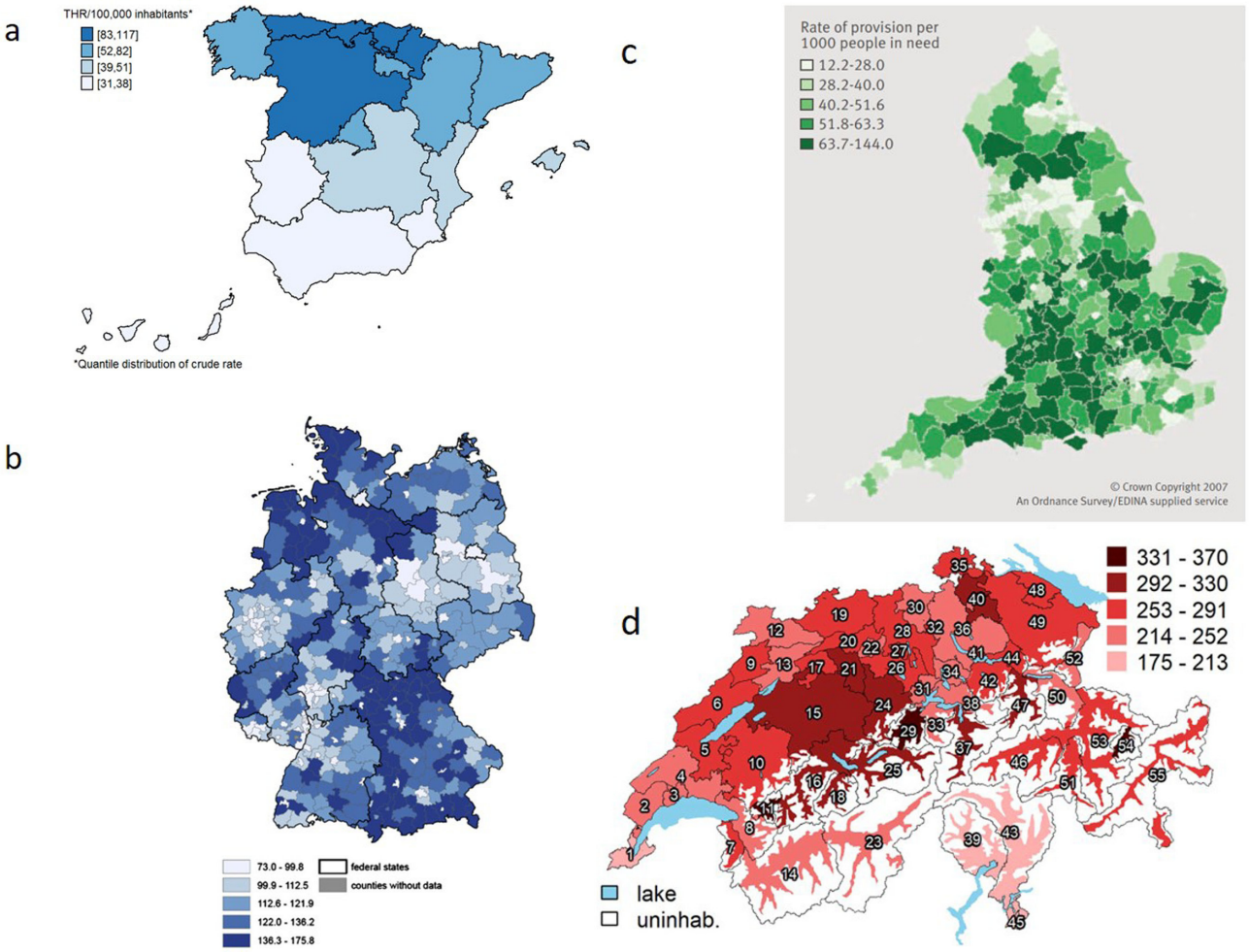

Figure 4: Regional age-standardized THA rates in four different European countries: THA-rates per 100.000 inhabitants in Spain (a) and Germany (b); provision per 1000 people in need in England (c). THA-rates per 100.000 inhabitants in Switzerland (d).

Source : (a) Padilla-Eguiluz et al. Regional variability in the rates of total hip replacement in Spain. Hip Int 2014;24(1):81-90. 2014, (b) Schäfer et al. Trends and geographical variation of primary hip and knee joint replacement in Germany. Osteoarthritis Cartilage 2013; 21(2):279-88., Judge et al. Equity in access to total joint replacement of the hip and knee in England: cross sectional study. BMJ 2010; 341:c4092, Wertli et al. Regional variation in hip and knee arthroplasty rates in Switzerland: A population-based small area analysis. PLoS One 2020; 15(9):e0238287.

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Section 3

C | Clinical Governance

Table of Contents

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1. Summary

Clinical governance occurs on several levels in European orthopaedics and traumatology (O & T). National Associations and European Subspecialty Societies, together with EFORT, are taking the lead in continuing medical education of both the younger as well as the more experienced surgeons, to enhance patient safety. Using real-world data from unique national databases, O & T surgeons are guided in their daily practice to use implants that are safe and have good long-term results. Since the EU Commission launched its new Medical Device Regulations, implemented in May 2021, EFORT and its collaborators have actively engaged in the newly established EU Commission Expert Panels to assist authorities in the validation of both new and existing instruments and implants. EFORT is also successfully taking part in a collaborative EU Horizon 2020 grant application (CORE-MD), which will look at the scientific validation of the process whereby new implants are safely introduced. Finally, EFORT has launched and taken responsibility for an ongoing project related to implant, patient and staff safety initiatives.

2. European and National Orthopaedics & Traumatology Organisations

National Orthopaedics and Traumatology Associations are organized in different ways through Europe. EFORT is the only organization representing the full spectrum of O & T practice, both in relation to the education of surgeons and politically in relation to professional representation at the EU Commission. Currently, 41 European National O & T Societies are members of EFORT and support the Federation in its activities (https://www.efort.org/membership/membership-and-network/).

At the European level, there are also several O & T subspecialty societies, some of which cover anatomical regions, whilst others are procedure related. Most work together with EFORT to improve the quality of patient treatment, not least through high quality education of surgeons.

At the National level, all European countries have organized, within themselves, O & T societies. In some countries, such as Denmark and Sweden, one society covers the entire spectrum of O & T. In other countries, such as Croatia, Austria and Germany, there are separate societies covering the fields of traumatology and orthopaedics.

At all levels, education is performed using the same base portfolio through conferences, courses, webinars and publications. These are usually based on the European Curriculum in Orthopaedics and Trauma, developed by EFORT and UEMS in close collaboration with its National Associations and European subspecialty societies (https://www.efort.org/european-curricula/).

3. Orthopaedic and Traumatology Registries in Europe

The EU has about 450 million citizens (the European continent has about 750 million), who all have the potential to experience musculoskeletal complaints at some time. Of these, trauma and sports-related problems mainly occur in the younger population, while degenerative changes such as osteoarthritis and its sequelae in joints (both the extremities as well as spine) present at an older age. As for the latter, one of the treatment modalities can be joint replacement surgery with implants like hip, knee and shoulder replacement. Alternatives include fusing joints, such as in spondylolisthesis when the spine is involved. At an even older median age, hip fractures occur and are treated with medical devices using, for example, osteosyntheses or arthroplasty surgery. Evaluation of the outcomes of treatment, both conservative and surgical, creates transparency on matters of performance and will thus improve outcomes for future patients (Fraser et al. 2018, van Schie et al. 2020, Engebretsen et al. 2015). Orthopaedic surgeons were among the first in Europe to study the implants they use by way of implant registers. The European Medicines Agency (https://www.ema.europa.eu/en/human-regulatory/post-authorisation/patient-registries) defines registries as *organised systems that use observational methods to collect uniform data on a population defined by a particular disease, condition, or exposure that is followed over time, with the aim to improve quality of patient care.* The importance of registries is acknowledged within the new MDR (Medical Device Regulations, article 108, Annex VII 4.11(g).

Key elements of registries are:

1. Efficient and actionable data embedded in healthcare (i.e. health records).
    a. Medical Device: article/lot number or unique device identification (UDI).
    b. Patient: patient-encrypted-data (general data protection regulations, GDPR).
    c. End-point: definition of outcome (e.g. revision, Patient Reported Outcome (PRO).
2. Coverage: the representativeness of collected data.
3. Completeness: data items used for analysis should be consistently captured
4. FAIR principles on data: Findable, Accessible, Interoperable, Reusable
5. Governance: orthopaedic / trauma surgeons are mandatory.

Globally, the best known and established registries are those dealing with the performance of orthopaedic implants (Table 1). Data from these registries can help to separate the best performing from mediocre implants, and also benchmark outcomes between hospitals (van Schie et al. 2020) or even countries (Engebretsen et al. 2015). Registries of medical devices are more, however, than just a traceability system of devices for recall purposes. In daily practice they are used as quality systems, which continuously monitor performance through the life-cycle of the devices used by orthopaedic surgeons. This therefore includes outlier identification at both implant and clinic levels (van Schie et al. 2020). Although the latter (outlier detection or Implant Performance Indicator – IPG - measures) are only used by some orthopaedic registries (e.g. UK, Sweden, Netherlands), it is obvious that correct feedback, including case-mix correction, is mandatory to prevent the drawing of conclusions based on incorrect assumptions.

European Database

In Europe, there are no Orthopaedic & Trauma databases that collect data from all European Countries on specific diseases, treatments or outcomes. On the national level, several countries have databases covering specific surgical procedures (i.e. THA, TKA, hip fracture, spine, trauma – see Table 1) in their country, and some also have created regional databases. As for trauma, the Injury Database can be accessed across Europe (https://ec.europa.eu/health/indicators_data/idb_en).

Table 1. National and Regional Registries on procedures and diseases in Europe

**List of arthroplasty registries with hyperlinks available at http://nore.efort.org/arthroplasty-registries. Accessed February 2021.*

Registry	Country / region
Arthroplasty (national)* *Hip, Knee, Ankle, Shoulder, Elbow, Wrist, Hand*	UK, Netherlands, Germany, Sweden, Norway, Denmark, Finland, Scotland, Romania, Slovakia, Estonia, Lithuania, Portugal, Ireland, Belgium, Hungary, Slovenia
Arthroplasty (regional)*	Catalonia, Geneva, Emilia-Romagna, Valdosta
Hip fractures	UK, Ireland, Spain, Sweden, Norway, Denmark, Netherlands, Italy, Germany
Cruciate ligaments	Sweden, Norway, Finland, Denmark, UK
Spine	Sweden, Netherlands, UK, Denmark, Spain, Norway, Switzerland
Osteoarthritis	Denmark, Norway, Sweden

A unified European Orthopaedic Database concerning arthroplasties, fracture care, spine surgery and the effect of several treatment modalities aimed at osteoarthritis would be valuable, enabling all to learn from best practice across Europe and thus improve patient outcomes. However, many hurdles have to be overcome. The complexities of European and national health care data ownership and management make the establishment of pan-European health databases difficult. Less complex is the use of generic software tools that can combine data from different sources. The latter enabled merging of the outcome data of total hip arthroplasty from 5 countries (Figure 2) (van Steenbergen et al 2021). In addition to these supranational initiatives within orthopaedics, the European Health Data Space (TEHDAS) aims to establish an infrastructure that has the potential to be used to combine health data within the EU in the future.

Interestingly, data from National databases differ (Figure 1). Neighbouring countries such as Denmark, Norway, Sweden, Finland and the Netherlands, with comparable societies and comparable health systems, may differ in the surgical techniques used and also in terms of the observed outcome when using the same procedure and implants (e.g. the number of cemented versus uncemented hip stems (Table 2, Figure 1, 2).

Table 2. Number of implants in established Arthroplasty Registries in Europe

Type of implant in Arthroplasty Registers in Europe	Number of implants in European Registries*
Hip	3080207
Knee	2892970
Shoulder	85059
Ankle	19077
Overall	6077313

**Data based on annual reports and supplied by registries (as of December 2020). Data from NORE (figure 1).*

EFORT's role: registry of "proven implants"

EFORT established NORE (Network of Orthopaedic & Traumatology Registries of Europe) to create a European Forum where issues related to database structure and management, and registries, could be discussed and handled. Within EFORT, NORE is a separate committee with its own Chairman. NORE meets at each EFORT Congress to stimulate activities and to discuss the challenges it is facing.

For these reasons, EFORT & NORE have decided to develop and regularly update a document that lists all implants on the European market that have a high (at least 90%) implant survival at 10-years follow-up in at least two European National Registries (Figure 1). The aim will be to assist surgeons and authorities

Figure 1. NORE: Network Orthopaedic Registries of Europe.
Source: Interactive map at: http://nore.efort.org. Accessed September 2021.

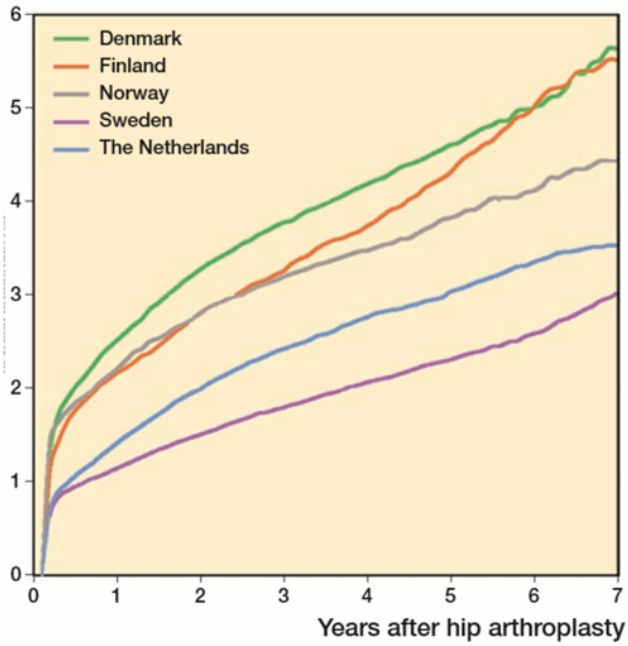

Figure 2. Cumulative revision proportion of total hip arthroplasty (THA) for osteoarthritis (OA) according to country, all fixation methods (adopted from Steenbergen et al. 2021).

Source: Van Steenbergen et al. Total hip arthroplasties in the Dutch Arthroplasty Register (LROI) and the Nordic Arthroplasty Register Association (NARA): comparison of patient and procedure characteristics in 475,685 cases. Acta Orthop Scand 2021;92(1):15-22.

to make decisions concerning the selection of implants or, for example, when a regional / national body needs assistance to select safe and proven implants for an ongoing tendering process.

Relation with European recall registry (run by the government in all countries) = EUDAMED.

The European database on medical devices (EUDAMED) is a key part of the Medical Devices Regulation (MDR), bringing with it transparency. The aim is to provide free access to relevant information for the public, thereby strengthening public and patient confidence in the safety of medical devices placed on the EU market. It will provide citizens with the option to search for information related to devices, their manufacturers and certificates

of conformity (CE), the notified bodies which have delivered them and some information related to the clinical investigations and the incident reports associated with the devices.

Conclusion

Registries represent very strong tools, with the potential to improve the quality of health care. The latter is achieved by providing feedback on the performance of implants as well as surgeons (comparing individual surgeon performance, as in the UK, or at hospital level, as in the Netherlands, Scotland, and Sweden, to the national mean level of performance). Secondly, benchmarking of implants within this mean performance can be done after a 5 or 10 year period. Thus new medical devices have to perform as least as well as the established medical devices they intend to replace (non-inferiority design).

The registration of clinical data by healthcare professionals, collected at the bedside or in the outpatient clinic, remains a challenging issue. For the easily automated (scannable) collection of quality data within a legal and secure environment, the European Health Data Space should facilitate this process. For that matter, a multitude of automatically collected clinical data, which are already routinely measured, should be used to enrich registries (eg, medical administrative data, accelerometer data, and also incorporating radiographic data such as Hounsfield units of the radiograph). Electronic health record data are a source of real-world data and have to be harmonized, which is key for data-sharing (following FAIR principles described above).

When taking the above into consideration, it will be a challenge to design a phased evidence-based introduction for a new implant which examines every possible mode of expected and unexpected failure, though early continuous migration can be used as a strong predictor for late poor survival of implants (Nelissen et al 2011). Innovation and evidence are not conflicting objectives, but there should be no innovation without evaluation for optimal patient outcomes and safety.

4. European Commission's New Medical Device Regulation

Medical devices and In Vitro diagnostic medical devices (IVDs) have a fundamental role in saving lives by providing innovative healthcare solutions for the diagnosis, prevention, monitoring, prediction, prognosis, treatment or alleviation of disease. The EU has a competitive and innovative medical devices sector, characterized by the active role of small and medium-sized enterprises. It is supported by a regulatory framework that aims to ensure the smooth functioning of the internal market, taking as a base a high level of protection of health for patients and users (https://ec.europa.eu/health/md_sector/overview). There are over 500000 types of medical devices and IVDs on the EU market, and orthopaedic and traumatology surgeons are among the health care providers that most frequently use implants in our patients.

On 5 April 2017, two new regulations on medical devices and in vitro diagnostic medical devices came into force, establishing a modernised and more robust EU legislative framework to ensure better protection of public health and patient safety. They were enacted on 25 May 2017 and will progressively replace the existing directives after a transition period. Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC. Regulation (EU) 2017/746 of the European Parliament and of the Council of 5 April 2017 on in vitro diagnostic medical devices and repealing Directive 98/79/EC and Commission Decision 2010/227/EU.

With patient health and safety as guiding principles, the Council and the Parliament adopted, on 23 April 2020, Regulation 2020/561 amending Regulation (EU) 2017/745 on medical devices regarding application dates of certain of its provisions. This Regulation postpones the date of application for most Medical Devices Regulation provisions by one year due to the coronavirus crisis. The IVDR Regulation (EU) 2017/746) corresponding date of application remains unaltered (May 2022).

Through its involvement in the Biomedical Alliance, a consortium of 34 European Medical Associations, EFORT on behalf of, and with the collaboration of, the National Associations and Specialty Societies, has followed closely the process and kept its membership informed of the details of the process of implementation of the new MDR, preparing our member associations for the potential impact of the new MDR.

EFORT has also stimulated its member associations and specialty societies to encourage recognised experts in the field to apply for positions on the Screening and Expert Panels working under the leadership of the EU Commission (https://ec.europa.eu/health/md_expertpanels/overview). These panels will have roles in:

- Providing an opinion on the notified bodies' assessments of the clinical evaluation of certain high-risk medical devices and the evaluation of the performance of certain in vitro diagnostic medical devices
- Providing advice to the Medical Device Coordination Group (MDCG) and the European Commission concerning safety and performance of medical devices and in vitro diagnostic medical devices
- Providing indirect advice through the Notified Bodies to manufacturers on their clinical development strategy and proposals for clinical investigations

The commission has now appointed orthopaedic and traumatology surgeons to its expert panels; EFORT and the National Associations representing the field of orthopaedics and traumatology is prominent in these panels.

Finally, in collaboration with European Society of Cardiology, EFORT led a successful Horizon 2020 Grant application in collaboration with a consortium of 24 organisations – the CORE-MD project (Coordination Research and Evidence for Medical Devices).

Regulatory policy concerning medical devices should be based on scientific and clinical evidence. Experts are in the best position to advise on how high-risk devices should be evaluated so that regulators can achieve an appropriate balance between innovation, safety, efficacy and cost-effectiveness. Implementation of the new Medical Device Regulation (EU) 2017/745 challenges the medical community to engage with regulators, notified bodies and industry to develop transparent and rigorous methods for evaluating devices and monitoring their performance. The CORE–MD consortium will address this challenge using a unique collaboration between medical associations, EU regulators, notified bodies, academic institutions, patient groups, health technology assessment agencies, and industry.

The project will systematically review and rank methodologies that have been used for the clinical evaluation of high-risk medical devices (Work Package 1), recommend how new trial designs can

contribute (Work Package 2) and advise on methods for aggregating real-world data from medical device registries with experience from clinical practice (Work Package 3). The essential principles of medical device trials will be considered jointly with the Wellcome Trust & Gates Foundation Clinical Trial Collaborative (Figure 3).

5. IPSSI: Implant Patient & Staff Safety Initiative

EFORT recently launched its "Implant, Patient and Staff Safety Initiative". Bringing together orthopaedic and trauma surgeons, scientists, representatives from implant manufacturers, regulatory authorities and patient organisations from different European countries. As its first task, a consensus initiative was started in order to provide guidance concerning the use of "off-label" procedures as well as "mix and match" in primary and revision arthroplasty.

In response to the responsibilities that the new Medical Device Regulation assigns to the medical profession, and particularly to Orthopaedic and Traumatology specialists, the "EFORT Implant, Patient and Staff Safety Initiative" was launched in January 2020. The goal of this initiative is to collect and structure existing knowledge on orthopaedic implants, enabling analysis to provide guidance on best practice for European patients, surgeons and society by validating implant safety and the scientific methods used in its investigation.

EFORT has dedicated three working groups to this initial project.

One group evaluates "*Collection and analysis of implants retrieved during revision*", as failed implants may be crucial to our understanding of what makes a good implant. Working also with implant registries, which analyse the benefit-risk profile of specific implant designs, the goal of this working group is to develop a common approach to the analysis of retrieved implants and its interpretation in relation to the failure of the initial treatment, and to find a consensus on how to collect and document this process. The ultimate goal is to develop a new culture of dealing with retrieved implants that is supported by surgeons, patients and industry.

A second group focuses on "*Recommendations on the introduction of innovations in artificial joint arthroplasty*". History and time have shown that some implants have been introduced without adequate analysis. Unexpected failures require vigilance from surgeons not only in interpreting data from national joint registries and research such as RSA or CT-based micro-motion studies, but also in discussing and evaluating instrumentation, surgical techniques and any adverse events that occur in the first cases performed by early adopters. Proof of safety and of adequate performance has become more challenging nowadays than it was in the past, but more surgeons are now adopting a more scientific strategy, based on clinical evidence, when selecting an implant to use in a particular patient. This puts the responsibility on early adopters to evaluate and analyse the results of their surgical interventions and patient outcomes using the new product in a rigorous way. Such a system of surgeon-user panel evaluation, where surgeons discuss with peers, experts and researchers their data and their experiences with the new implant and instrumentation, improves the outcome for patients but also fosters product and surgical treatment innovation.

Finally, a third working group has been detailed to analyse "*Off-label use and mix & match in hip and knee arthroplasty*". Most surgeons have used implants "off label" at some time in their career. This may take the form of utilization of an implant outside the scope of indications or population subgroups specifically approved by manufacturers or regulatory authorities. Although off-label use, as well as "mix and match", are frequent practice in primary and revision arthroplasty, there is an increasing concern about potential medico-legal issues. Therefore, EFORT raised the question: "should surgeons, who have no other alternative than the application of off-the-shelf implants in high-risk patients,

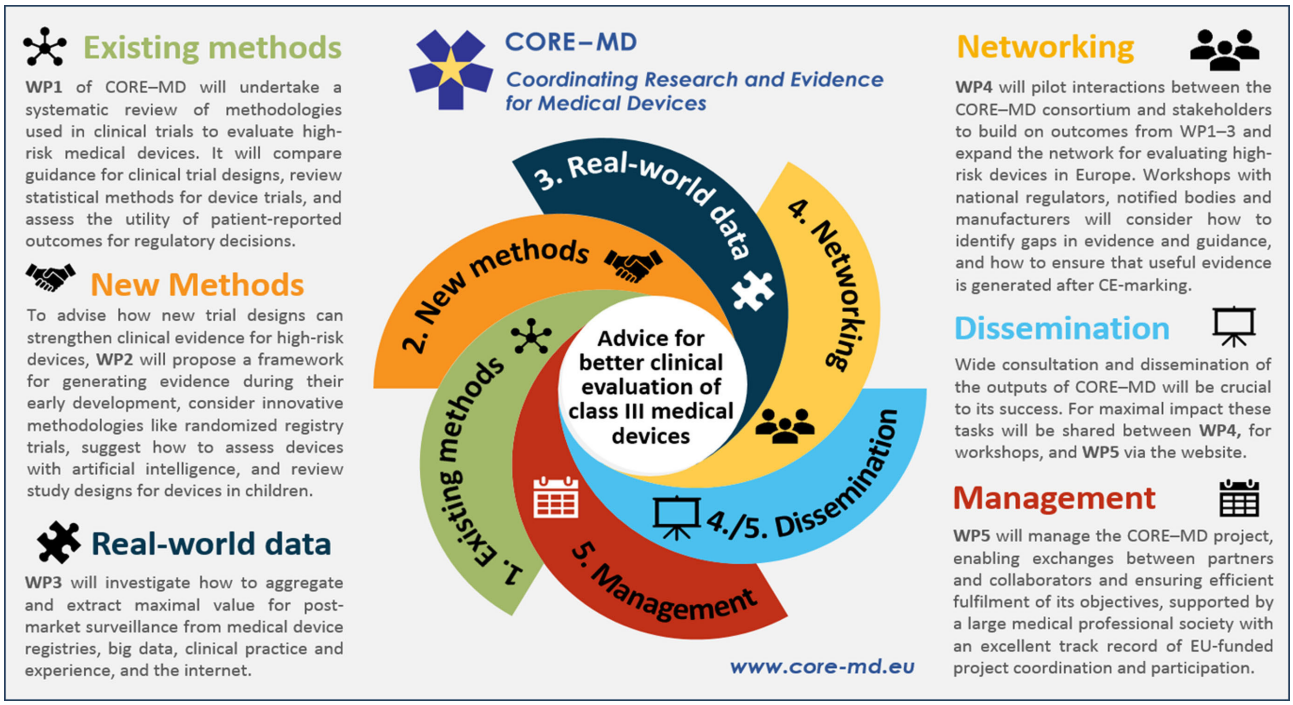

Figure 3. The Horizon 2020 project "CORE-MD" project leaded by EFORT and ESC.
Source: Available at: https://www.core-md.eu/. Accessed: September 2021.

and surgeons, who have used mixing and matching with excellent long term results over many years, change their practice just to protect themselves from possible medico-legal issues, or should they continue in a practice which they believe, in their hands, is best for their patients?

6. List of Activities Needed

- EFORT needs to continuously stimulate European orthopaedic and traumatology surgeons to improve their knowledge and skills through education including national and international courses, conferences and webinars.
- EFORT should prepare the next generation of registry scientists for the forthcoming demands to use European Registry data to understand and handle the diversity in practice and outcomes across Europe.
- EFORT needs to support competent authorities and national societies in creating effective European Clinical Databases.
- EFORT will continuously support and inform the European National Associations and Specialty Societies in the challenges and demands arising from the new medical device regulations, launched by the EU Commission in May 2021, as well as any forthcoming regulatory changes.
- EFORT will actively join and support projects that improve transparency and the safety of implants and techniques used in treatment of the O & T patient.

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Section 3

D | Prevention of MSK Conditions: The Obesity Epidemic

Table of Contents

Authors

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1. Summary

Obesity has tripled globally since 1975. Excess body weight and obesity leads to increased joint loading, which stresses the articular cartilage beyond its biological reparative capabilities, resulting in subsequent joint failure. There is evidence that weight loss in overweight and obese persons can significantly reduce the risk of development of knee osteoarthritis (OA) and pain. On the other hand, it seems that the body mass index (BMI) is not in itself associated with the incidence and progression of hip osteoarthritis.

Performing surgery on overweight or obese patients increases the technical demands on the surgeon. Surgical exposure and implant positioning may be more challenging due to the volume of fat tissue precluding optimal visualisation of the surgical field. Moreover, perioperative complications such as infection, as well as overall in-hospital deaths, are more frequent in obese patients. The need for revision surgery after joint replacement also increases, since the risk of prosthetic loosening has been shown to increase with obesity. Weight loss prior to joint replacement surgery has been shown to reduce the length of hospital stay. However weight loss immediately before surgery, as an acute preoperative measure, may also have negative implications and increase the risk of complications. New policies and strategies combatting obesity have emerged and must be developed to incorporate considerations relating to musculoskeletal health and surgery.

2. Introduction

During the last century, technological developments in orthopaedic and trauma care have led to major benefits for patients. Many surgical procedures have a good outcome, but in order to improve the results further a focus on patient-related risk factors has become increasingly important. Obesity is one of these factors.

Obesity poses a major risk for serious non-communicable diseases. Obesity paradoxically coexists with undernutrition in a global perspective.

A person with a BMI of 30 or more is generally considered to be obese and a person with a BMI equal to or more than 25 is considered as overweight (WHO 2020). Apart from being a major risk factor for diabetes, cardiovascular disease and cancer, obesity and being overweight pose specific problems for the musculoskeletal system.

3. Epidemiology

The condition has tripled in prevalence since 1975. In 2016, more than 1.9 billion adults aged 18 or over were overweight. Of these, over 650 million were considered to be obese. (WHO obesity-and-overweight 2020). In the OECD area more than one in two adults and nearly one in six children are overweight or obese today (https://www.oecd.org/health/obesity-update.htm).

During recent years it has become clear that the obesity epidemic not only affects high-income countries, but is now also on the rise in middle- and low- income countries, particularly in urban contexts (WHO, obesity-and-overweight 2020). More than one in two adults and nearly one in six children are overweight or obese in the OECD area, as reported 2017 (OECD Obesity update 2017)

The level of BMI seen in children and adolescents has levelled off at high levels in high income countries, but is accelerating in Asia (NCD Risk Factor Collaboration 2017). This causes a health concern for future generations.

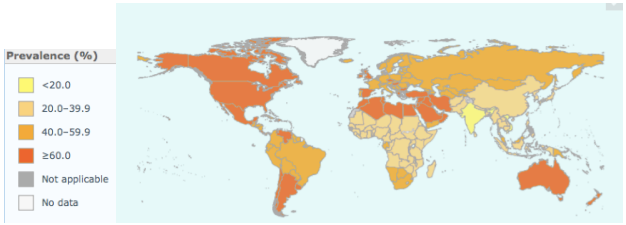

Figure 1. Prevalence of overweight among adults (>18 years) 1975-2016. (WHO risk factors/ overweight 2020)

Source: Available at: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight . Accessed September 2021

New policies and strategies combatting obesity have emerged and must include considerations of musculoskeletal health. The lifespan of obese persons is up to 8-10 years shorter (for a BMI of 40-45) than that of a normal-weight person, reflecting the same loss of life expectancy suffered by smokers. In some European countries the odds of disability, defined as a limitation in activities of daily living (ADL), are almost twice as high in the obese population compared to individuals of normal weight (OECD Health systems 2017).

4. Obesity and Joint Problems

a- Obesity and joint loading

Excess body weight and obesity leads to increased joint loading, which primarily affects load-bearing joints. This can stress the articular cartilage beyond its biological reparative capabilities, resulting in joint failure and osteoarthritis. The knee joint is particularly at risk. For example, it is estimated that a force of nearly 3 to 6 times one's body weight is exerted across the hip and knee while walking; an increase in body weight of 1kg therefore increases the force acting on the joint by this factor – 3-6kg. (Felson DT et al. 1996, Bergmann G et al. 2007). Interestingly, being overweight has also been associated with higher rates of hand osteoarthrosis (OA) in some studies, suggesting the involvement of a circulating systemic factor as well as simple mechanical considerations (Carman WJ et al. 1994). Data from the first National Health and Nutrition Examination Survey (HANES I) indicates that obese women have nearly 4 times the risk of knee OA compared to non-obese women; for obese men, the risk was nearly 5 times higher (Anderson et al. 1988). Reijman et al. (2007) found, in a cohort study including more than 3500 patients, that increasing BMI is associated with a corresponding increase in the incidence and progression of knee osteoarthritis. On the other hand, however, it seems that BMI is not related to the incidence and progression of hip osteoarthritis.

There is evidence that weight loss in the overweight and obese can significantly reduce the risk of development of knee OA (Felson DT et al. 1992). In the Framingham study, Felson and colleagues noted that if obese men (BMI over 30) lost enough weight to fall into the overweight category (BMI 26-30) and men in the overweight category lost enough weight to move into the normal weight category (BMI less than 26), knee OA would decrease by 21.5%. Similar changes in weight category by women would result in a 33% decrease in the burden of knee OA. A handful of studies have indicated that weight loss substantially reduces reports of pain as well.

b- Metabolic syndrome

Obesity is often linked to metabolic syndrome. This condition includes the deposition of excess body fat around the waist, high blood pressure, high levels of blood sugar and high serum levels of triglycerides in parallel with low serum levels of high density lipoproteins. Cardiovascular diseases such as myocardial infarction and stroke, as well as type 2 diabetes, are common complications. Inflammation in the white adipose tissue is considered to be a crucial step contributing to the pathologies characterizing metabolic syndrome, as well as to atherosclerosis.

c- Worse outcomes after fracture surgery in patients with metabolic syndrome

There are conflicting data regarding the fracture risk in patients with metabolic syndrome compared to controls. This possibly reflects nutritional status and its importance to general health. Epidemiological studies have shown a lower fracture incidence in patients with metabolic syndrome (Yang L et al. 2016). However, patients with metabolic syndrome who sustain a hip fracture were found to have increased risk of complications but decreased odds of in-hospital mortality, again possibly due to nutritional status (Cichos et al. 2018). The surgical treatment for supination-external rotation ankle fractures (the most common variety) in patients with metabolic syndrome have shown worse clinical outcomes compared to controls (Park et al. 2019).

d- Obesity and Low Back Pain

Dario et al. (2017) found, in interesting studies involving sets of twins, that obesity-related measurements did not increase the risk of developing chronic Low Back Pain (LBP) or care-seeking for LBP. The results do not support a causal direct relationship between obesity and chronic LBP. On the other hand, familial factors such as genetics play a major role.

Somewhat different is the situation in juveniles, however. Studies by Samartzis et al. (2011) found that the presence of juvenile disc degeneration was strongly associated with being overweight and with obesity, LBP, increased LBP intensity and diminished physical and social functioning. Furthermore, an elevated BMI was significantly associated with increased severity of disc degeneration. This study has public health implications regarding being in the overweight or obese categories and the development of lumbar disc disease.

e- Obesity and outcome after joint replacement

Obesity increases the risk of joint failure with the subsequent need for joint replacement. Furthermore, the age at which arthroplasty of the hip and the knee was carried out was markedly lower for patients with a BMI over 35. This association was found to be stronger for knee than for hip replacement (Changulani et al. 2008). Barrett (2018) included eight studies in his review and there were 66238 THAs in morbidly obese patients and 705619 THAs in patients with a BMI < 30. The overall revision rate was higher, with 7.99% in the morbidly obese patients versus 2.75% in the non-obese controls. On the other hand, the functional outcome of arthroplasty was at least comparable to non-obese patients, so the rewards are maintained even if the risks are greater.

The need for revision surgery after joint replacement increases with obesity, particularly since the risk of prosthetic loosening has been shown to be higher in the obese (Electricwala et al. 2016, Goodnough et al. 2018).

5. Perioperative Challenges When Operating on Overweight and Obese Patients

Performing surgery on overweight or obese patients puts additional technical demands on surgeons. Surgical exposure and implant positioning may be more challenging due to the volume of fat tissue precluding optimal vision of the surgical field. Moreover, perioperative complications, such as infection and overall in-hospital deaths, are more frequent in obese patients (D´Apuzzo et al. 2015). Weight loss prior to joint replacement surgery has been shown to reduce the length of stay, which has implications on cost and patient burden (Keeney et al. 2019).

Despite the goal of normal weight, weight loss immediately before surgery as an acute preoperative measure may have negative implications on nutritional status. A catabolic state in the lead up to surgery may also increase the perioperative risks. It must always be kept in mind that obesity and nutritional status are not the same.

Conclusion

- Excess body weight and the global obesity epidemic pose risks for musculoskeletal health, adding to the already known suffering and costs stemming from metabolic and cardiovascular health problems.
- Increased joint loading due to obesity increases the risk of osteoarthritis.
- Subsequent weight loss in obese patients has been shown to reduce the risk of developing osteoarthritis apart from mitigating perioperative risks.
- Metabolic syndrome, often linked to obesity, has been shown to lead to worse clinical outcomes after fracture surgery.

6. List of Activities Needed

- EFORT needs to stimulate engagement in public health policy and strategies combatting the obesity epidemic.
- EFORT needs to support European orthopaedic and trauma surgeons in efforts to improve their knowledge on perioperative optimisation and rehabilitation of obese patients.
- The EFORT Foundation invites experienced institutes, as well as National and Speciality Societies, to share their experience and information material, descriptions of working routines and their web links to create a European data bank on the topic of obesity.
- EFORT aims to stimulate national authorities to support public health policies and strategies aimed at combatting the obesity epidemic and bringing the topic into public view via media.

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Section 3

D | Prevention of MSK Conditions: Tobacco Smoking

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1. Summary

Large scientific studies consistently show that smokers have a 2 to 5 times higher risk for perioperative complications compared to non-smokers. One reason is that smoking increases carbon monoxide levels in the circulation, resulting in lower tissue levels of oxygen.

Smokers can reduce their perioperative risks markedly, since smoking cessation a minimum of 4 to 6 weeks preoperatively and 6 weeks post operation, or post trauma, reduces complication rates in elective surgery by up to 50% and after trauma by approximately 40%. Even if heavy smokers are allowed to use nicotine replacement products during this cessation period, around one in three patients involved in such programmes stop smoking permanently following surgery.

The EFORT Foundation is focusing on this topic and the so-called ESCAPE project intends to increase awareness of the topic. Perioperative Smoking cessation programmes should be implemented into European operational standards. Some operative procedures in heavily smoking patients should be reconsidered if cessation is not achieved.

2. Introduction

Tobacco smoking is the main reason for morbidity and mortality from pulmonary and coronary arterial diseases in Europe. However, besides these well-known effects there is also an important influence of smoking on tissue healing in the musculoskeletal system. Particularly during the perioperative phase, the number of complications experienced by smokers is significantly higher than is seen in non-smokers. The planned surgical procedure and a desire for the optimal outcome of this procedure may be a good motivator for the patient to stop smoking to prepare for the procedure. Today there are effective tools to support smoking cessation.

3. Epidemiology and Smoking Rates in Europe

Smoking is still a huge problem in Europe and there are large regional differences in smoking prevalence. Smoking rates in Europe are illustrated in Figure 1.

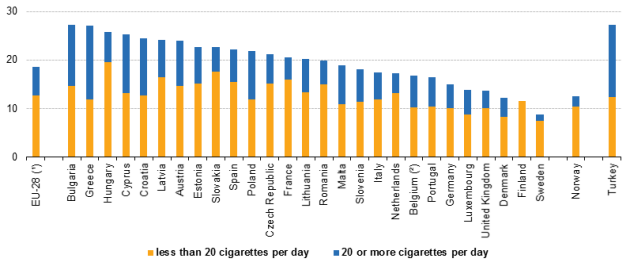

Figure 1. Tobacco Consumption EU 28 Rates EU 28, Eurostat data from European health interview survey (EHIS) Update 2017.

Source: Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Tobacco_consumption_statistics. Accessed: September 2021.

Smoking rates differ a lot between males and females, and between age groups. Recent data on smoking prevalence come from the European Commission's (EC's) Eurobarometer survey, based on data from 27 EU countries. Overall smoking prevalence was 28% (32% in males and 24% in females). The proportion of daily smokers ranged from 8.7 % in Sweden to 27.0 % in Greece and 27.3 % in Bulgaria. Age differences exist in smoking habits: prevalence was 29% in the 15-24 year age-group, 37% in the 25-39 year age group, 34% in the 40–54-year age group and 17% in those aged 55 years or more.

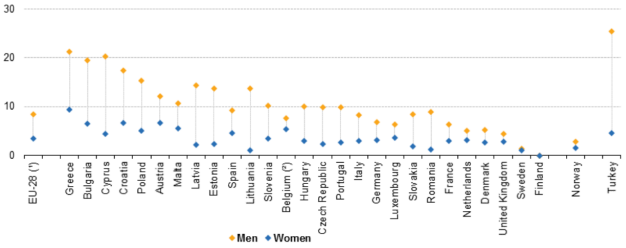

Figure 2. Male/Female Smoking Rates EU 28

Source: Eurostat data from European health interview survey (EHIS) Update 2017. Available at: https://ec.europa.eu/eurostat/web/microdata/european-health-interview-survey. Accessed: September 2021.

A comparison within the 2011 OECD Data between 1979 and 2010 shows the positive effects of recent initiatives against tobacco use. The prevalence of smoking declined by an average of 36% in females and 32% in males, but with wide variation between countries (from 0% to 71%). Among males, the overall tendency in European countries shows a gradual decline of tobacco consumption. In females an overall decline can also be seen, but in a minority of countries smoking prevalence has remained constant for the past 30 years.

Reducing the health burden of tobacco smoking involves both treatment and prevention. In order to affect morbidity and mortality due to smoking over the next 20 years the most powerful intervention will be to persuade today's smokers to quit. It takes 20 years or more for most smoking-related diseases to develop, therefore the most effective means of reducing morbidity and mortality in that future time is legislation in the present time to reduce the uptake of smoking among young people. In practice, we need to focus on both cessation and prevention.

4. Toxic Effects of Tobacco on Musculoskeletal Structures

Tobacco smoke contains more than 4000 constituents. Nicotine itself plays only a minor role in atherosclerosis (hardening of the arteries). Nicotine and carbon monoxide decrease microperfusion and tissue oxygenation, whilst both increase platelet aggregation and cause endothelial damage. Furthermore, they increase blood viscosity and produce microclotting (5-8). Carbon monoxide in tobacco smoke also reduces the amount of oxygenated haemoglobin in red blood cells. When smoking 20 cigarettes per day tissue is seen to be hypoxic for fifteen to twenty hours per day (9). Hydrogen cyanide in tobacco smoke primarily interferes with oxidative metabolism at the cellular level (Lee et al. 2013, Jensen et al. 1991). Therefore, the risk of the development of idiopathic osteonecrosis of the femoral head among smokers has been shown to be four times higher in smokers compared with control patients (Hirota et al. 1993).

Furthermore Osteoblast (bone forming cells) formation is inhibited at high levels of circulating nicotine, and smoking constituents may also affect osteoclasts (cells that remove and regulate bone) function and formation. Nicotine alone shows no

particular detrimental effect on bone healing. On the other hand, tobacco extracts not containing nicotine significantly reduce the mechanical strength of bone.

The following lifestyle variables are often associated with smoking and may also have an impact on the musculoskeletal system: reduced physical activities, decreased appetite, higher consumption of caffeine and alcohol.

a. Smoking effects on the outcome of acute traumatic disorders

The effect of smoking on bone healing is clearly documented. A meta-analysis reviewing 17 studies has shown a significant deficit in bone healing compared to non-smokers (Patel et al. 2013).

Another systematic review of 7000 scientific articles, including 22 studies comparing fracture healing in smokers and non-smokers, demonstrated a significantly higher rate of non-union (odds ratio 2.16) after tibial fractures and after open fractures (odds ratio 1.95) in smokers. The mean healing time for all fractures was on average 6 weeks longer for smokers (30 weeks against 24 weeks.) (Scolaro et al. 2014).

In a later systematic review (2016) 40 studies were analysed, encompassing a large a large sample size of over 8000 adults. The meta-analysis this contained identified that smokers take 27.7days (14.2 to 41.3) longer for union to occur and smokers have double the risk of non-union 2.2 (1.9 to 2.6) (Pearson et al. 2016).

Looking at the influence of smoking on the outcome following tendon ruptures and their surgical repair a highly significant difference was found (29.4% re-rupture in smoker's compared to 5.9 % in non-smokers in a MRI-based study (Park et al. 2018).

b. Smoking effects on the outcome of elective orthopaedic surgery

Møller (Møller et al. 2002) found that smoking was the single most important risk factor for the development of postoperative complications after hip arthroplasty, particularly those related to wound healing, cardiopulmonary complications and the requirement for postoperative intensive care. The proportion of smokers with wound complications and prolonged hospitalisation was twice that of non-smokers.

The outcomes of Hip and Knee Arthroplasty were analysed using data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. 78000 Patients were stratified by smoking status and pack-year history of smoking. Current smokers had a higher rate of wound complications (1.8%) (odds ratio 1.47) and both current and former smokers had an increased overall complication risk following total hip or total knee arthroplasty. Increasing pack-year history of smoking resulted in an increasing total complication risk (Duchmann et al. 2015).

Following primary shoulder arthroplasty similar results are seen. Multivariate analyses showed that both current and former smokers had a significantly higher risk of periprosthetic infection (hazard ratios (HR) of 7.27 and 4.56 respectively). Additionally, current smokers showed a higher risk of postoperative fracture than both former smokers (HR, 3.63) and non-smokers (HR, 6.99) (Hatta et al. 2017).

Another study on revision Hip Arthroplasty analysed more than 8000 patients from the ACS NSQIP Program. The data revealed a significantly higher risk of deep infection (OR 1.58) and for reoperation (OR 1.37) (Bedard et al. 2018) A large meta-analysis following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines showed a 27-day delay in healing of osteotomy, spinal fusion and arthrodesis in smokers. Beside these findings, a significantly greater risk of delayed and/or non-union was shown (Pearson et al. 2016).

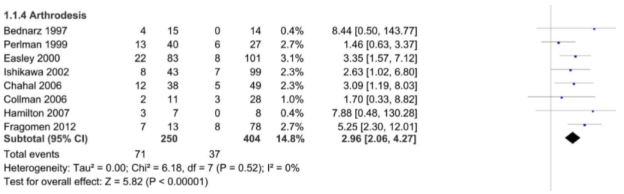

Figure 3. From Pearson: shows a significantly higher incidence of non-unions in smokers (PRISMA Metanalysis 2016).

Source: Pearson et al. 2016. Do smokers have greater risk of delayed and non-union after fracture, osteotomy and arthrodesis? A systematic review with meta-analysis. BMJ Open. 2016; 6(11):e010303.

c. Influence of perioperative smoking cessation in musculoskeletal surgery

Perioperative smoking cessation has an important influence on the results of orthopaedic surgical interventions. In numerous studies it is well documented that preoperative smoking cessation improves postoperative results by, on average, 50 %.

5. Pharmacotherapy for Smoking Cessation and Delivery of Advice

Abstinence from smoking can be monitored with a urine cotinine test or direct carbon monoxide measurement tests. Several meta-analyses have investigated pharmaceutical interventions for smoking cessation, and guidelines have been published by several organisations. First-line pharmacological drugs for smoking cessation are nicotine replacement products (patch, gum, nasal and oral sprays and tablets). Varenicline and bupropion, with scientifically well-documented efficacy when used for 2–3 months, has mostly mild side-effects and at least a doubling of the 1-year quit rate compared with placebo. However, a 100% cessation rate is not achievable by any known means and a typical finding in most studies of smoking cessation studies is a 1-year cessation rate of about 25–35%, which is similar to the cessation rates seen in the management of other dependencies, such as alcohol and opiates. To stop smoking is to break a complex habit and addiction and, to achieve reasonable quit rates, it is necessary to provide psychological support combined with pharmacological agents.

Economic burden of smoking

Beside the case that smoking leads to more than 650000 premature deaths every year in Europe, smoking remains a tremendous economic burden on European society. The WHO estimates that in Europe smoking, according to a report published in 2012, cost the economy €544 billion in 2009 – equivalent to about 4.6% of the EU's GDP. According to the WHO, the economic burden of tobacco is even higher in less developed countries. The poor are disproportionately affected, because buying tobacco reduces expenditure available for other necessities such as food, housing, healthcare and education.

The economic costs of smoking include not only the direct costs of smoking-related illness and death but also indirect costs: 1) Healthcare expenditure not only on active smokers but also for those affected by second-hand smoke. 2) Loss of earnings and employment separate from reduced productivity. 3) Disability and premature mortality 4) Indirect costs, such as fire damage related to smoking and costs related to cleaning and litter.

6. Conclusions

Orthopaedic surgeons should inform all patients before orthopaedic procedures that cessation of smoking improves the rate of successful outcomes significantly. Smoking cessation programmes before surgery should be implemented. Some procedures in some patients should be reconsidered if smoking continues and cessation is not achieved. A beneficial side-effect of cessation programs in the perioperative period is that one of three patients then stop smoking for at least one year. Smoking cessation programs are highly cost-effective for society.

- Orthopaedic surgeons should inform all patients before orthopaedic procedures that cessation of smoking improves the outcome significantly by reducing complications
- Smoking cessation programs before surgery should be implemented
- Some procedures in some patients should be reconsidered if smoking continues and cessation is not achieved.
- A beneficial side-effect of cessation programs is that one in three patients stop smoking for at least one year
- Smoking cessation programs are highly cost-effective for society.

7. List of Activities Needed

- EFORT needs to stimulate European Orthopaedic and Trauma surgeons to improve their knowledge of perioperative risk management, especially regarding the negative influence of tobacco smoking . This has to be done utilising National and Europe-wide conferences and webinars .
- EFORT needs to support national Orthopaedic and Trauma societies, and European Specialty Societies, by promoting the Tobacco risk topic and smoking cessation programs into their education activities.
- The EFORT Foundation invites experienced institutes and National Societies to share their experience and information material, descriptions of working routines and their web links to create a European data bank on this topic.
- The EFORT Foundation will focus on this topic in the quest for enhanced patient safety: besides informing surgeons it is also necessary to inform all patients preoperatively, in a standardized fashion, of their specific Tobacco risk profile and the possibility they have to reduce these complications, even if this means using Nicotine replacement products.
- EFORT aims to stimulate national authorities to support perioperative smoking cessation programs, formulating official recommendations and bringing the topic into public view via media, having in mind the beneficial side-effect of cessation programs that one in three patients involved stops smoking for at least one year

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Section 3

D | Prevention of MSK Conditions: Alcohol

Table of Contents

Authors

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1. Summary

A major contributor to the optimization of outcomes in Orthopaedic and Trauma surgery is addressing lifestyle changes such as alcohol consumption. Chronic alcohol use can lead to adverse immunological consequences and it has been shown that adolescents and young people are particularly vulnerable to the harmful effects of alcohol.

Looking at the specific risks of alcohol consumption as they pertain to orthopaedics, it can be seen that its effects are clearly dose-dependent. Moderate consumption (meaning one or two drinks per day) might even have a positive influence on some aspects of musculoskeletal diseases , such as rheumatoid arthritis or low back pain. On the other hand, alcohol consumption, even in low doses, is known to be a major risk factor in the development of myopathy and osteoporosis. Alcohol consumption of more than 2 drinks per day can be seen as damaging the whole body, including the musculoskeletal system, in various ways.

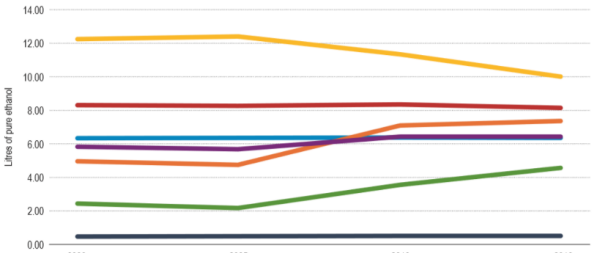
Since it has been shown that brief interventions in the context of primary health services have proven effects in reducing heavy drinking or alcohol-related problems, this topic should be emphasized when discussing orthopaedic therapies with our patients

2. Introduction

During the last century, technological developments in orthopaedic care have led to major benefits to patients. Emerging evidence shows that more attention is needed to non-technical factors, including pre-operative lifestyle changes, one of which is alcohol consumption.

3. Epidemiology

Total annual alcohol consumption per capita has increased globally after a relatively stable phase between 2000 (5.7 litres of pure ethanol) and 2005 (5.5 litres). Since then, the total annual per capita consumption has increased to 6.4 litres in 2016. However, there are diverging trends in different regions of the world (WHO Global status report on alcohol and health 2018).



	2000	2005	2010	2016
AFR	6.2	6.3	6.3	6.3
AMR	8.2	8.2	8.2	8.0
EMR	0.4	0.5	0.6	0.6
EUR	12.1	12.3	11.2	9.8
SEAR	2.4	2.1	3.5	4.5
WPR	4.8	4.6	7.0	7.3
World	5.7	5.5	6.4	6.4

Figure 1. Trends in alcohol consumption in litres of pure ethanol in different WHO Regions.

Source: WHO Global status report on alcohol and health 2018. Available at: https://www.who.int/publications/i/item/9789241565639 Accessed: September 2021

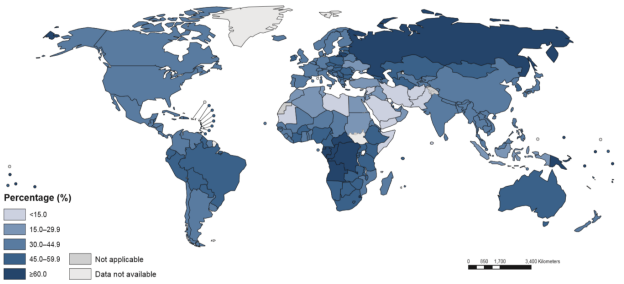


Figure 2. Percentage of heavy episodic drinkers 2016.

Source: WHO Global status report on alcohol and health 2018. Available at: https://www.who.int/publications/i/item/9789241565639 Accessed: September 2021

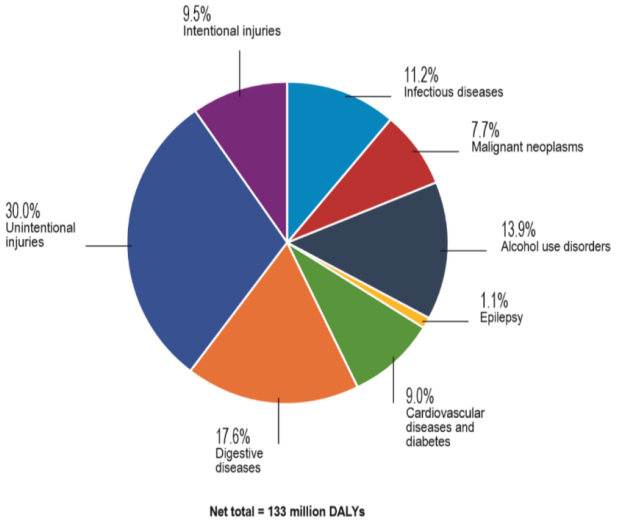


Figure 3. Distribution (%) of Alcohol attributable disability-adjusted life years (DALYs)

Source: WHO Global status report on alcohol and health 2018. Available at: https://www.who.int/publications/i/item/9789241565639 Accessed: September 2021

4. Alcohol Induced Disorders

a. General disorders

Important social harms that can be related to alcohol consumption include violence in all forms, which has vast implications for trauma and orthopaedics.

Over the long-term, the abuse of alcohol results in weakening of the immune system, increasing the risk of infection and numerous other diseases.

In contrast to the negative effects of chronic alcohol abuse, regular moderate consumption of one, or as a maximum 2 glasses of beer or wine per day, has been shown to have positive influences in healthy adults on many orthopaedic diseases and even on the rate of mortality (Mostofsky et al. 2016).

b. Musculoskeletal disorders

Wound healing and wound infection: Excessive alcohol consumption is detrimental to **wound healing**. It significantly increases the risk of **wound infection** by diminishing the body's resistance to bacteria and other harmful agents.

Rheumatoid Arthritis and Gout: While the risk of developing the disease appears to be lower amongst those with high

alcohol consumption, it has been shown that in patients already suffering from Rheumatoid arthritis, alcohol interferes with many antirheumatic drugs and increases the magnitude of their negative side effects, with implications for gastrointestinal-, renal- and liver complications. In cases of gout, alcohol is particularly problematic. Gout attacks can be brought on by purine-rich foods or drinks, and the latter includes beer. Furthermore, distilled liquor and many types of wine can also precipitate problems for patients suffering from gout (Neogi et al. 2014).

Chronic Muscular Conditions and Low Back Pain: Bezerra et al. (2018) evaluated 60202 individuals in Brazil and found that 21.6% reported musculoskeletal conditions. There was a discrete positive association between a low level of reported symptoms and moderate alcohol consumption. Individuals with no alcohol consumption showed a higher prevalence of Chronic Muscular Conditions (23.3%) (Bezerra et al 2018). Another systematic review reported similar results regarding the association between moderate drinking and Low Back Pain (Ferreira et al. 2013).

Hospital stay: Hapaanen-Niemi et al. (1999) showed that patients who had an average of less than 1 drink per day had 21% (95% CI= 10%, 31%) fewer hospital days stay due to any reason. Among women, heavy users of alcohol had 113% (95% CI= 18%, 285%) more injury- and accident-related hospital admissions than non-drinkers.

Myopathy: Alcoholic myopathy is considered to be a toxic myopathy resulting from the body's response to long-term and/or heavy exposure to alcohol. It can either be acute, following heavy alcohol consumption of more than 4-5 alcoholic beverages within two hours, or chronic, developing over time after regular, heavy alcohol consumption over several months. Chronic myopathy can also present with muscle pain and weakness. Alcoholism is therefore a major risk factor for the development of myopathy, which is a debilitating and often painful condition. A study by Wijnia et al. (2012) has explored the similarities between alcoholic myopathy and Vitamin D deficiency and concludes that there is a connection. Nevertheless alcoholic myopathy is reversible, whether it is acute or chronic. An acute episode following a binge causes symptoms that usually resolve within a week or two. Chronic myopathy, in which damage is more severe, can take much longer to resolve after removing the precipitating cause, requiring weeks or even months for the muscles to recover function.

Osteoporosis: A meta-analysis from a pool of 3479 studies identified a positive relationship between alcohol consumption and osteoporosis (Cheraghi et al. 2019). Compared to abstainers from alcohol, persons consuming 0.5-1 drinks per day had 1.38 times the risk of developing osteoporosis (adjusted RR = 1.38, 95% CI: 0.90-2.12); persons consuming 1-2 drinks per day had 1.34 times the risk of developing osteoporosis (adjusted RR = 1.34, 95% CI: 1.11-1.62) and persons consuming two drinks or more per day had 1.63 times the risk of developing osteoporosis (adjusted RR = 1.63, 95% CI: 1.01-2.65) (Cheraghi et al. 2019). This study clearly demonstrates a positive relationship between alcohol consumption and osteoporosis.

Another study (Berg et al 2008) demonstrated that alcohol intake was associated with a significant increase in osteoporotic and hip fracture risk, but the effect was nonlinear. Compared with abstainers and heavier drinkers, persons who consume 0.5 to 1.0 drink per day have a lower risk of hip fracture. Although available evidence suggests a favourable effect of alcohol consumption on bone density, a precise range of beneficial alcohol consumption cannot be determined. This study demonstrates again that there may be no negative effect of up to 2 drinks per day, but a positive association between alcohol consumption of more than 2 drinks and osteoporosis. Kanis et al. (2005) published a study on 5939 men and 11032 women followed for 75433 person-years. During this time, there were 1753 fractures, with 1207 fractures thought to be related to osteoporosis, including 279 hip fractures. Bone mineral density measurements were available in 91% of individuals. No significant increase in risk was observed at intakes of 2 units or less daily. Above this threshold, alcohol intake was associated with an increased risk of any fracture (risk ratio [RR]=1.23; 95% CI, 1.06–1.43), any osteoporotic fracture (RR=1.38; 95% CI, 1.16–1.65), or hip fracture (RR=1.68; 95% CI, 1.19–2.36). Risk ratio increased with more than 2 units per day in both men and women, but was not increased below this level. Furthermore, the risk of hip fracture increased by 7% for each additional unit of intake above 1 unit daily.

5. Economic Burden of Alcohol and the Cost-Effectiveness of Alcohol Reduction Strategies

A primary locus for studying and quantifying the social harm caused by drinking has been the series of studies on the social cost of alcohol in what is called the "cost of illness" tradition. By now, over 30 such studies have been carried out in Europe alone, and others elsewhere, with an increasingly standardized methodology in accordance with WHO guidelines. The biggest single cost estimated in such studies is usually the "indirect cost" of premature mortality. This is a calculation of the loss to the future economy of what would have been produced by those who suffered an alcohol-attributed death in the index year. Counting this indirect cost as a health cost, and considering it together with such direct costs as absenteeism, unemployment, damage from crime and traffic crashes and the provision of health, criminal justice and social services to those affected by an alcohol-attributable problem, the costs of "social harms" typically outweigh the health costs. Focusing just on governmental costs of services in a developed society, the costs for police, fire and social work services attributable to alcohol often far outweigh the costs of health services (Johansson et al 2006 and London strategy unit 2003).

6. Therapy for Alcohol Reduction and Sources of Advice

There is now a substantial evidence base on the relative effectiveness of different strategies for reducing rates of alcohol-related harm. In general, research findings show that the conditions of alcohol supply — when and under what circumstances alcohol is available — can considerably affect rates of alcohol-related problems. Specific alcohol control legislation and licensing systems have proved beneficial in a variety of sociocultural circumstances. Prohibition of the sale of alcohol to a person under a specified minimum age, or to someone who is apparently intoxicated, are also common and potentially effective measures. High rates of taxation on alcoholic beverages have likewise proven effective as a strategy to control levels of alcohol-related problems. Evidence is also strong for a specific set of drink-driving countermeasures: these include setting a low blood alcohol level as a requirement for driving and enforcing this limit actively with a programme of random breath-tests or equivalent measures. Both have implications for the reduction of trauma. Brief interventions in the context of primary health services have proven effective in reducing heavy drinking or alcohol-related problems in a variety of different sociocultural situations (Anderson and Baumberg 2006).

7. List of Activities Needed

- EFORT needs to stimulate engagement in public health policy and strategies combatting alcoholism and assist in bringing the topic into public view via media.
- EFORT aims to stimulate national and specialty societies into discussing the major influence of patients lifestyle including alcoholism on musculoskeletal health issues during their educational activities.

The EFORT Foundation invites experienced institutes as well as National and Speciality Societies to share their experiences and educational materials, descriptions of working routines and their web links.

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Section 4

Practising Orthopaedics and Trauma Care in Europe

Section 4

A | Workforce and Infrastructure

Table of Contents

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1. Summary

This chapter begins with a brief overview of demographics, economy, health expenditure and basic health indicators in Europe. Population, median age, life expectancy, gross domestic product per capita and health expenditures for each country are presented with comparisons. Figures for the European pharmaceutical and medical technology industries are discussed, as well as the coverage of the population by health insurance.

The next section considers the health workforce in Europe. Numbers of medical doctors, orthopaedic surgeons, orthopaedic trainees, practicing nurses, physiotherapists and occupational therapists per 100,000 inhabitants are provided for each European country. We also present information about membership of EFORT and the national orthopaedic societies.

The last section concerns healthcare resources and their utilisation in Europe. The number of hospitals, hospital beds and operating theatres in European countries are listed, together with data on the radiological and nuclear medicine devices that are used in the investigation and management of musculoskeletal diseases and trauma. Hospital discharges are discussed, highlighting those with a diagnosis of 'disease of musculoskeletal system and connective tissue' along with the percentage of such discharges within the hospital discharges for all causes. Among the other data presented are the average length of hospital stay for diseases of the musculoskeletal system and the waiting times for several orthopaedic procedures.

2. Overview of Demographics, Economy and Basic Health Indicators in Europe

The population of the World in 2020 was 7.8 billion and 9.6% of this population (748 million) lived in Europe (United Nations - 2021e). The median age of the world population is 30.9, which means that half of all people are younger than this age and half are older (United Nations - 2021d). Europe is the continent with the oldest population, with a mean age of 42.5 years. Africa has the youngest population, half of its population being under 19.7 years old. In Europe, Italy has the highest median age at 47.3 years followed by Portugal, Germany, Greece and Lithuania. The countries with the youngest populations in Europe are Kosovo, Turkey, Albania, Cyprus and Iceland (United Nations - 2021d, Indexmundi - 2020).

Life expectancy at birth in Europe is 78.3 years; higher than the global average of 72.3 (United Nations - 2021b). Out of 33 countries with a life expectancy at birth greater than 80 years across the world, 20 (61.8%) are European countries. Switzerland has the longest life expectancy at birth for males and both sexes combined in Europe, whilst Italy has the longest life expectancy at birth for females.

As in other regions of the world, women live longer than men in European countries (United Nations - 2021b, United Nations – 2021a, United Nations – 2021c). The difference is more than 8 years in Belarus (10.0), Estonia (8.5), Latvia (9.9), Lithuania (11.2), Moldova (8.5), the Russian Federation (10.7) and Ukraine (9.8). The countries with a difference less than 4 years are: Albania (3.4), Iceland (3.1), Ireland (3.4), Malta (3.7), Netherlands (3.5), Sweden (3.6), Switzerland (3.8) and the United Kingdom (3.5). Women live 4-8 years longer than men in all other European countries. Median age and life expectancy at birth in European countries are shown in Table 1.

Table 1. Median age (2020) and life expectancy at birth (2015-2020) in European countries.

Source: Data for median age and life expectancy for Kosovo: Index mundi. Kosovo Demographics Profile. Available at: https://www.indexmundi.com/kosovo/demographics_profile.html. Accessed March 2021. Data for median age of all other countries: United Nations. World Population Prospects: Median Age by Region, Subregion and Country. Available at https://population.un.org/wpp/Download/Standard/Population/. Accessed March 2021. Data for life expectancy (both sexes) of all other countries: United Nations. World Population Prospects: Life Expectancy at Birth (Both Sexes Combined) by Region, Subregion and Country. Available at: https://population.un.org/wpp/Download/Standard/Mortality/. Accessed March 2021). Data for life expectancy (females) of all other countries: United Nations. World Population Prospects: Female Life Expectancy at Birth by Region, Subregion and Country. Available at: https://population.un.org/wpp/Download/Standard/Mortality/. Accessed March 2021. Data for life expectancy (males) of all other countries: United Nations. World Population Prospects: Male Life Expectancy at Birth by Region, Subregion and Country. https://population.un.org/wpp/Download/Standard/Mortality/. Accessed March 2021.

Country	Median age (Both sexes)	Life expectancy (Both sexes)	Life expectancy (Females)	Life expectancy (Males)
Albania	36.4	78.4	80.1	76.7
Austria	43.5	81.4	83.8	78.9
Belarus	40.3	74.5	79.3	69.3
Belgium	41.9	81.4	83.7	79.0
Bosnia and Herzegovina	43.1	77.2	79.7	74.7
Bulgaria	44.6	74.8	78.5	71.3
Croatia	44.3	78.2	81.4	75.0
Cyprus	37.3	80.7	82.8	78.7
Czechia	43.2	79.1	81.8	76.5
Denmark	42.3	80.7	82.7	78.7
Estonia	42.4	78.5	82.5	74.0
Finland	43.1	81.6	84.5	78.8
France	42.3	82.5	85.4	79.4
Germany	45.7	81.1	83.6	78.7
Greece	45.6	82.0	84.5	79.5
Hungary	43.3	76.6	80.1	73.0
Iceland	37.5	82.8	84.3	81.2
Ireland	38.2	82.0	83.7	80.4
Italy	47.3	83.3	85.4	81.0
Kosovo	30.5	72.7	75.1	70.5
Latvia	43.9	75.1	79.8	69.9
Lithuania	45.1	75.7	81.1	70.0
Luxembourg	39.7	82.0	84.2	79.8
Malta	42.6	82.3	84.1	80.4
Moldova	37.6	71.7	75.9	67.4
Montenegro	38.8	76.7	79.1	74.2
Netherlands	43.3	82.1	83.8	80.3
North Macedonia	39.1	75.6	77.7	73.6
Norway	39.8	82.2	84.2	80.2
Poland	41.7	78.5	82.4	74.5
Portugal	46.2	81.8	84.6	78.7
Romania	43.2	75.8	79.3	72.4
Russian Federation	39.6	72.3	77.5	66.8
Serbia	41.6	75.8	78.4	73.2
Slovakia	41.2	77.3	80.8	73.7
Slovenia	44.5	81.1	83.9	78.3
Spain	44.9	83.4	86.1	80.6
Sweden	41.1	82.6	84.4	80.8
Switzerland	43.1	83.6	85.4	81.6
Turkey	31.5	77.3	80.2	74.3
Ukraine	41.2	71.8	76.6	66.8
United Kingdom	40.5	81.2	82.9	79.4

While comprising almost 1/10 of the world population, the contribution of European countries to the gross world product (GWP) is much higher than this ratio. GWP is the combined gross domestic product (GDP) of all the countries in the world (Statistics Times – 2021). The GWP is around USD 83.8 trillion in 2020. The sum of GDPs of the European countries is around USD 20.4 trillion, which is roughly ¼ of the GWP (International Monetary Fund – 2021b). Germany has the highest GDP in Europe at USD 3.78 trillion in 2020, which makes it fourth in global ranking after the United States, China and Japan. In Europe, Germany is followed by the United Kingdom (USD 2.64 trillion), France (USD 2.55 trillion), Italy

(USD 1.85 trillion) and Spain (USD 1.25 trillion). The average GDP per capita in the World is USD 11,442 in 2020. The average GDP per capita is higher (USD 27,520) in Europe and much higher (USD 33,560) in EU Countries (International Monetary Fund – 2021a).

Health expenditure varies widely throughout the countries and regions of the World. Health expenditure (HE) per capita is higher in most of the European countries than the World average of USD 1,111 (2018) (World Bank – 2021b). According to World Bank data, HE per capita was highest in North America at USD 10,050 in 2018. It was USD 2,347 in Europe & the Central Asia Region, USD 3,525 in EU countries and USD 4,063 in the Euro zone in the same year. Countries with highest HE per capita in Europe are Switzerland (USD 9,871), Norway (USD 8,239), and Iceland (USD 6,531). Moldova (USD 213), Ukraine (USD 228) and Albania (USD 275) spend the least amount of money per capita on health in Europe.

The total HE of European countries, as a percentage of their GDP, ranges from 4.1 to 11.9 (World Bank – 2021a). HE as % of GDP in the European Union is exactly the same as the World average of 9.85. Europe is second to North America (16.4) regarding HE as % of GDP. Population, GDP per capita, HE per capita and total HE as percentage of GDP of the European countries are shown in Table 2.

As reported by the WHO, global spending on health was USD 7.8 trillion in 2017, or about 10% of GWP (WHO 2021a). An average of approximately 10% of GDP was spent on healthcare in European countries in 2017, too. Out of the total healthcare expenditure, around 76.9% was attributed to inpatient & outpatient care in Europe in that year, followed by 15.9 on pharmaceuticals and other medical non-durables, with 7.2% spent on medical technologies (MedTech Europe 2019).

Pharmaceutical industry

The European pharmaceutical market is around one fifth of the global pharmaceutical market. The pharmaceutical industry directly employs some 750,000 people in Europe and generates three to four times more employment indirectly (EFPIA 2018). Total pharmaceutical sales in the continent was USD 177 billion in 2017, which was 19% of global sales of USD 930 billion in that year (Statista 2021). The EFPIA (European Federation of Pharmaceutical Industries and Associations) reported total European pharmaceutical sales as 22% of the global pharmaceutical market for 2017 (EFPIA 2018). That report also included the sale figures of Turkey and Russia. The global musculoskeletal drugs market was valued at USD 130.1 billion in the same year (The Business Research Company 2018). This group of drugs includes antirheumatic drugs, muscle relaxants and other drugs used in the treatment of osteoarthritis, analgesics, and immunosupressives used in treatment of various musculoskeletal disorders.

Medical devices industry

The European medical technology industry directly employs more than 675,000 people in 27,000 medical technology companies in Europe (MedTech Europe 2019). The largest number of these companies are based in Germany, followed by the UK, Italy, Switzerland, Spain and France. Small and medium-sized companies make up around 95% of the medical technology industry, the majority of which employ less than 50 people.

Based upon manufacturer prices, the European medical technology market is estimated to make up 27% of the world market, which makes it the second largest medical technology market after the US (43%). The European medical technology market was estimated at roughly € 115 billion in 2017 (MedTech Europe 2019).

Table 2. Population, gross domestic product per Capita, health expenditure per Capita and total health expenditure as % of gross domestic product in European countries.

Source: Data for population for Kosovo: Indexmundi. Kosovo Demographics Profile. Available at: https://www.indexmundi.com/kosovo/demographics_profile.html. Accessed March 2021. Data for population of all other countries: United Nations. World Population Prospects: Total Population (Both Sexes Combined) by Region, Subregion and Country Available at: https://population.un.org/wpp/Download/Standard/Population/. Accessed March 2021. Data for gross domestic product (GDP) per capita for Kosovo: World Bank. GDP per Capita (current US$). Available at: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD . Accessed March 2021. Data for GDP for all other countries: World Bank. Current Health Expenditure per capita 2018. Available at: https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD . Accessed March 2021. Data for health expenditure (HE) per capita: World Bank. Current Health Expenditure per capita 2018. Available at: https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD . Accessed March 2021. Data for total HE (% of GDP): World Bank. Current Health Expenditure (% of GDP) 2018. Available at: https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS. Accessed March 2021.

Country	Population[a]	GDP per capita[a] (USD)	HE per capita[a] (USD)	Total HE[a] (% of GDP)
Albania	2,878,000 (2020)	4,900 (2020)	275 (2018)	5.3 (2018)
Austria	9,006,000 (2020)	48,630 (2020)	5,326 (2018)	10.3 (2018)
Belarus	9,449,000 (2020)	6,130 (2020)	356 (2018)	5.6 (2018)
Belgium	11,590,000(2020)	43,810 (2020)	4,913 (2018)	10.3 (2018)
Bosnia and Herzegovina	3,281,000 (2020)	5,760 (2020)	540 (2018)	8.9 (2018)
Bulgaria	6,948,000 (2020)	9,830 (2020)	690 (2018)	7.4 (2018)
Croatia	4,105,000 (2020)	14,030 (2020)	1.014 (2018)	6.8 (2018)
Cyprus	1,207,000 (2020)	26,240 (2020)	1,954 (2018)	6.8 (2018)
Czechia	10,709,000(2020)	22,630 (2020)	1,766 (2018)	7.7 (2018)
Denmark	5,792,000 (2020)	58,440 (2020)	6,217 (2018)	10.1 (2018)
Estonia	1,327,000 (2020)	22,990 (2020)	1,553 (2018)	6.7 (2018)
Finland	5,541,000 (2020)	45,470 (2020)	4,516 (2018)	9.0 (2018)
France	65,274,000(2020)	39,260 (2020)	4,690 (2018)	11.3 (2018)
Germany	83,784,000(2020)	46,445 (2020)	5,472 (2018)	11.4 (2018)
Greece	10,423,000(2020)	18,170 (2020)	1,567 (2018)	7.7 (2018)
Hungary	9,660,000 (2020)	15,370 (2020)	1,082 (2018)	6.7 (2018)
Iceland	341,000 (2020)	57,190 (2020)	6,531 (2018)	8.5 (2018)
Ireland	4,938,000 (2020)	79,670 (2020)	5,489 (2018)	6.9 (2018)
Italy	60,462,000(2020)	30,660 (2020)	2,989 (2018)	8.7 (2018)
Kosovo	1,933,000 (2020)	4,418 (2019)	-	-
Latvia	1,886,000 (2020)	17,230 (2020)	1,102 (2018)	6.2 (2018)
Lithuania	2,722,000 (2020)	19,880 (2020)	1,249 (2018)	6.6 (2018)
Luxembourg	626,000 (2020)	109,600(2020)	6,227 (2018)	5.3 (2018)
Malta	442,000 (2020)	28,470 (2020)	2,754 (2018)	9.0 (2018)
Moldova	4,034,000 (2020)	4,270 (2020)	213 (2018)	6.6 (2018)
Montenegro	628,000 (2020)	7,930 (2020)	732 (2018)	8.4 (2018)
Netherlands	17,135,000(2020)	51,290 (2020)	5,307 (2018)	10.0 (2018)
North Macedonia	2,083,000 (2020)	6,020 (2020)	399 (2018)	6.6 (2018)
Norway	5,421,000 (2020)	67,990 (2020)	8,239 (2018)	10.1 (2018)
Poland	37,847,000(2020)	15,300 (2020)	979 (2018)	6.3 (2018)
Portugal	10.197,000(2020)	21,610 (2020)	2,215 (2018)	9.4 (2018)
Romania	19,238,000(2020)	12,810 (2020)	687 (2018)	5.6 (2018)
Russian Federation	145,934,000(2020)	9,970 (2020)	609 (2018)	5.3 (2018)
Serbia	8,737,000 (2020)	7,500 (2020)	617 (2018)	8.5 (2018)
Slovakia	5,460,000 (2020)	18,670 (2020)	1,300 (2018)	6.7 (2018)
Slovenia	2,079,000 (2020)	25,040 (2020)	2,170 (2018)	8.3 (2018)
Spain	46,755,000(2020)	26,830 (2020)	2,736 (2018)	9.0 (2018)
Sweden	10,099,000(2020)	50,340 (2020)	5,982 (2018)	10.9 (2018)
Switzerland	8,655,000 (2020)	81,870 (2020)	9,871 (2018)	11.9 (2018)
Turkey	84,339,000(2020)	7,720 (2020)	390 (2018)	4.1 (2018)
Ukraine	43,734,000(2020)	3,420 (2020)	228 (2018)	7.7 (2018)
United Kingdom	67,886,000(2020)	39,230 (2020)	4,315 (2018)	10.0 (2018)

[a] *Parenthesized superscripts denote the year data are from GDP: Gross domestic product, HE: Health expenditure*

Spending on medical technology is judged to vary significantly across European countries, ranging from around 5% to 10% of total healthcare expenditure (MedTech Europe 2019). Expenditure per capita on medical technology in Europe is at around € 213 (weighted average).

The majority of the European population is well covered by public and primary private health insurance, but there is still a need for out-of-pocket payments for health expenditure (OECD 2021k, World Bank 2021e). Such out-of-pocket expenditure constituted 9.3% to 49.4% of total health spending in European

countries in 2018; the world average was 18.1% the same year. Higher proportions of out-of-pocket expenditure usually exist in low income countries, both in the world and in Europe. The average is 15.6% for EU countries and 17.7% for Europe and Central Asia, both of which are slightly lower than the world average, but when the high income countries are excluded, the average for Europe and Central Asia becomes 36.4%.

The proportion of the global population at risk of catastrophic expenditure when surgical care is required is 28.15% (Our World in Data 2017). Catastrophic expenditure is defined as direct out-of-pocket payments for surgical and anaesthetic care exceeding 10% of total income. This proportion is 7.6% for the region of Europe & Central Asia and 2.3% for the EU.

Coverage of the population by health insurance, out-of-pocket health expenditure and the percentage of people at risk of catastrophic expenditure for surgical care in European countries are given in Table 3.

3. Health Workforce and Orthopaedic Surgeons in Europe

The distribution of the health workforce shows wide variation across the world and between the continents (OECD – 2021i, World Bank – 2021f). At a global level, the number of medical doctors per 100,000 population is 157. Sub-Saharan Africa has the lowest provision, with 20, whereas the European Union has 370 and Europe & Central Asia, as a region, has 340, followed by North America with 260 medical doctors per 100,000 population. The distribution is not homogeneous within Europe, either. Lithuania, Greece, Austria, Belarus and Portugal have more than 500 medical doctors per 100,000 inhabitants whereas this figure is less than 250 in Poland, Bosnia & Herzegovina, Cyprus, Turkey and Albania (World Bank – 2021f).

Greece, Germany, Cyprus and Italy have more than 15 orthopaedic surgeons per 100,000 inhabitants (Eurostat – 2021d). The Netherlands, Serbia, Ireland, Slovenia, France and Turkey have less than 6. Other countries have 6-15 orthopaedic surgeons per 100,000 inhabitants. The number of orthopaedic trainees per 100,000 inhabitants ranges from 0.8 to 7.5 among European countries (Madanat et al. 2017).

The number of nurses per 100,000 population shows similar significant variation. There are more than 1,400 nurses per 100,000 inhabitants in Norway, Finland, and Iceland and less than 400 in North Macedonia, Greece and Turkey (WHO – 2021d, OECD – 2021b, OECD – 2021j).

In many countries physiotherapists and occupational therapists take part in the management of musculoskeletal disorders but their distribution in Europe is also heterogenous (WHO – 2021e, OECD – 2021c, COTEC – 2020). Table 4 shows the number of medical doctors, orthopaedic surgeons, orthopaedic trainees, practicing nurses, physiotherapists and occupational therapists per 100,000 inhabitants in European countries.

The percentage of orthopaedic surgeons as a proportion of all medical doctors varies from 2 to 4% in most European countries. The outliers are Cyprus, Germany and Greece at the higher end of this range and France, Ireland, the Netherlands, Serbia and Slovenia at the lower end (Figure 1).

EFORT is the Federation of National Associations of Orthopaedics and Traumatology in Europe and the National Association of each member country declares the number of their full paying members to EFORT every year. These declared numbers are different, and

Table 3. Percentage of population covered by total public and primary private health insurance, out-of-pocket expenditure as % of health expenditure and % of people at risk of catastrophic expenditure for surgical care in European countries.

Sources: Percentage of total population covered by total public and primary private health insurance: OECD. Total Public and Primary Private Health Insurance 2018. Available at: https://stats.oecd.org/index.aspx?queryid=30137. Accessed March 2021. Out-of-pocket expenditure as % of health expenditure: World Bank. Out-of-Pocket Expenditure (% of Current Health Expenditure) 2018. Available at: https://data.worldbank.org/indicator/SH.XPD.OOPC.CH.ZS . Accessed March 2021. Percentage of people at risk of catastrophic expenditure for surgical care: Our World in Data. Risk of Catastrophic Expenditure for Surgical Care (% of People at Risk) 2017. Available at: https://ourworldindata.org/grapher/risk-of-catastrophic-expenditure-for-surgical-care?tab=table. Accessed March 2021.

Country	% of total population covered by total public and primary private health insurance [a]	Out-of-pocket expenditure[a] (% of HE)	% of people at risk of catastrophic expenditure for surgical care[a]
Albania	-	44.6 (2018)	7.4 (2017)
Austria	99.9 (2018)	18.4 (2018)	0.4 (2017)
Belarus	-	24.9 (2018)	11.5 (2017)
Belgium	98.7 (2018)	19.1 (2018)	0.1 (2017)
Bosnia and Herzegovina	-	29.3 (2018)	3.2 (2017)
Bulgaria	-	40.5 (2018)	9.8 (2017)
Croatia	-	10.5 (2018)	3.7 (2017)
Cyprus	-	44.6 (2018)	10.4 (2017)
Czechia	100.0 (2018)	14.2 (2018)	0.3 (2017)
Denmark	100.0 (2019)	13.8 (2018)	0.1 (2017)
Estonia	95.0 (2019)	24.7 (2018)	79.6 (2017)
Finland	100.0 (2019)	18.4 (2018)	0.1 (2017)
France	99.9 (2019)	9.3 (2018)	0.0 (2017)
Germany	99.9 (2018)	12.7 (2018)	0.1 (2017)
Greece	100.0 (2018)	36.4 (2018)	7.7 (2017)
Hungary	94.0 (2018)	26.9 (2018)	35.7 (2017)
Iceland	100.0 (2018)	16.0 (2018)	35.3 (2017)
Ireland	100.0 (2018)	12.1 (2018)	1.1 (2017)
Italy	100.0 (2018)	23.6 (2018)	1.0 (2017)
Latvia	100.0 (2018)	39.3 (2018)	88.8 (2017)
Lithuania	98.7 (2019)	31.6 (2018)	40.2 (2017)
Luxembourg	-	10.47 (2018)	1.0 (2017)
Malta	-	34.3 (2018)	4.6 (2017)
Moldova	-	40.1 (2018)	20.8 (2017)
Montenegro	-	39.6 (2018)	2.6 (2017)
Netherlands	99.9 (2018)	10.8 (2018)	0.2 (2017)
North Macedonia	-	42.1 (2018)	61.2 (2017)
Norway	100.0 (2019)	14.3 (2018)	0.1 (2017)
Poland	92.9 (2018)	20.8 (2018)	0.2 (2017)
Portugal	100.0 (2018)	29.5 (2018)	6.2 (2017)
Romania	-	19.5 (2018)	0.0 (2017)
Russian Federation	99.6 (2018)	38.3 (2018)	21.9 (2017)
Serbia	-	38.3 (2018)	4.4 (2017)
Slovakia	94.6 (2017)	18.9 (2018)	0.0 (2017)
Slovenia	100.0 (2018)	12.0 (2018)	1.0 (2017)
Spain	100.0 (2019)	22.2 (2018)	1.9 (2017)
Sweden	100.0 (2018)	13.8 (2018)	0.2 (2017)
Switzerland	100.0 (2018)	28.0 (2018)	2.9 (2017)
Turkey	98.5 (2018)	17.5 (2018)	1.1 (2017)
Ukraine	-	49.4 (2018)	14.4 (2017)
United Kingdom	100.0 (2018)	16.7 (2018)	0.1 (2017)

[a] Parenthesized superscripts denote the year data are from

HE: Health expenditure

Table 4. Medical doctors, orthopaedic surgeons, orthopaedic trainees, practicing nurses, physiotherapists and occupational therapists per 100,000 inhabitants in European countries.

Source: Medical doctors: OECD. Health Resources: Doctors. Available at: https://data.oecd.org/healthres/doctors.htm . Accessed March 2021. World Bank. Physicians (per 1,000 People). Available at: https://data.worldbank.org/indicator/SH.MED.PHYS.ZS. Accessed March 2021. Orthopaedic surgeons: Eurostat. Physicians by Medical Speciality: Orthopaedics. Available at: https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_SPEC__custom_379664/default/table?lang=en. Accessed March 2021. Orthopaedic trainees: Madanat et al. The current state of orthopaedic residency in 18 European countries. Int Orthop. 2017 Apr;41(4):681-687. Nurses: Data for Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Malta, Romania, Russian Federation and Ukraine: WHO. Practising Nurses per 100 000. Available at: https://gateway.euro.who.int/en/indicators/hlthres_189-practising-nurses-per-100-000/visualizations/#id=28405&tab=table. Accessed March 2021. Data for France, Ireland, Portugal and Turkey: OECD. Health Resources: Nurses. Available at: https://data.oecd.org/healthres/nurses.htm . Accessed March 2021. Data for all other countries: OECD. Health Care Resources: Nurses. https://stats.oecd.org/Index.aspx?DatasetCode=HEALTH_STAT#. Accessed March 2021. Physiotherapists: Data for Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Malta, Moldova, North Macedonia, Romania, Russian Federation, Serbia and Ukraine: WHO. Practising Physiotherapists, per 100 000. Available at: https://gateway.euro.who.int/en/indicators/hlthres_195-practising-physiotherapists-per-100-000/visualizations/#id=28411&tab=table. Accessed March 2021. Data for all other countries: OECD. Health Care Resources: Physiotherapists. Available at: https://stats.oecd.org/Index.aspx?DatasetCode=HEALTH_STAT#. Accessed March 2021. Occupational therapists: COTEC. Summary of the Occupational Therapy Profession in Europe. Available at: https://www.coteceurope.eu/wp-content/uploads/2020/06/Summary-of-the-Profession-2020.pdf. Accessed March 2021

Country	MD[a]	OS[a]	OT[a]	N[a]	PT[a]	OTh[a]
Albania	122 (2016)	-	-	430 (2013)	-	-
Austria	524 (2018)	11.9 (2015)	-	687 (2018)	44 (2018)	43.6 (2020)
Belarus	519 (2015)	-	-	1.016 (2013)	-	-
Belgium	313 (2018)	8.9 (2015)	-	1.122 (2017)	198 (2018)	106.8 (2020)
Bosnia and Herzegovina	216 (2015)	-	-	515 (2013)	10.1 (2013)	-
Bulgaria	403 (2015)	11.2 (2015)	-	447 (2013)	21.6 (2013)	0.7 (2020)
Croatia	300 (2016)	6.1 (2015)	1.3 (2014)	621 (2013)	63.3 (2013)	5.3 (2020)
Cyprus	195 (2016)	16.9 (2015)	-	490 (2013)	9.9 (2013)	18.9 (2020)
Czechia	404 (2018)	-	-	807 (2018)	87 (2013)	12.5 (2020)
Denmark	419 (2018)	13.0 (2014)	2.9 (2014)	1.010 (2018)	172 (2018)	187.6 (2020)
Estonia	448 (2018)	10.6 (2015)	-	629 (2018)	38 (2013)	0.1 (2020)
Finland	381 (2016)	8.9 (2014)	4.6 (2014)	1.426 (2014)	207 (2014)	61.5 (2020)
France	337 (2018)	5.0 (2016)	0.8 (2014)	1.080 (2018)	132 (2016)	17.9 (2020)
Germany	431 (2018)	20.1 (2015)	-	1.322 (2018)	229 (2018)	72.2 (2020)
Greece	548 (2017)	27.0 (2015)	4.4 (2014)	337 (2018)	79 (2013)	16.8 (2019)
Hungary	341 (2018)	-	-	662 (2018)	54 (2018)	-
Iceland	408 (2018)	10.9 (2015)	-	1.552 (2018)	179 (2019)	104.1 (2020)
Ireland	331 (2018)	5.4 (2016)	0.9 (2014)	1.290 (2018)	104 (2019)	56.4 (2020)
Italy	398 (2018)	15.4 (2016)	-	564 (2018)	102 (2018)	3.0 (2020)
Kosovo	-	-	0.9 (2014)	-	-	-
Latvia	330 (2018)	7.9 (2015)	-	435 (2018)	42 (2018)	8.2 (2020)
Lithuania	635 (2018)	-	-	778 (2018)	134 (2018)	7.2 (2019)
Luxembourg	298 (2017)	9.9 (2016)	-	1.172 (2017)	201 (2017)	47.9 (2020)
Malta	286 (2015)	8.6 (2016)	1.4 (2014)	798 (2014)	95.0 (2014)	23.7 (2020)
Moldova	321 (2017)	-	-	607 (2014)	3.2 (2013)	-
Montenegro	276 (2018)	6.1 (2016)	-	512 (2013)	-	-
Netherlands	361 (2017)	5.7 (2015)	-	1.113 (2018)	199 (2018)	28.7 (2020)
North Macedonia	257 (2015)	6.2 (2015)	-	366 (2013)	14.9 (2013)	-
Norway	493 (2019)	10.1 (2015)	7.5 (2014)	1.797 (2019)	248 (2019)	96.9 (2020)
Poland	238 (2017)	8.4 (2015)	-	510 (2017)	70 (2017)	1.2 (2020)
Portugal	512 (2017)	10.8 (2015)	2.5 (2014)	690 (2018)	14 (2018)	17.7 (2020)
Romania	298 (2017)	6.6 (2015)	-	565 (2013)	4.4 (2013)	-
Russian Federation	409 (2018)	-	-	389 (2014)	3.8 (2013)	0.03 (2019)
Serbia	311 (2016)	5.7 (2015)	-	596 (2012)	36.7 (2013)	1.7 (2020)
Slovakia	352 (2018)	-	1.7 (2014)	570 (2018)	36 (2018)	-
Slovenia	318 (2018)	5.2 (2015)	1.1 (2014)	1.014 (2018)	68 (2018)	25.6 (2020)
Spain	402 (2018)	12.6 (2015)	2.4 (2014)	587 (2018)	116 (2018)	19.0 (2019)
Sweden	427 (2017)	13.4 (2014)	2.9 (2014)	1.088 (2017)	135 (2017)	116.2 (2020)
Switzerland	434 (2018)	12.6 (2016)	5.5 (2014)	1.759 (2018)	-	36.6 (2020)
Turkey	188 (2018)	4.9 (2015)	1.2 (2014)	230 (2018)	7 (2018)	-
Ukraine	299 (2014)	-	-	717 (2013)	39.2 (2013)	-
United Kingdom	295 (2019)	10.6 (2016)	1.6 (2014)	778 (2018)	42 (2018)	59.4 (2020)

[a] Parenthesized superscripts denote the year data are from (Latest available data are given)
MD = Medical Doctor, OS = Orthopaedic Surgeon, OT = Orthopaedic Trainee, N = Nurses, PT = Physiotherapist, OTh = Occupational Therapist

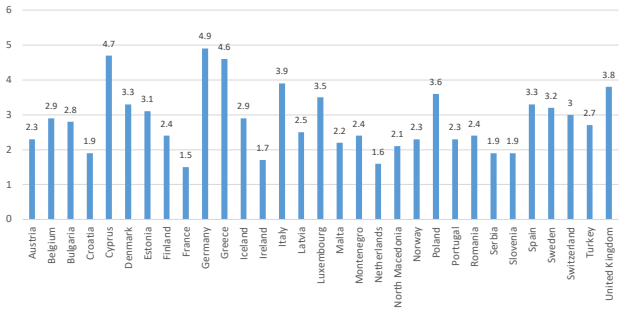

Figure 1. Percentage of orthopaedic surgeons among all medical doctors in European countries

Denmark, Finland, Sweden: 2014 data; Austria, Belgium, Bulgaria, Croatia, Cyprus, Estonia, Germany, Greece, Iceland, Latvia, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Turkey: 2015 data; France, Ireland, Italy, Luxembourg, Malta, Montenegro, Switzerland, United Kingdom: 2016 data.

Sources: Data for the number of medical doctors: Eurostat – 2021a, data for the number of orthopaedic surgeons: Eurostat – 2021d.

Eurostat (2021a). Health Personnel by NUTS 2 Regions.

https://ec.europa.eu/eurostat/databrowser/view/hlth_rs_prsrg/default/table?lang=en (Last accessed on 7 March 2021).

Eurostat (2021d). Physicians by Medical Speciality: Orthopaedics.

https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_SPEC__custom_379664/default/table?lang=en (Last accessed on 7 March 2021).

lower than, the number of orthopaedic surgeons in any given country. Being a member of the national society is not a mandatory requirement to practice in most countries. For the same reason the number of members of most national societies is smaller than the total number of orthopaedic surgeons in that country. In some countries, trainees are accepted as full members of the national orthopaedic societies. This is why the number of members of the national association can be greater than the number of qualified orthopaedic surgeons in these countries (Table 5).

*Table 5. Number of orthopaedic surgeons and members of national orthopaedic societies in European countries, 2015**

Sources: Number of orthopaedic surgeons in European countries: Eurostat. Physicians by Medical Speciality: Orthopaedics. Available at: https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_SPEC__custom_379664/default/table?lang=en. Accessed March 2021. Number of members of national associations of orthopaedics and traumatology: EFORT database

Country	Number of orthopaedic surgeons	Number of members of national association(s) of orthopaedics and traumatology**
Albania	-	47
Austria	1,028	972
Belarus	-	177
Belgium	1,002	781
Bosnia and Herzegovina	-	82
Bulgaria	806	-
Croatia	257	233
Cyprus	143	95
Czechia	-	274
Denmark	731	1065
Estonia	140	108
Finland	488	617
France	3,241	1,660
Germany	16,478	10,233
Greece	2,926	525
Hungary	-	318
Iceland	36	42
Ireland	238	130
Italy	9,081	3,000
Kosovo	-	75
Latvia	157	-
Lithuania	-	215
Luxembourg	58	40
Malta	38	24
Moldova	-	-
Montenegro	35	23
Netherlands	972	702
North Macedonia	128	97
Norway	525	967
Poland	3,190	825
Portugal	1,120	600
Romania	1,315	350
Russian Federation	-	-
Serbia	407	129
Slovakia	-	200
Slovenia	108	134
Spain	5,827	2,004
Sweden	1,294	1,168
Switzerland	1,025	673
Turkey	3,854	2,057
Ukraine	-	150
United Kingdom	6,869	3,324

**Number of orthopaedic surgeons of Denmark, Finland and Sweden 2014; all other data 2015*

*** All countries were being represented by one national association of orthopaedics and traumatology in EFORT in 2015 except for Germany (3 national associations), Belgium (2 national associations) and Croatia (2 national associations).*

Most of the orthopaedic surgeons represented by EFORT in Europe are from EU countries. However, the total number of members of the National Associations of Orthopaedics and Traumatology of EU countries has decreased in the last five years, while the corresponding number for non-EU countries has increased. One of the main reasons for the decrease in membership from EU countries was the re-organization of the EFORT member societies in Germany and the other was Brexit. Figures 2 and 3 show the situation of EFORT membership from EU and non-EU countries in 2015 and 2020, respectively.

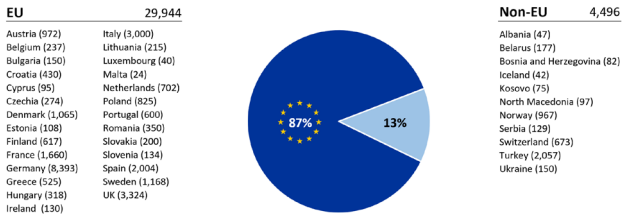

Figure 2. Members of EFORT from EU and Non-EU Countries, 2015
Source: EFORT Database – 2021.

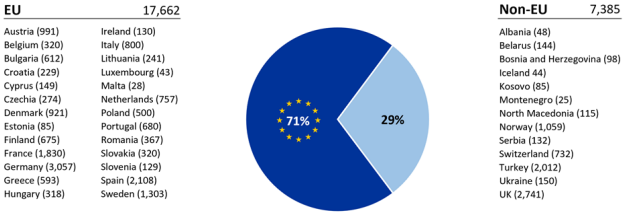

Figure 3. Members of EFORT from EU and Non-EU Countries, 2020
Source: EFORT Database – 2021.

4. Healthcare Resources and Their Usage in Europe

The number of hospital beds per 1000 inhabitants has been decreasing in many European countries and in Europe for the last 3 decades (World Bank – 2021d). The World average for the number of hospital beds per 1,000 inhabitants (2017) was 2.9 : 5.3 for high income countries and 2.3 for low and middle income countries. The average for EU countries was 4.6 (2018). Among EU Member States, Bulgaria and Germany have the highest number of hospital beds per 1,000 inhabitants.

The numbers of operating theatres in hospitals per 100,000 inhabitants varies from 4 to 16.6 in European countries (Eurostat – 2021e). Cyprus, Latvia and France have the highest numbers and the UK, Ireland and Austria have the lowest number relative to population size (Table 6).

Imaging techniques are important in the management of musculoskeletal diseases and trauma. The distribution of radiological and nuclear medicine devices shows large variation across Europe. Among the countries reporting data, the number of inhabitants per CT scanner varies from 137,602 (North Macedonia) to 20,748 (Iceland). The number of inhabitants per MRI unit varies from 723,771 (Albania) to 28,810 (Germany). The number of inhabitants per PET scanner varies from 3,491,302 (Serbia) to 125,949 (Denmark). The number of inhabitants per gamma camera varies from 666,667 (Albania) to 65,837 (the Netherlands) (Eurostat – 2021c).

Countries with the highest number of CT examinations per 100,000 inhabitants are Iceland, Turkey, Greece, Belgium and Luxembourg, whereas Albania, Romania, North Macedonia, Serbia and Finland are the countries with the lowest numbers (Eurostat – 2021b). Countries with the highest number of MRI examinations per 100,000 inhabitants are Turkey, Germany, Austria, France and Iceland, whereas Cyprus, North Macedonia, Romania, Bulgaria and Serbia are the countries with the lowest numbers (Eurostat – 2021b, Republic of Turkey Ministry of Health – 2018). Countries with the highest number of PET examinations per 100,000 inhabitants are Denmark, Belgium, France, the Netherlands and Italy. Slovenia, Romania, Serbia, North Macedonia and Lithuania are the countries with the lowest number of PET examinations per 100,000 inhabitants (Eurostat – 2021b) (Table 7).

Table 6. Hospitals, hospital beds and operation theatres in European countries

Source: Number of hospitals: OECD. Health Care Resources: Hospitals. Available at: https://stats.oecd.org/index.aspx?queryid=30182 . Accessed February 2021. Hospital beds per 1000 inhabitants: World Bank. Hospital Beds (per 1,000 People). Available at: https://data.worldbank.org/indicator/SH.MED.BEDS.ZS?locations=BY . Accessed March 2021. Number of operation theatres in hospitals and operation theatres in hospitals per 100.000 inhabitants: Eurostat. Technical Resources in Hospital: Operation Theatres in Hospitals. Available at: https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_TECH__custom_273749/default/table?lang=en. Accessed March 2021

Country	Number of hospitals	Hospital beds per 1,000 inhabitants	Number of operating theatres in hospitals	Operation theatres in hospitals per 100,000 inhabitants
Albania	-	2.9 (2013)	-	-
Austria	264 (2018)	7.3 (2018)	350 (2018)	4.0 (2018)
Belarus	-	10.8 (2014)	-	-
Belgium	174 (2018)	5.6 (2019)	1,414 (2018)	12.4 (2018)
Bosnia and Herzegovina	-	3.5 (2014)	-	-
Bulgaria	322 (2018)	7.5 (2017)	-	-
Croatia	-	5.5 (2017)	452 (2018)	11.1 (2018)
Cyprus	-	3.4 (2017)	144 (2018)	16.6 (2018)
Czechia	256 (2018)	6.6 (2018)	866 (2018)	8.2 (2018)
Denmark	-	2.6 (2019)	-	-
Estonia	30 (2018)	4.6 (2018)	134 (2018)	10.1 (2018)
Finland	241 (2018)	3.6 (2018)	-	-
France	3,042 (2018)	5.9 (2018)	10,777 (2018)	16.1 (2018)
Germany	3,084 (2018)	8 (2017)	-	-
Greece	271 (2018)	4.2 (2018)	1,334 (2018)	12.4 (2018)
Hungary	165 (2018)	7 (2018)	-	-
Iceland	8 (2018)	2.8 (2019)	-	-
Ireland	86 (2018)	3 (2018)	266 (2018)	5.5 (2018)
Italy	1,059 (2018)	3.1 (2018)	6,164 (2018)	10.2 (2018)
Latvia	62 (2018)	5.5 (2018)	319 (2019)	16.6 (2018)
Lithuania	95 (2018)	6.4 (2018)	-	-
Luxembourg	10 (2018)	4.3 (2019)	58 (2019)	9.5 (2018)
Malta	-	4.5 (2017)	52 (2018)	10.7 (2018)
Moldova	-	5.7 (2014)	-	-
Montenegro	-	3.9 (2017)	-	-
Netherlands	549 (2018)	3.2 (2018)	1,163 (2018)	6.8 (2018)
North Macedonia	-	4.3 (2017)	-	-
Norway	75 (2018)	3.5 (2018)	-	-
Poland	1,276 (2018)	6.5 (2018)	3,587 (2018)	9.5 (2018)
Portugal	230 (2018)	3.5 (2018)	891 (2018)	8.7 (2018)
Romania	-	6.9 (2017)	1,867 (2018)	9.6 (2018)
Russian Federation	-	7.1 (2018)	-	-
Serbia	-	5.6 (2017)	539 (2018)	7.7 (2018)
Slovakia	130 (2018)	5.7 (2018)	-	-
Slovenia	29 (2018)	4.4 (2018)	179 (2018)	8.6 (2018)
Spain	782 (2018)	3 (2018)	4,573 (2018)	9.8 (2018)
Sweden	81 (2018)	2.1 (2018)		
Switzerland	281 (2018)	4.6 (2018)	1,017 (2018)	11.9 (2018)
Turkey	1,534 (2018)	2.9 (2018)	6,658 (2018)	8.2 (2018)
Ukraine	1,631 (2018)	7.5 (2014)	-	-
United Kingdom	1,910 (2018)	2.5 (2019)	3,826 (2016)	5.8 (2016)

[a] Parenthesized superscripts denote the year data are from.

The percentage of hospital discharges with diagnoses of diseases of the musculoskeletal system and connective tissue within total hospital discharges for all causes is between 3.8 and 12.3 in European countries (OECD – 2021e). The countries with higher ratios of hospital discharges for the diseases of musculoskeletal system and connective tissue are Switzerland, Austria, Germany, Luxembourg and Hungary. Greece, Portugal, Ireland, Turkey and Denmark are the countries with the lowest ratios. (Figure 4)

The number of hospital discharges for the diseases of the musculoskeletal system and connective tissue per 100,000 population shows large variation across Europe (OECD – 2021e, WHO – 2021b). This figure is more than 2,000 in Austria, Germany, Belarus and Switzerland, whereas it is less than 300 in the Russian Federation, Albania, Cyprus and Bosnia & Herzegovina (Figure 5).

The average length of hospital stay for the diseases of the musculoskeletal system and connective tissue varies from 3.1 days (the Netherlands) to 12.4 days (Hungary) in European countries, whereas the average length of hospital stay for all causes shows a variation from 4.2 days (Turkey) to 9.6 days (Hungary). While the average length of hospital stay for the diseases of musculoskeletal system and connective tissue is shorter than the average length of

Table 7. Radiology and nuclear medicine devices and their usage in European countries

Sources: CT scanners per 100,000 inhabitants: Albania, Bulgaria, Croatia, Cyprus, Malta, North Macedonia, Romania, Russian Federation, Serbia, United Kingdom: Eurostat. Medical Technology. Available at: https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_EQUIP__custom_272481/default/table?lang=en. Accessed March 2021). All other countries: OECD. Health Equipment: Computed Tomography (CT) Scanners. https://data.oecd.org/healtheqt/computed-tomography-ct-scanners.htm#indicator-chart. Accessed March 2021. MR units per 100,000 inhabitants: Albania, Bulgaria, Croatia, Cyprus, Malta, North Macedonia, Romania, Russian Federation, Serbia, United Kingdom: Eurostat. Medical Technology. Available at: https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_EQUIP__custom_272481/default/table?lang=en. Accessed March 2021). Denmark: WHO. Magnetic Resonance Units per 100 000. https://gateway.euro.who.int/en/indicators/hlthres_95-magnetic-resonance-imaging-units-per-100-000/visualizations/#id=28035. Accessed March 2021. All other countries: OECD. Health Equipment: Magnetic Resonance Imaging (MRI) Units. Available at: https://data.oecd.org/healtheqt/magnetic-resonance-imaging-mri-units.htm#indicator-chart. Accessed March 2021. PET scanners and gamma cameras per 100,000 inhabitants: Eurostat. Medical Technology. https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_EQUIP__custom_272481/default/table?lang=en. Accessed March 2021. MRI examinations per 100,000 inhabitants: Turkey: Republic of Turkey Ministry of Health, General Directorate of Health Information Systems. Health Statistics Yearbook 2018. 2019:170. All other countries: Eurostat. Medical Technologies - Examinations by Medical Imaging Techniques (CT, MRI and PET). Vailable at: https://ec.europa.eu/eurostat/databrowser/view/hlth_co_exam/default/table?lang=en. Accessed March 2021. PET examinations per 100,000 inhabitants: Eurostat. Medical Technologies – Examinations by Medical Imaging Techniques (CT, MRI and PET). Available at: https://ec.europa.eu/eurostat/databrowser/view/hlth_co_exam/default/table?lang=en. Accessed March 2021.

Country	Devices per 100,000 inhabitants				Examinations per 100,000 inhabitants		
	CT	MRI	PET	Gamma camera	CT	MRI	PET
Albania	0.76 (2013)	0.14 (2013)	-	-	-	-	-
Austria	2.88 (2018)	2.35 (2018)	0.27 (2018)	1.05 (2018)	18,36 (2018)	14,14 (2018)	484 (2018)
Belgium	2.37 (2019)	1.16 (2019)	0.26 (2018)	-	20,190 (2018)	9,360 (2018)	918 (2018)
Bulgaria	3.89 (2018)	1.04 (2018)	0.11 (2018)	0.31 (2018)	7,460 (2018)	1,249 (2018)	243 (2018)
Croatia	1.96 (2018)	1.25 (2018)	0.12 (2018)	0.64 (2018)	10,15 (2018)	5,066 (2018)	240 (2018)
Cyprus	3.33 (2018)	2.07 (2018)	0.11 (2018)	1.15 (2018)	15,03 (2018)	570 (2018)	0 (2018)
Czechia	1.61 (2018)	1.04 (2018)	0.16 (2018)	1.19 (2018)	11,09 (2018)	5,472 (2018)	525 (2018)
Denmark	4.07 (2019)	1.02 (2004)	0.79 (2018)	1.52 (2018)	18,46 (2018)	8,700 (2018)	1,024 (2018)
Estonia	1.89 (2018)	1.36 (2018)	0.23 (2018)	0.23 (2018)	13,35 (2018)	5,034 (2018)	111 (2018)
Finland	1.65 (2018)	2.88 (2019)	0.27 (2018)	0.76 (2018)	5,750 (2018)	4,954 (2018)	91 (2018)
France	1.82 (2019)	1.54 (2018)	0.23 (2018)	0.70 (2018)	19,57 (2018)	11,96 (2018)	906 (2018)
Germany	3.51 (2017)	3.47 (2017)	-	-	15,32 (2017)	14,92 (2017)	-
Greece	4.06 (2018)	2.94 (2018)	0.12 (2018)	1.34 (2018)	21,39 (2018)	8,338 (2018)	233 (2018)
Hungary	0.94 (2018)	0.49 (2018)	0.09 (2018)	1.16 (2018)	13,17 (2018)	4,539 (2018)	193 (2018)
Iceland	4.76 (2019)	1.96 (2019)	0.28 (2018)	0.85 (2018)	22,73 (2018)	10,28 (2018)	-
Ireland	2.14 (2019)	1.60 (2018)	0.18 (2018)	0.47 (2018)	-	-	-
Italy	3.51 (2018)	2.87 (2018)	0.35 (2018)	0.77 (2018)	9,360 (2018)	7,370 (2018)	559 (2018)
Latvia	3.84 (2018)	1.35 (2018)	0.1 (2018)	0.36 (2018)	18,08 (2018)	6,461 (2018)	-
Lithuania	2.65 (2019)	1.25 (2018)	0.07 (2018)	0.29 (2018)	11,42 (2018)	5,749 (2018)	64 (2018)
Luxembourg	1.61 (2019)	1.45 (2019)	0.16 (2018)	1.15 (2018)	19,62 (2018)	7,454 (2018)	496 (2018)
Malta	1.86 (2018)	1.03 (2018)	0.41 (2018)	0.41 (2018)	9,725 (2018)	5,626 (2018)	395 (2018)
Netherlands	1.42 (2018)	1.31 (2018)	0.47 (2018)	0.82 (2018)	9,482 (2018)	5,215 (2018)	646 (2018)
North Macedonia	0.73 (2013)	0.29 (2013)	-	0.15 (2013)	3,207 (2013)	1,079 (2013)	53 (2013)
Poland	1.81 (2018)	0.92 (2018)	0.09 (2018)	0.37 (2018)	8,541 (2018)	3,724 (2018)	162 (2018)
Romania	1.59 (2018)	0.90 (2018)	0.04 (2018)	0.25 (2018)	2,738 (2018)	1,083 (2018)	32 (2018)
Russ. Federation	13.4 (2018)	0.48 (2018)	-	-	-	-	-
Serbia	1.12 (2018)	0.39 (2018)	0.03 (2018)	0.29 (2018)	5,182 (2018)	1,330 (2018)	46 (2018)
Slovakia	1.84 (2018)	0.96 (2018)	0.15 (2018)	0.55 (2018)	15,5 (2018)	6,952 (2018)	226 (2018)
Slovenia	1.83 (2019)	1.25 (2019)	0.14 (2018)	0.82 (2018)	7,60 (2018)	6,97 (2018)	20 (2018)
Spain	1.91 (2018)	1.72 (2018)	0.18 (2018)	0.66 (2018)	11,88 (2018)	9,238 (2018)	419 (2018)
Switzerland	3.97 (2018)	2.43 (2018)	0.38 (2018)	-	-	-	-
Turkey	1.49 (2018)	1.12 (2018)	0.16 (2018)	0.37 (2018)	22,51 (2018)	15,70 (2016)	367 (2018)
United Kingdom	0.95 (2014)	0.72 (2014)	-	-	-	-	-

[a] Parenthesed superscripts denote the year data are from. United Kingdom: estimated values. Switzerland MRI units: only units in hospitals.

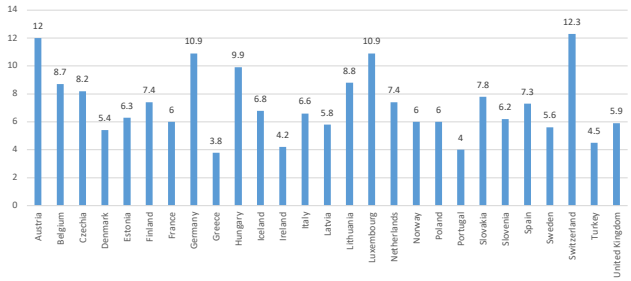

Figure 4. Percentage of hospital discharges for the diseases of musculoskeletal system and connective tissue in hospital discharges for all causes. Greece: 2014 data; Denmark, Luxembourg: 2016 data; Germany, Iceland: 2017 data; all other countries: 2018 data.

Source: Technical resources in hospital. Available at: https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_TECH__custom_273749/default/table?lang=en . Last accessed on 7 March 2021.

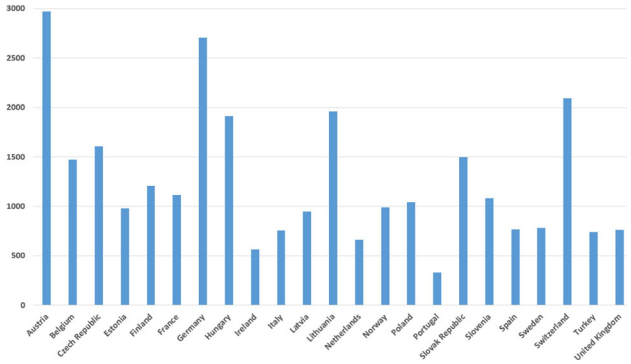

Figure 5. Hospital discharges for the diseases of musculoskeletal system and connective tissue per 100,000 population in European countries: Bosnia and Herzegovina: 1989 data; Cyprus: 2008 data; Bulgaria, Croatia, Malta, North Macedonia and Romania: 2010 data; Albania and Serbia: 2012 data; Montenegro: 2013 data; Greece: 2014 data; Moldova and Ukraine: 2015 data; Belarus, Denmark, Luxembourg and Russian Federation: 2016 data; Germany and Iceland: 2017 data; all other countries 2018 data.

Sources: Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Malta, Moldova, Montenegro, North Macedonia, Romania, Russian Federation, Serbia and Ukraine : WHO – 2021b, all other countries: OECD – 2021e.

Hospital Discharges: Musculoskeletal System and Connective Tissue Diseases, per 100 000.

Available at: https://gateway.euro.who.int/en/indicators/hfa_407-2530-hospital-discharges-musculoskeletal-system-and-connective-tissue-diseases-per-100-000/visualizations/#id=19393&ttab=table . Last accessed on 5 March 2021.

Health Care Utilisation: Hospital Discharges by Diagnostic Categories. Available at:

https://stats.oecd.org/Index.aspx?DatasetCode=HEALTH_STAT#. Last accessed on 5 March 2021.

hospital stay for all causes in the majority of European countries, this is not the case in Austria, Czech Republic, Germany, Latvia, Lithuania, Poland and Turkey (OECD – 2021d). Figure 6 shows the average length of hospital stays in different European countries.

Despite the fact that health systems in Europe are better resourced than many other regions of the World, there can still be long waiting times for some procedures, such as hip and knee replacement (OECD – 2021f). One of the reasons is the high demand due to the aged population of the continent. The mean waiting time for hip replacement, from specialist assessment to treatment, varies from 45 days in Denmark (where only 10% of the patients wait more than 3 months) to 430 days in Estonia (where 77% of the patients wait more than 3 months). (Table 8).

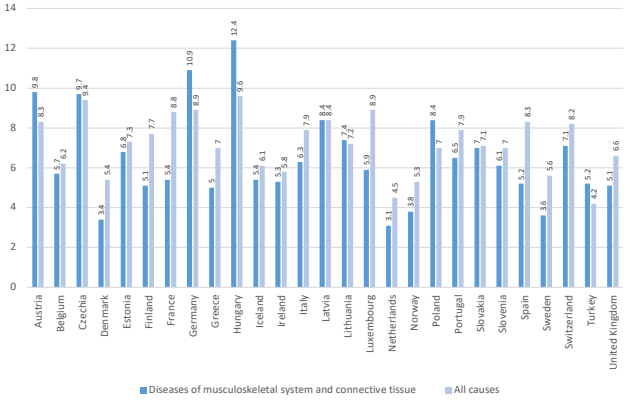

Figure 6. Average length of hospital stay for the diseases of musculoskeletal system and connective tissue, and for all causes in European countries (Days). Greece: 2014 data; Denmark and Luxembourg: 2016 data; Germany and Iceland: 2017 data; all other countries 2018 data.

Source: Health Care Utilisation: Hospital Average Length of Stay by Diagnostic Categories. Available at: https://stats.oecd.org/Index.aspx?DatasetCode=HEALTH_STAT# . Last accessed on 5 March 2021.

Table 8. Waiting times from specialist assessment to treatment for hip replacement (Total and partial including the revisions)

Source: OECD. Health Care Utilisation: Waiting Times. https://stats.oecd.org/Index.aspx?DatasetCode=HEALTH_STAT#. Accessed March 2021.

Country	Mean waiting time from specialist assessment to treatment[a] (days)	Median waiting time from specialist assessment to treatment[a] (days)	% of all patients waiting more than 3 months[a]
Denmark	45 (2018)	35 (2018)	10 (2018)
Estonia	430 (2019)	253 (2019)	77 (2019)
Finland	95 (2018)	77 (2018)	42 (2018)
Hungary	92 (2019)	38 (2019)	36 (2019)
Italy	82 (2018)	46 (2018)	31 (2018)
Lithuania	75 (2019)	-	-
Netherlands	58 (2019)	-	-
Norway	141 (2018)	123 (2018)	68 (2018)
Poland	373 (2018)	179 (2018)	66 (2018)
Portugal	139 (2018)	126 (2018)	56 (2018)
Spain	147 (2019)	130 (2019)	66 (2019)
Sweden	92 (2019)	71 (2019)	29 (2019)
United Kingdom	120 (2018)	92 (2018)	51 (2018)

[a] *Parenthesed superscripts denote the year data are from.*

The situation for knee replacements is even worse. The mean waiting time for knee replacement from specialist assessment to treatment varies from 54 days in Denmark (where only 14% of the patients wait more than 3 months) to 634 days in Estonia (where 85% of the patients wait more than 3 months (OECD – 2021f) (Table 9).

5. Conclusions and Activities Needed:

- Almost 10% of the world population lives in Europe. The median age of the European population is 42.5, which is 11.6 years higher than the median age of the world. Life expectancy in Europe is 6 years longer than the world average.
- The sum of GDP's of the European countries is ¼ of the GWP and an average of approximately 10% of GDPs is being spent on healthcare in the continent.
- The distribution of healthcare professionals and health resources across Europe shows great variation. There should be scope for improvement to provide better musculoskeletal health for European people.

Table 9. Waiting times from specialist assessment to treatment for knee replacement

Source: OECD. Health Care Utilisation: Waiting Times. Available at: https://stats.oecd.org/Index.aspx?DatasetCode=HEALTH_STAT#. Accessed March 2021.

Country	Mean waiting time from specialist assessment to treatment[a] (days)	Median waiting time from specialist assessment to treatment[a] (days)	% of all patients waiting more than 3 months[a]
Denmark	54 (2018)	44 (2018)	14 (2018)
Estonia	634 (2019)	472 (2019)	90 (2019)
Finland	116 (2018)	99 (2018)	55 (2018)
Hungary	135 (2019)	91 (2019)	50 (2019)
Italy	80 (2018)	41 (2018)	29 (2018)
Lithuania	120 (2019)	-	-
Netherlands	63 (2019)	-	-
Norway	168 (2018)	152 (2018)	80 (2018)
Poland	482 (2018)	253 (2018)	72 (2018)
Portugal	215 (2018)	204 (2018)	85 (2018)
Spain	191 (2019)	157 (2019)	77 (2019)
Sweden	131 (2019)	96 (2019)	48 (2019)
United Kingdom	130 (2018)	98 (2018)	54 (2018)

[a] *Parenthesed superscripts denote the year data are from.*

- The percentage of orthopaedic surgeons as a proportion of all medical doctors varies from 2 to 4% in most European countries.
- Hospital discharges after management of a disorder of the musculoskeletal system and connective tissue disease form 4% - 12% of all hospital discharges in European countries.
- There are long waiting times for some orthopaedic procedures, such as hip and knee replacements, in many European countries, which needs to be improved. The importance of this issue continues to increase as then population ages.

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Section 4

B | Diversity in Orthopaedic and Trauma Practice

Table of Contents

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1. Summary

Orthopaedic surgeons in Europe are responsible for the management of musculoskeletal disorders and trauma, as they are worldwide. However, there is significant diversity across European countries concerning the infrastructure, practice, and the stage in disease at which an Orthopaedic surgeon is engaged. The spectrum of pathology in which other specialties are involved varies as well. European countries also have remarkable differences in their educational processes, qualification and certification of Orthopaedic surgeons and relevant Orthopaedic subspecialties. Moreover, the planning of Orthopaedic surgical manpower to meet future demands is unique to each country. Integration of a framework of Orthopaedic practice and training across European countries, based on systematic data collection and aiming for medical care at the highest possible level, along with continued improvement, will be one of the greatest challenges for the European Federation of National Associations of Orthopaedics and Traumatology in the years ahead.

2. Introduction

Orthopaedic surgeons worldwide are involved in the diagnosis and management of musculoskeletal disorders and trauma. Musculoskeletal trauma management is practised by trained orthopaedic surgeons in the majority of European countries.

In some countries traumatology is a separate speciality, dealing with trauma affecting all body systems. Traditionally, in German-speaking countries, trauma patients are treated by general surgeons specializing in trauma surgery ('Unfallchirurg'). However, over the last decade, there has been a trend towards greater involvement of subspecialties in emergency management. German orthopaedic surgery postgraduate training changed its nomenclature from "Orthopaedics and Traumatology" to "Orthopaedic Surgery" in 2003 in order to match similar educational residency programs in the European Union (Kuhn-Régnier et al. 2019, Niethard and Depeweg 2010, Rixen 2006).

Plastic and orthopaedic surgeons may both practice microsurgical techniques (eg limb re-vascularisation and free vascularised flaps for acute or delayed trauma soft tissue management). There are overlapping areas of interest between some specialities. For example metabolic bone disease and osteoporosis may be managed by Rheumatology and Orthopaedic Surgery, hand surgery by Orthopaedics and Plastic Surgery and spinal surgery by Orthopaedic Surgery and Neurosurgery. In most European countries, the areas of specialty practice are not clearly defined, which sometimes causes friction and has legal implications.

A General Practitioner (GP) is often the first health professional to deal with an orthopaedic patient, particularly those with a chronic problem or minor trauma. In countries with GP's positioned as gatekeepers to specialist services, the care of certain categories of chronic patient frequently crosses the border between primary and secondary levels of care. In western Europe, GP's have comprehensive service profiles, particularly regarding their first contact with health problems and the provision of medico-technical procedures. On the other hand, in countries with self-employed GP's paid per item of service, the GP's tend to be more involved in the treatment and follow-up of disease, make more home visits and spend more working time on direct patient care than GP's in other countries. Under these circumstances, GP's may be involved in orthopaedic practice as long as no surgical intervention is required (Wienke 2003).

In German-speaking countries there are orthopaedic surgeons who own and work in in small practises that provide minor surgical procedures. Orthopaedic surgeons employed by hospitals in both public and private sectors mainly focus on major orthopaedic surgery. Usually, patients need a referral from a GP before seeing a specialist doctor (Facharzt).

3. Orthopaedic Surgery Manpower and Future Demands

The number of doctors per capita varies widely across EU countries (Table. 1). In 2016, Greece had the highest number - more than 6 doctors per 1000 population. However, this number is an over-estimation of service capacity, as it includes all doctors who are licensed to practice, including those who have retired and those who have emigrated to other countries. Austria and Portugal also have a high number of doctors per population, but the Portuguese number is also an overestimate for the same reasons as described for Greece. Without this over-estimation the number of practising doctors in Portugal is probably slightly below the EU average. The number of doctors per capita was lowest in Poland, the United Kingdom and Romania.

The number of orthopaedic surgeons (per 100000 of the population) varies widely across European countries (Figure 1a). In 2014, the highest densities were in the Nordic countries, with nearly 20 orthopaedic surgeons per 100000 population. More than half of participating countries had numbers of only two to six orthopaedic specialists per 100000 of the population. The number of trainees per orthopaedic surgeon may be considered, in order to understand differences in surgeon replacement rates. This ratio varies across countries, from a ratio of 1:2 to 1:7, with no clear geographic pattern within Europe (Figure 1b). The highest replacement rates were in Finland, Switzerland, Spain and Ireland and the lowest in France, Sweden, and Denmark .

The demographic data on the numbers of Orthopaedic Surgeons and trainees in 18 European countries in 2014, are shown in table 2.

It is notable that most medical students are now female. The proportion of female orthopaedic trainees was higher (mean 20%) than the proportion of female orthopaedic specialists (mean 9%) in nearly all countries in 2014 (Figure 2).

Despite the fact that the representation of female residents in Orthopaedics has increased over the last decade, the proportion of women continues to lag compared with many other medical specialties in European countries, just as it does in the USA where, in an effort to deal with this, the American Academy of Orthopedic Surgeons adopted a 5-year strategic plan (December 2018) (Madanat 2017).

The uneven geographic distribution of doctors and the difficulties in recruiting and retaining doctors in certain regions is another important policy issue for many European countries, especially those with remote and sparsely populated areas. The density of physicians is consistently greater in urban regions, reflecting the concentration of specialised services such as surgery, as well as the preference of physicians to practise in urban settings. Differences between the numbers of doctors in urban regions and in rural regions are highest in the Slovak Republic, the Czech Republic and in Greece. High levels of uncertainty over retirement, migration patterns and possible changes in the demand for services make the projection of future needs in orthopaedic manpower a difficult task. Many EU countries have anticipated

Table 1. Physicians by medical speciality

Source of data: Eurostat. Physicians by medical specialty. Available at: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=hlth_rs_spec&lang=en. Accessed March 2021.

	(number)									(per 100.000 inhabitants)								
	Total	General practitioners	Other generalist medical practitioners	General pediatricians	Gynecologists and obstetricians	Psychiatrists	Medical group of specialists	Surgical group Of specialists	Other specialists not elsewhere classified	Total	General practitioners	Other generalist Medical practitioners	General pediatricians	Gynecologists and obstetricians	Psychiatrists	Medical group Of specialists	Surgical group Of specialists	Other specialists not elsewhere classified
Belgium	35762	13178	0	1586	1495	1969	10079	6933	:	313.0	115.3	0.0	13.9	13.1	17.2	88.2	60.7	:
Bulgaria	29625	4199	123	1735	1742	724	11162	8292	1648	421.7	59.8	1.8	24.7	24.8	10.3	158.9	118.0	23.5
Czechia	42919	6981	0	1424	3059	1572	16519	11640	227	403.8	65.7	0.0	13.4	28.8	14.8	155.4	109.5	2.1
Denmark(1)	24301	4649	:	485	656	1092	4435	3719	111	419.4	80.24	:	8.4	11.3	18.9	76.6	64.2	1.9
Germany	357401	58940	23818	14093	21197	22756	115204	99216	2178	431.1	71.1	28.7	17.0	25.6	27.5	139.0	119.7	2.6
Estonia	4605	964	133	163	304	253	1680	1108	0	348.3	72.9	10.1	12.3	23.0	19.1	127.1	83.8	0.0
Ireland	15962	4081	4884	492	374	806	2969	2270	66	327.9	83.8	100.3	10.1	7.7	16.6	61.0	46.6	1.4
Greece	65513	3642	748	4278	3412	2768	28725	15455	523	610.4	33.9	7.0	39.9	31.8	25.8	267.61	144.0	4.9
Spain (2)	188166	35798	0	12610	5782	5117	51549	45839	664	402.1	76.5	0.0	27.0	12.4	10.9	110.2	98.0	1.4
France	212337	59399	35524	8134	8036	15315	51414	32030	2485	317.1	88.7	53.1	12.2	12.0	22.9	76.8	47.8	3.7
Croatia	14075	2478	1029	898	826	657	5181	2979	27	344.1	60.6	25.2	22.0	20.2	16.1	126.7	72.8	0.7
Italy	240301	42987	10011	16968	12209	10322	87722	60082	0	397.7	71.1	16.6	28.1	20.2	17.1	145.2	99.4	0.0
Cyprus	3544	912	0	253	188	101	1122	968	0	407.3	104.8	0.0	29.1	21.6	11.6	129.0	111.3	0.0
Latvia	6367	1411	0	249	389	309	1846	1383	780	330.4	73.2	0.0	12.9	20.2	16.0	95.8	71.8	40.5
Lithuania	12881	2560	324	710	684	653	4633	3113	204	459.8	91.4	11.6	25.3	24.4	23.3	165.4	111.1	7.3
Luxembourg(3)(4)	1780	534	0	98	101	128	513	406	0	298.5	89.6	0.0	16.4	16.9	21.5	86.0	68.1	0.0
Hungary	33078	4390	2706	2383	1497	1461	12705	6795	1062	338.4	44.9	27.7	24.4	15.3	15.0	130.0	69.5	10.9
Malta	1925	396	0	87	79	55	417	420	:	397.2	81.7	0.0	18.0	16.3	11.4	86.1	86.7	:
Netherlands	63233	15091	13617	1818	1645	4162	15881	7296	3723	367.0	87.6	79.0	10.6	9.6	24.2	92.2	42.3	21.6
Austria	46337	7163	7843	1313	1838	1588	9728	8704	75	524.1	81.0	88.7	14.9	20.8	18.0	110.0	98.5	0.9
Poland(3)	90284	8418	7490	5497	4976	3504	39508	20592	299	237.8	22.2	19.7	14.5	13.1	9.2	104.0	54.2	0.8
Portugal	52966	25123	2541	2135	1837	1379	12789	7866	808	515.0	244.3	24.7	20.8	17.9	13.4	124.4	76.5	7.9
Romania	59333	12026	2865	2710	2697	2313	23861	12253	608	304.7	61.8	14.7	13.9	13.9	11.9	122.5	62.9	3.1
Slovenia	6591	1275	130	660	378	306	2233	1391	44	317.8	61.5	6.3	31.8	18.2	14.8	107.7	67.1	2.1
Slovakia	19178	:	:	:	:	:	:	:	:	352.1	:	:	:	:	:	:	:	:
Finland(1)(5)	25627	6837	:	696	856	1293	4322	3088	394	464.6	124.8	:	12.7	15.6	23.6	78.9	56.4	7.2
Sweden(3)	42898	6411	0	1083	1441	2360	9985	6758	1042	426.5	63.7	0.0	10.8	14.3	23.5	99.3	67.2	10.4
UK(1)	188783	49569	:	10693	7809	11948	48016	54457	6315	284.1	74.6	:	16.1	11.8	18.0	72.3	81.9	9.5
Iceland	1373	218	:	15	54	83	392	258	0	389.3	61.8	:	4.3	15.3	23.5	11.1	73.2	0.0
Liechtenstein(6)	135	25	19	5	8	14	34	30	0	353.0	65.4	49.7	13.1	20.9	36.6	88.9	78.4	0.0
Norway	25538	4218	473	925	641	1375	4501	3012	423	480.0	79.4	8.9	17.4	12.1	25.9	84.7	56.7	8.0
Switzerland	36940	9683	:	1869	1896	4454	6695	7084	198	433.9	113.7	:	22.0	22.3	52.3	78.6	83.2	2.3
Montenegro	1720	336	0	183	117	71	684	339	0	276.4	54.0	0.0	29.4	18.8	11.4	109.9	54.5	0.0
North Mac.(1)(2)	6219	2032	:	428	405	190	1983	997	184	299.8	97.95	:	20.6	19.5	9.2	95.6	48.1	8.9
Serbia	20824	4839	1352	1890	1259	847	5552	3842	1243	298.2	69.3	19.4	27.1	18.0	12.1	79.5	55.0	17.8
Turkey(1)	153128	48688	:	8312	7785	4434	44348	36093	3468	188.1	59.8	:	10.2	9.6	5.5	54.5	44.3	4.3

Note: practising physicians except Slovakia, North Macedonia and Turkey (professionally active physician), Greece, Portugal and Finland (physicians licensed to practise)

(1)General practitioners: includes also other generalist medical practitioners

(2)Except for the total medical practitioners and general pediatricians as only includes physicians working in hospitals

(3) 2017

(4)Medical group of specialists: physicians working in laboratories (such as microbiologists, pathologists and hematologists) are excluded.

(5)Total: 2018. All remaining data are for 2015 and professionally active physicians.

(6)Except for the total: physicians licensed to practice.

(7)Except for the total: excludes physicians in training.

current and future retirement of a significant number of doctors and have increased education and training efforts, aiming to have enough newly qualified doctors to replace those who plan to retire (OECD 2016, OECD 2017).

Increasing demand for the treatment of orthopaedic diseases has resulted in growing concern over whether the supply of orthopaedic specialists will be sufficient to meet the mounting demand for reconstructive procedures. Improving the quality and conditions of work and training in hospitals, as well as providing economic benefits and social care for female orthopaedic surgeons, are important issues in tackling these problems.

Maintaining the balance between public and private orthopaedic practice is important. At the beginning of their career, Orthopaedic surgeons usually make decisions about which type of practice to enter. In the past, about 60% of European orthopaedic surgeons entered exclusively into private practice and 40% into public practice with the possibility of working in a private institution as well. In France, currently, about 80% of orthopaedic surgeons emerging from the French residency program enter private practice, so many public hospitals need to find orthopaedic surgeons from elsewhere. Frequently the surgeons filling these gaps come from Eastern Europe and North Africa; however, French hospitals have no control over the educational requirements in the source countries, so the competency of some of these surgeons may be of concern.

The percentage of citizens covered by a public or private medical insurance schemes provides some indication of financial protection against the costs associated with health care. However, this is not a complete indicator of affordability, as the range of services covered and the degree of cost-sharing applied to those services also differ.

The percentage of citizens covered by private health insurance has increased in some countries over the past decade, particularly in Denmark, Slovenia and Belgium (Figure 3). The development of

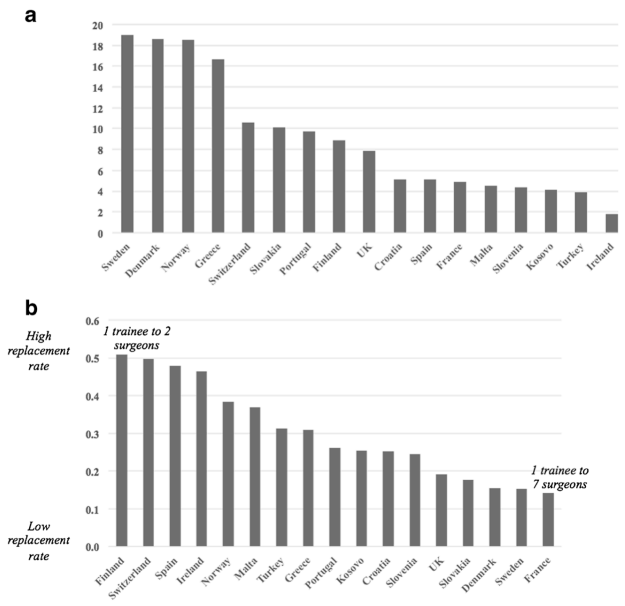


Figure 1a. Orthopaedic surgeon densities (number of specialists per 105 population) and Figure 1b. Orthopaedic surgeon replacement rates (number of trainees per orthopaedic specialist) in different European countries in 2014.

Source: Madanat et al. The current state of orthopaedic residency in 18 European countries. Int Orthop. 2017 Apr;41(4):681-7

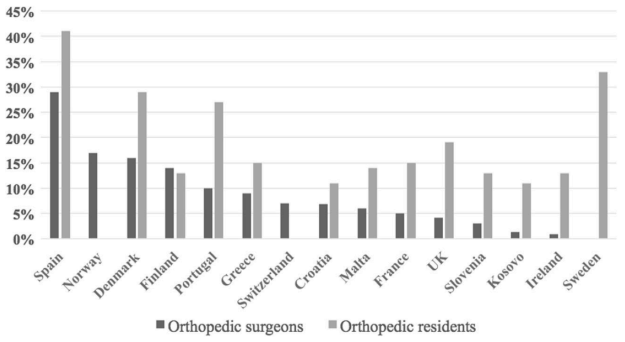


Figure 2. Proportion of female orthopaedic trainees and specialists for the different European countries in 2014.

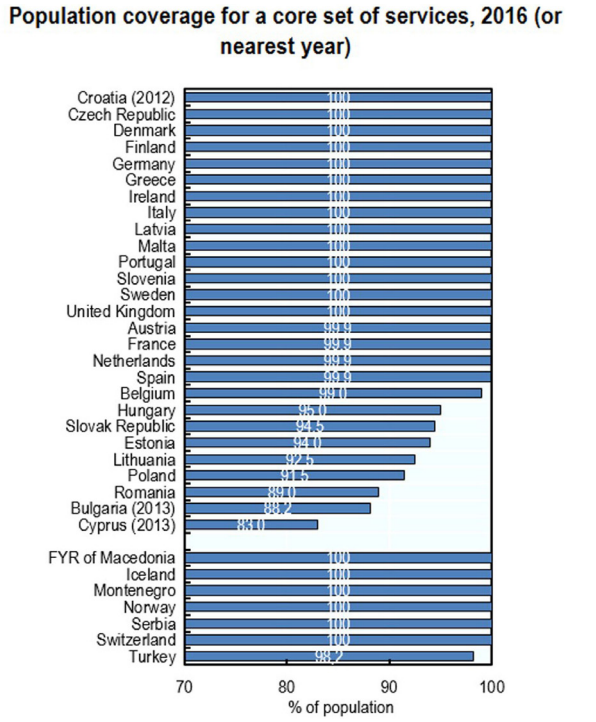
Source: Madanat et al. The current state of orthopaedic residency in 18 European countries. Int Orthop. 2017 Apr;41(4):681-7

private health insurance is linked to several factors, including gaps in access to publicly financed services, government interventions directed at private health insurance markets and historical development (Figure 4) (OECD and EC 2012, OECD/EU 2018).

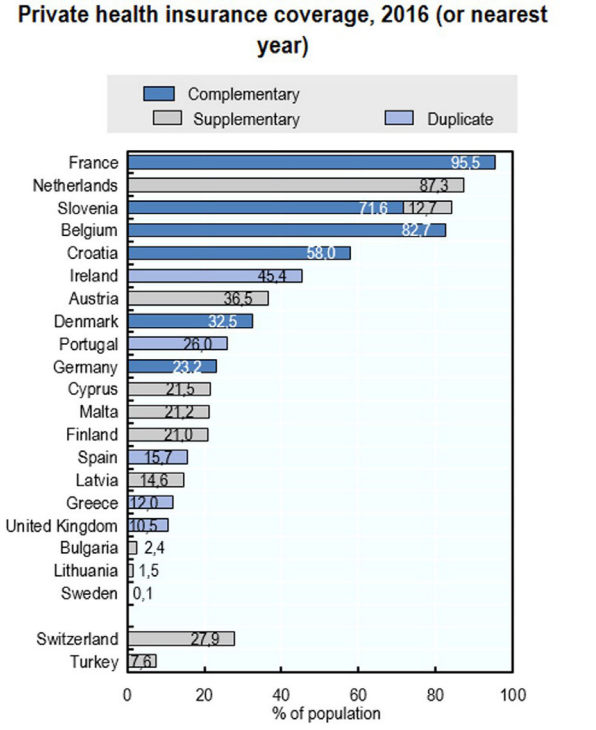
4. Training

Within the EU, the specialist qualification of orthopaedic surgery obtained in one country is automatically recognized (Directive 2005/36/EC on recognition of professional qualifications) in several other countries. Furthermore, even if the qualification does not meet the criteria for automatic recognition, it may still be recognised in another EU country under the general system for recognition of qualifications (Costigliola 2011). Nonetheless, little is known about the similarities and differences between orthopaedic and trauma training programs across European countries, as this information is, in general, not readily available.

The selection process for entering a residency program in Europe varies widely. In more than half of the participating



Note: This includes public coverage and primary private health coverage. Data for Luxembourg is not available.



Note: These data exclude primary PHI . PHI can be both complementary and supplementary in Denmark and Germany.

Figure 3. Public and primary private (complementary and supplementary) health insurance coverage in different European countries.

Source: OECD Health Statistics 2018, https://doi.org/10.1787/health-data-en; European Observatory Health Systems in Transition (HiT) Series for non-OECD countries. (http://dx.doi.org/10.1787/888933836314). Accessed March 2021

Source: OECD Health Statistics 2018, https://doi.org/10.1787/health-data-en; and Voluntary health insurance in Europe: country experience, Observatory Studies Series, 2016, for non-OECD countries. (http://dx.doi.org/10.1787/888933836333). Accessed March 2021

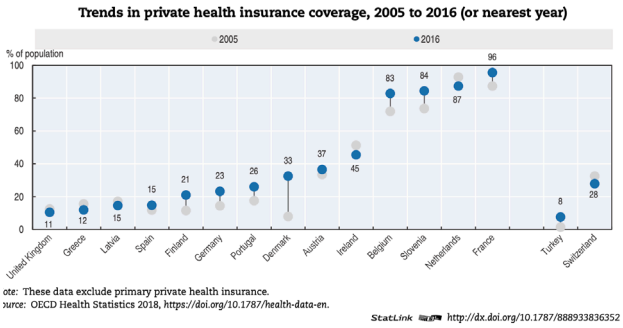


Figure 4. Trends in private health insurance (PHI) coverage from 2005 to 2016 (or nearest year)

Source: OECD Health Statistics 2018, https://doi.org/10.1787/health-data-en. (http://dx.doi.org/10.1787/888933836352). Accessed March 2021

countries in the above survey selection is based on an interview or a combination of merit and interview. In the remainder, selection is based on the results of a national exam or a simple application process. The residency program is generally five to six years length in all countries. Nearly all countries utilize a mandatory logbook through residency, but only a few countries were utilising a web-based logbook (Ireland, Malta, Slovenia, the United Kingdom, the Netherlands). There were still a small number of countries (France, Norway, Sweden) that did not require a logbook to keep track of residents' achievements (Figure 5).

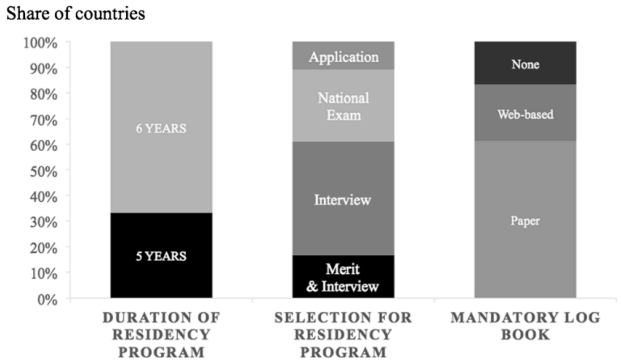


Figure 5. Residency programs, selection process and logbook requirement vary in different European countries.

Source: Madanat et al. The current state of orthopaedic residency in 18 European countries. Int Orthop. 2017 Apr;41(4):681-7

Nearly 80% of European countries have a final examination on completion of residency, with the remainder having have some form of interim exams without a mandatory final examination. Most of the participating countries do not have a mandatory fellowship requirement. When assessing the components of training, it was found that two countries (the United Kingdom and the Netherlands) had mandatory minimum requirements for (1) courses, (2) surgical procedures, (3) research and (4) leadership. Surprisingly, nearly 40% of participating countries had only one or none of these four training components as a mandatory part of residency requirements (Figure 6).

For those countries that have minimum requirements for course attendance and surgical procedures, these requirements vary from 50-360 hours and 300-1800 procedures, respectively. Research and leadership training are only a mandatory part of orthopaedic training programmes in 40% of the countries (Figure 6). In Germany

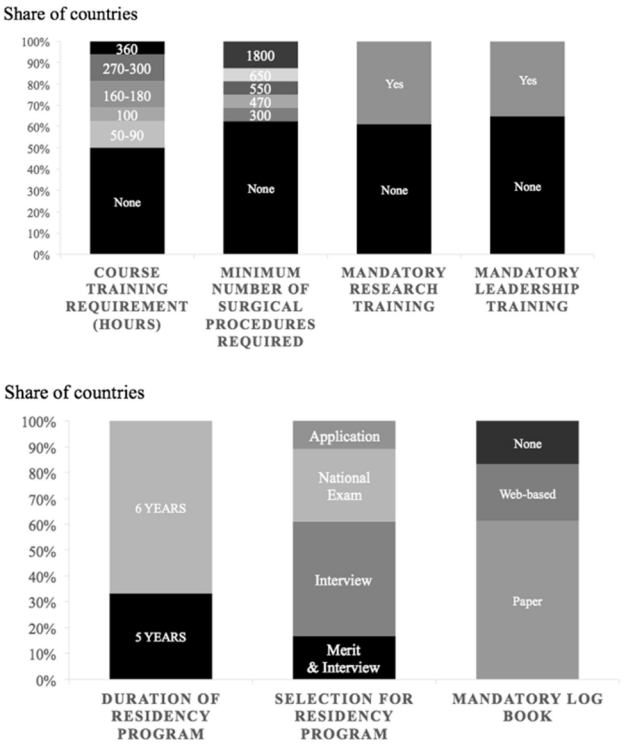


Figure 6. Differences in mandatory minimum requirements and training components of Orthopaedic residency among European countries.

Source: Madanat et al. The current state of orthopaedic residency in 18 European countries. Int Orthop. 2017 Apr;41(4):681-7

the post-2003 structure allows for a more flexible timeline to complete specialization, compared to other countries. The program "Chefarzte" (Chairman) now determines when the resident is ready to graduate, as opposed to a resident completing the programme based simply on strict timelines (Pape and Dougherty 2015).

Finally, nearly 70% of the countries surveyed had an association for orthopaedic residents. Most of these associations were dependent on the National Orthopaedic Association.

Movement of the medical workforce across Europe has become more commonplace. However, concerns have been raised regarding the level of knowledge and professional competence of surgeons who have qualified in one country and move to practise in another. It is clear that not only are there differences in training programs between countries, but there may also be considerable variation in training systems and assessments within larger European countries. The European Union of Medical Specialists (UEMS) was founded in Brussels in 1958 by the representative delegates of the professional organizations of medical specialists of the six member countries of the European Economic Community (EEC). The main objectives of UEMS were to establish a high quality and comparable level of medical specialist training in the EU. The section of Orthopaedics and Traumatology was founded in 1962, shortly after UEMS took the initiative to establish specialist sections. As was the pattern in other sections of the UEMS, a European Board of Orthopaedics and Traumatology (EBOT) was established in 1994, and its first undertaking was to organize a board examination. The EBOT fellowship examination was designed to both standardize and improve the standards of orthopaedic training in Europe, but it is still not a mandatory requirement. Since its inception, The Federation of Orthopaedic Trainees in Europe (FORTE) has also aimed to promote and improve standards of Orthopaedic

and Trauma training in Europe. FORTE also strives to harmonize orthopaedic training across European countries. This objective is becoming increasingly important with recent developments in the medical profession that have resulted in considerable movement of medical graduates across Europe. Full standardization of training in Europe would allow for easier migration within the European Union. More importantly, a standardized curriculum would allow for more consistent education and postgraduate performance.

A modern European orthopaedic curriculum should include:

- a minimum required number of essential surgical procedures that need to be mastered
- a minimum mandatory number of hours of course training
- a final comprehensive examination that assesses the trainee's knowledge at the end of training
- the adoption of shared responsibility within orthopaedic teams in order to meet the younger generation's demands for more flexible and efficient education

It is also believed that a mandatory logbook, preferably web-based, is an efficient way to track progress and performance throughout training. Leadership training, research projects and fellowships are also valuable and could be included as an elective addition to the training programmes (Madanat 2017, Pape and Dougherty 2015).

5. Trauma Management

A recent review has identified three structures of trauma surgery, education and practice currently practised in Europe. The first is like the old United States model, with trauma systems and trauma surgery-based education (Advanced Trauma Life Support, regionalisation of trauma care, trauma centres). The second aims to integrate trauma care with non-trauma emergency surgery, such as the acute care surgery model in the United States. The third type is based on the historical orthopaedic surgeon-dominated trauma surgery model, with visceral and vascular injuries managed either by broadly trained trauma orthopaedic surgeons or by visceral specialists coordinated and led by an orthopaedic surgeon.

Although each country and region proceeds along their own pathway depending on local circumstances, some general guidelines and recommendations, at least at the European Union level, are urgently needed, especially for training and certification purposes. Surgeons with an interest in trauma care must take the lead in this process and involve colleagues from other surgical and relevant non-surgical specialties to formulate a policy that could then be advocated to political decision makers. The recently established European Society for Trauma and Emergency Surgery (ESTES), united and founded on the great traditions of the two former societies, the European Trauma Society (ETS), and the European Association for Trauma and Emergency Surgery (EATES), could play a central role in this activity (Leppäniemi 2007, Leppäniemi 2008).

Trauma management is different in France. In-hospital care begins either in an emergency room, managed by physician qualified in Emergency Medicine, or in a recovery room, managed by a surgical intensive-care team. There is no such specialisation as trauma surgery in France. All specialist surgeons treat those aspects of trauma pathology that concern them. All surgeons operate on those trauma patients with injuries related to their field of practice: digestive, orthopaedic, etc. The challenge nevertheless remains that of maintaining facilities at a sufficient level to deal with those everyday pathologies, known for the seriousness of their consequences in both human and financial terms, within an increasingly sparse hospital infrastructure. Suggestions are emerging in response to these challenges. Organisation at the European level of hand emergency units (FESUM) is a targeted example (Masmejean et al. 2003).

In Spain, severe and multiply injured patients are treated by emergency hospital doctors: first in the triage or resuscitation areas and then, when stabilised, they are passed to the observation area or to the Intensive Care Unit (ICU), and from there either to the Emergency Hospital Unit (EHU) or ICU from where doctors call on the appropriate specialists. There is close collaboration and coordination between the orthopaedic surgeon, the EHU doctors and the other specialist surgeons in order to comply with treatment prioritization protocols. We should also mention the residents' registry of trauma patients, the ICU professional's training in ATLS and the future guidelines for trauma care in the ICU (Pino Sánchez 2015).

One the other hand, more than 13 years after the implementation of the new curricula for orthopaedic and general surgery training in Germany, fracture care is still predominantly provided by general surgeons specialised in trauma surgery. General surgeons specialised in trauma surgery still play, and want to play, the key role in polytrauma patient management and fracture care in German-speaking countries (Kuhn-Régnier et al. 2019).

In Scandinavian countries trauma research is characterised by active collaboration between countries. Current challenges include a focus on the role of traumatology within an increasingly fragmented health care system. Regional networks of predictable and accountable pre- and in-hospital resources are needed for efficient trauma systems. Successful development requires both novel research and scientific assessment of imported principles of trauma care. Trauma training using simulators or simulated patients is an important factor in overcoming a lack of practical training. The traditional trauma education offered in Scandinavia includes damage control surgery courses e.g., the Definitive Surgical Trauma Care (DSTCTM), and trauma life support courses (ATLS, PHTLS, TNCC) (Kristiansen et al. 2010).

The new trauma surgeon, for the next generation, will have to be skilled in the management of fractures in the elderly, and this is a completely different ballgame compared with what surgeons have been trained to do in the recent past.

Elective orthopaedic surgery

Rapid advancements in treatments for musculoskeletal disorders have created the expectation of a more active way of life for older people than has been the case in the past. The demand for joint replacements, and surgery to treat degenerative disease in the spine, feet and upper and lower extremities, continues to increase. The rate of hip and knee replacement has increased over the past 10 years in many European countries, as the population ages and the prevalence of obesity, which is the main risk factor for osteoarthritis beyond age and sex, grows.

However, there are wide variations in hip and knee replacement rates between countries. Although the comparability of the data is limited, differences in population structure may explain some of this variation across countries. A number of other factors may also explain observed variation in the rate of hip and knee replacement: i) differences in the prevalence of osteoarthritis; ii) differences in

the capacity to deliver and pay for these expensive procedures; iii) differences in clinical treatment guidelines and practices.

Long waiting times for elective surgery have become a policy concern in many European countries. They generate dissatisfaction in patients when the expected benefits of treatments are postponed, and the pain and disability remain while waiting. Waiting times are the result of a complex interaction between the demand and supply of health services. The demand for elective surgery is determined by the health needs of the population, progress in medical and surgical technologies and patient preferences, but undoubtedly doctors play a crucial role in the decision whether to operate on a patient or not. On the supply side, health resources, including the availability of surgeons and other staff in surgical teams, as well as the supply of the required equipment and implants, are all factors affecting surgical activity rates (Figure 7, 8) (OECD/EU 2018).

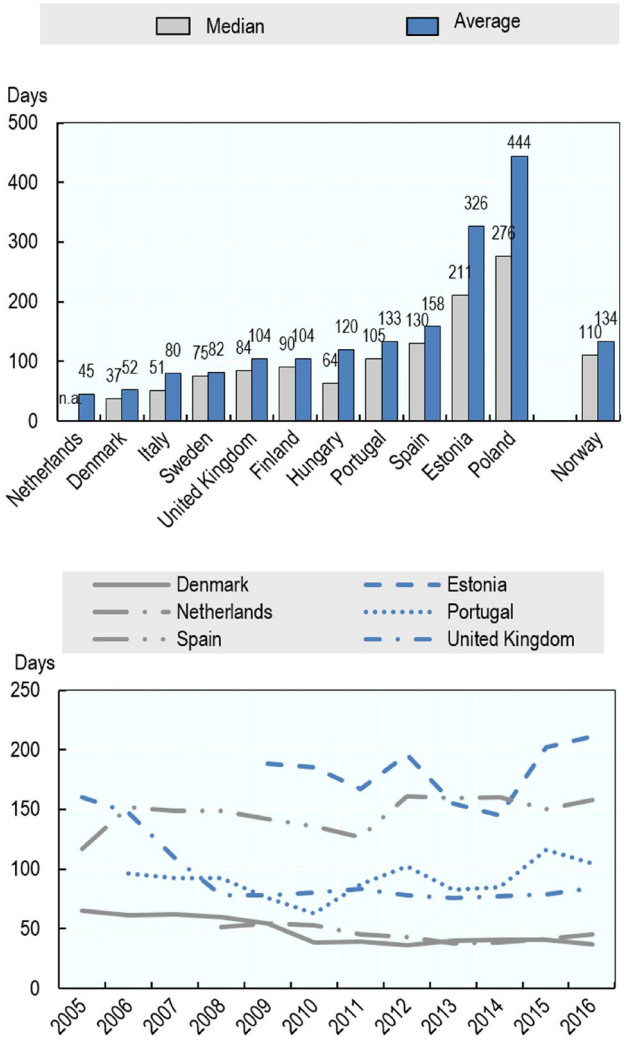


Figure 7. Waiting times of patients for hip arthroplasty in 2016 and trends since 2005.

Source: OECD Health Statistics 2018, https://doi.org/10.1787/health-data-en. (http://dx.doi.org/10.1787/888933836675). Accessed March 2021

6. Data Collection

Limited economic resources force health care administrators to target the provision of care where it is most needed. Despite the advantages of simpler measures in the implementation and acceptance of health policy, more sophisticated measures may possibly reduce costs as well as improve health care. Significant geographical variations necessitate the reallocation of health resources, reducing oversupply in less deprived urban areas in order to enable adequate care in more deprived rural areas. Accessibility is a major issue, especially for the orthopaedic patient. Therefore, health care planners should consider geospatial techniques in order to prioritise and, optimise resource allocation (Bauer et al. 2017).

Standardisation of the quality of data collection and comparability of recorded outcome measures across EU member states are important issues in raising the awareness of musculoskeletal conditions among health policy makers and in the planning for future Orthopaedic services in the EU.

Reliable European population demographic data, showing age and disease trends, are needed in order to predict future orthopaedic manpower needs (trainees and specialists) and to prevent expected orthopaedic surgeon shortages as the European population ages.

Orthopaedic registries (implant registries and trauma registries) form one basis for research and quality assessment of orthopaedic management and can inform policy makers to enable strategies for the optimal care of orthopaedic patients. There are examples of countries in which specialised implant registries have identified differences in practice and outcomes, driving decision making for the optimisation of management. In several countries, fragility fracture registries have recently been developed and many trauma centres have established local, but not nationwide, trauma registries. The development of official trauma network protocols must be evidence based. Trauma registries have been identified as crucial for quality assessment and research. However, national registries have yet to be implemented in the most European countries (Kristiansen et al. 2010).

7. List of Activities Needed

- Establishment of European standards of education for specialization in Orthopaedics in an effort to harmonise European countries, together with the introduction of a European system of examinations and certificate of specialization.
- Establishment of Orthopaedic subspecialisation and corresponding certification, with binding validity across European countries
- Strengthening of the educational process in a variety of ways (conferences and seminars, courses and webinars, as well as rotational fellowships in certified referral centres throughout Europe) on a pan-European scale, with investment in life-long learning among orthopaedic surgeons
- Review of the framework of medical ethics, responsibility and malpractice, by improvement and modernization of the relevant legislation and governance across European countries
- Vigilance and removal of discrimination, exclusion and restrictions for any reason (gender, colour, race, etc.) during both specialist education and the remainder of the professional career in Orthopaedics, on the basis of the right to equal opportunities
- Creation and implementation of European protocols for the optimization of Orthopaedic practice and trauma care, as well as creation and maintenance of pan-European registration systems for collection and analysis of relevant data (registries)

- Planning for the future needs of specialized medical personnel in Orthopaedics and monitoring the production of qualified Orthopaedic surgeons in European countries and patterns of medical staff migration.
- Establishment of liaison between European policy-making centres, Institutions delivering care and those representing Trauma and Orthopaedic surgeons in the development of health policy.

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Section 4

C | Patient Empowerment

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1. Summary

Patients are only engaged or involved to a limited extent in the activities, including board and scientific meetings, of both European and National Orthopaedic and Traumatology Associations. The potential benefits from such involvement are therefore missed by the Orthopaedic and Traumatology community. Examples from other medical specialties shows what impact patient involvement may have.

2. Patient Empowerment

Patient empowerment is defined as a process through which patients gain greater control over decisions and actions affecting their health and treatment. From a political and WHO perspective this is a key theme within global health and social care strategies. The benefits of incorporating empowerment strategies in care are well documented, but little is known about their application or impact for patients with advanced, life-limiting illness (Wakefield et al. 2018).

In European Orthopaedic and Traumatology organisations, there are scant examples of patients or patient organisations being involved in their work and being empowered to take the floor at educational or scientific meetings. The vast majority of such organisations do not have any patient representation in their Committees or Boards. There may be several reasons for this lack of patient involvement. One might be that management issues surrounding surgery is too complex an area for patients to become involved in without specialist knowledge. Involvement in the field of Traumatology might be limited due the acute and unforeseen nature of trauma care. On a national level there are examples of Patient Organisations that exist and are active, primarily being related to a specific disease (Calve-Leg-Perthes support group, or groups supporting patients with clubfoot or hip dysplasia) or surgical procedures (Periacetabular Support Group). These groups mainly serve as peer support organisations to families or patients with newly diagnosed disease or those needing assistance through treatment. They provide advice on self-help and signpost where to find high quality information, as well as suggesting forms of self-management. Although providing support for each other and help with knowledge and recommendations, on the whole these groups are not directly involved with the professional orthopaedic and traumatology surgical community.

An excellent example on how to interact with professional patient organisations is provided by EULAR (European Alliance of Associations for Rheumatology; www.eular.org). This organisation has successfully incorporated patient organisations into their own structures and committees. Interestingly, EULAR facilitates patient participation at their medical meetings. While the majority of the attendees at these meetings are healthcare professionals, the number of patient representatives has increased in recent years. It is a form of user engagement that helps to deliver a high-quality product. To achieve this, two guiding principles are followed. "Nothing about us without us": patients have a right to participate in discussions about their care, and "Ask, never assume." By involving patient groups in activities throughout the year, EULAR ensure that the topics of most relevance to their patients are included in the educational programmes. Importantly, EULAR considers that "communication is everything"; ask, listen, and respond. They stimulate people to make it known in advance if there are perceived barriers. Patients know that the world is not perfect, but if they encounter reasonableness, their experience will be positive.

Involving patients in setting research priorities has the potential to reduce waste in commissioned research. For example, the British Medical Journal now requires all authors submitting research papers to include a statement detailing if, and how, they involved patients in their work (www.bmj.com). The success of the involvement of patients in EULAR is, however, based on the existence of strong patient organisations in many European nations. The chronic character of the conditions managed by our colleagues in Rheumatology, and the significant impact it has on quality of life, stimulate patients to become involved in such organisations. This is in sharp contrast with many orthopaedic conditions which, after treatment, have a more limited residual effect on the ongoing quality of life.

Pharmaceutical companies producing medications used to treat rheumatological conditions regularly invite patients to meetings, and many have patient groups to consult about research and development. The imperative is to identify and disseminate best practice so that patient involvement in drug research and development delivers outcomes that patient's value.

Many organisations and foundations who fund research already embrace patient involvement and public engagement, including the Patient Centred Outcomes Research Institute, the National Institute for Health Research, and the Canadian Institute for Health Research. The same trend is also occurring in Europe. Here, too, the challenge is to identify and implement meaningful partnerships, and to assess their effect on improving healthcare through better targeted research funding, outcomes that matter to patients and a more patient-oriented research agenda.

Patient involvement in strategies to improve the design, delivery, and quality of care has become routine in some settings, although "involvement" usually falls well short of partnership. PatientOpinion.org.uk, an online feedback mechanism concerning care in NHS trusts, is a good example.

Encouragingly, shared decision making, the cornerstone of partnership and patient-centred care, is beginning to show modest movement from a policy imperative to routine practice. In many specialities including orthopaedics, shared decision making is increasingly important and some National Orthopaedic Societies have developed nice examples of it in practice. There is also a move towards partnership in undergraduate medical education as universities respond to requests for patient involvement in admissions, teaching, curriculum design, assessment, and governance.

In the coming years EFORT and the national orthopaedic and trauma associations should strive to involve patients in their organisation and activities wherever possible. New digital technologies, medical devices and apps may help promote and advance such partnership, as well as facilitating self-management. Orthopaedic and trauma surgeons should give higher priority to patient partnership and patient-centred care in their routine clinical practice. The development of new patient-oriented quality indicators to encourage and reward those who do will help.

Many national implant registers have experience with PROMs (Patient Reported Outcome Measures). Based on the information from the National Registries, at least currently for hip and knee replacements, surgeons can inform their patients better and use this information to help shared decision making.

However, Orthopaedics and Traumatology as a specialty, on both European and National fronts, still has a lot to learn and to do. The key challenge will be how to find and involve patients and their organisations in our activities. However, we will almost

certainly soon find that patient empowerment and involvement will be a mandatory requirement for all health care professionals as a political imperative.

3. List of Activities Needed

- EFORT should encourage its National Member Associations and Specialty Societies to develop patient empowerment strategies and use these to involve patient organisations in relevant activities and decisions

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Section 5

Education and Training of Professionals

Section 5

Education and Training of Professionals

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Authors

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1. Summary

The University education of medical students in Europe encompasses a large variety of training conditions and curricula. The extent of knowledge transfer to undergraduates in the basics of musculoskeletal disorders and injuries seems inappropriately small, given the fundamental impact of these conditions on society. Postgraduate Specialty training is also very heterogeneous, both between and within countries. EFORT has provided a curriculum for musculoskeletal specialty training in Europe, which can serve as a minimum standard and provides the basis for an increasingly accepted European Board of Orthopaedics and Traumatology (EBOT) examination. Appropriate measures are needed to address diversity in the orthopaedic workforce, specifically to increase the number of female orthopaedic trainees and thereafter female orthopaedic surgeons. In addition, harmonization of European initiatives for subspecialisation as well as revalidation strategies is necessary in order to further improve the quality of care.

2. Introduction

The management of musculoskeletal disorders and injuries is constantly changing due to new information and technology. Health care providers need to keep abreast of these changes in order to deliver the best possible care to patients. Appropriate musculoskeletal education of physicians is a continuum from undergraduate medical training, through postgraduate Specialty training, and eventually into subspecialisation. Ongoing educational activities after graduation (Continuing Medical Education (CME)) keep Orthopaedic Surgeons up-to-date with newest medical knowledge. In addition, Continuous Professional Development (CPD) is necessary and refers to the adoption of concepts beyond traditional medical topics, such as management skills, teaching skills, appraisal skills, communication skills and information management. This chapter highlights the current framework of European medical education in the field of musculoskeletal disorders.

3. University Education

The burden of musculoskeletal (MSK) conditions on the healthcare system is increasing, as they are common and the general population is ageing. Basic competency in MSK disorders is therefore essential for all clinicians. Substantial prerequisites are, that (1) enough medical students are educated in European countries in general to meet future health needs and (2) these students are well prepared to evaluate and treat MSK disorders in a confident manner as they enter the workforce.

Medical students in Europe

According to EU directive 2005/36 of 2005 minimum training conditions for doctors of medicine must consist of a "Basic medical training" (total of at least six years of study or 5500 hours of theoretical and practical training provided by, or under the supervision of, a university) and a "Specialist medical training" thereafter. Basic medical training at Universities can either be organized in Bachelor- and Masters Education (only Masters degrees allow physicians to practice) or through conventional educational formats. Although many European countries have implemented Masters degrees in higher education in order to comply with the Bologna process, the transformation is not yet fully accomplished. In most countries medicine has either not at all, or only partially, adopted the reformed system, keeping the previous courses.

Figure 1 shows the number of medical graduates in a given year (OECD 2019a).

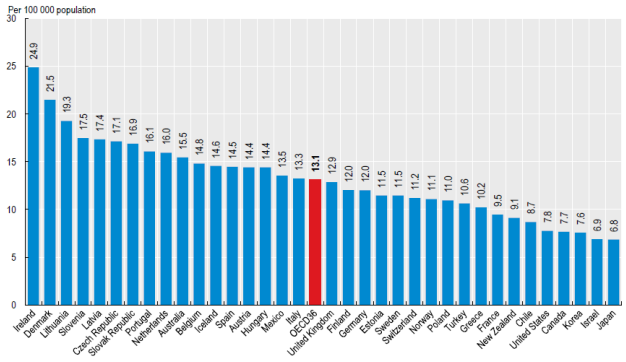

Figure 1. Medical graduates per 100 000 inhabitants (2017 or latest year available)

Source: Health at a Glance 2019: OECD Indicators, OECD Publishing, Paris. Available at: https://www.oecd.org/health/health-systems/health-at-a-glance-19991312.htm. Accessed: September 2021.

Nearly all European countries limit the number of available training places, but in addition to public medical schools there are also private institutions, where students can apply. In recent years, most countries have increased the number of students admitted to medical education in response to concerns about current or possible future shortages of doctors. Therefore, throughout Europe, in most countries except Greece, the number of new medical graduates per capita has risen since 2000. According to OECD (OECD 2019b), however, increases have not been steady, with numbers falling to less than 90% of levels in 2000 in Belgium, the Slovak Republic and Switzerland (countries close to the OECD average), as well as in Turkey and France, with numbers considerably below the OECD average. In the United Kingdom, for example, the number of medical graduates doubled between 2000 and 2015, reflecting an effort to increase the domestic supply and rely less on foreign-trained doctors (Department of Health 2016). Nevertheless, large variations in the number of medical students still remain across countries.

Orthopaedic and trauma education of medical students

Recent studies have raised concern that medical schools may not give sufficient instruction on MSK disorders and injuries (Menon and Patro 2009, DiGiovanni et al 2016, Al-Nammari et al 2015). There is no generally accepted European curriculum of Orthopaedics and Trauma during medical education. The content of specific clinical curricula in this area, which can be identified on individual websites of universities, shows large variations between different universities as well as different countries. While in many places traditional core clerkships in "Orthopaedics" continue to be well represented in clinical years, in other institutions modified teaching formats which include Orthopaedics and Trauma in newer curricula (e.g. together with teaching in pain disorders or emergency medicine) have been developed. Whatever teaching format is used, institutions must provide dedicated musculoskeletal content. Not only orthopaedic surgeons, but also primary care doctors, physicians, pediatricians, rheumatologists, physiotherapists, and emergency care providers form part of musculoskeletal care services. It is well known, for example, that the most commonly

reported complaints at the General Practitioner level are related to the musculoskeletal system, especially knee and lower back problems. Therefore fundamental knowledge of MSK disorders and injuries is essential to the practice of medicine and must be taught appropriately during undergraduate medical education in order to ensure that physicians are equipped to manage musculoskeletal diseases in the 21st century appropriately.

4. Specialty Training in Orthopaedics and Traumatology

Whilst there is inconsistency in the curricula and time spent delivering musculoskeletal education to medical students, the role of Universities in organising and delivering this teaching to medical undergraduates is relatively uniform across Europe. The same cannot be said for specialist training in Orthopaedics and Traumatology, which takes diverse forms both between and within countries.

In some European countries the Universities still play a key role, whilst in others they have no role whatsoever: training in medical specialties is a function of Local or National Government, Independent Training Authorities, National Surgical or Specialist Professional Colleges or Associations or even individual Hospitals or Hospital Groups. To add further complexity, there is no European directive indicating specific standards for training and no universally accepted curriculum for training. However, satisfactory completion of training, marked by the 'Certificate of Completion of Training', is a qualification that is recognised at European Parliament level and is key to the assumption that a specialist trained in one European country becomes part of a potentially mobile workforce that can work in any other European country. A noble aim, but one that creates tension due to the diversity in requirements for the completion of training across European states.

The European Union of Medical Specialists (UEMS) was formed in 1958 by representatives of the Professional Organisations representing medical specialists in the six member states of the European Economic Community, as it existed at that time. As the European Community expanded more delegates joined and individual specialty sections emerged, the European Board of Orthopaedics and Traumatology (EBOT) being formed in 1994. Their first step in trying to standardise training was to develop an examination – the EBOT examination – which acquired broad support from many European countries but never became mandatory in any country. It was not until 2015 that EFORT and EBOT developed the first curriculum for training in Europe, which used the EBOT interim and final examinations as assessments within the curriculum. The number of candidates sitting the examination has increased year on year, but it remains optional, and across Europe only a small percentage of trainees sit the examination. The curriculum has been widely accepted but to accommodate the diversity in training it remains a document that sets out minimum standards of content to allow the training of a safe mobile workforce. For that reason it is not detailed enough for countries that have a more sophisticated curriculum in place that is used to train a workforce for unique national needs.

There is no pan-European monitoring of specialty training in Orthopaedics and Traumatology. An insight into the trainee workforce was obtained by a snapshot provided by a survey carried out by FORTE in 2016 (Madanat et al 2017). FORTE is the Federation of Orthopaedic and Trauma Trainees in Europe, formed in 2005. The aforementioned survey of 25 national orthopaedic trainee organisations in Europe received data from 18 respondents. The poll confirmed that the length of the training programme was 5-6 years in all countries responding. The orthopaedic workforce was found to vary widely – from 2 to 20 orthopaedic surgeons per 100000 population. The highest ratio was in the Nordic countries, with more than 50% of respondents reporting only 2-6 orthopaedic specialists per 100000 population.

There is no consistent way that trainers and trainees are connected – in some countries trainees are managed by a training director and can move from hospital to hospital and even from trainer to trainer, with no constant training relationship except with the director. In others, trainees spend their entire education in one hospital department and under the oversight of the departmental professor. In some countries more graduates are trained as specialists than are needed to replace specialists who retire or otherwise leave the profession, whereas in others the numbers are more or less balanced. The ratio of trainees to specialists therefore varied in the survey from 1:2 to 1:7, with no clear geographic pattern (the highest surgeon replacement rates being in Finland, Switzerland, Spain and Ireland and the lowest in France, Sweden and Denmark). The distribution of trainees and specialists in 2014 was reported as follows:

Table 1. Demographic data on the number of orthopaedic surgeons and trainees in European countries in 2014

Source: Madanat et al. The current state of orthopaedic residency in 18 European countries. Int Orthop. 2017 Apr;41(4):681-687

Country	Orthopaedic Surgeons (% female)	Orthopaedic Surgeons/100000 population	Orthopaedic trainees (% female)	Orthopaedic trainees / 100000 population
Croatia	218 (6.8%)	5.0	55 (11%)	1.3
Denmark	1057 (16%0	18.9	164 (29%)	2.9
Finland	488 (14%)	9.0	248 (13%)	4.6
France	3157 (5%)	5.0	450 (15%)	0.8
Germany	NA	NA	500*(NA)	NA
Greece	1819 (9%)	14.2	562 (15%)	4.4
Ireland	84 (0.9%)	1.8	39 (13%)	0.9
Kosovo	75 (1.3%)	3.8	19 (11%)	0.9
Malta	19 (6%)	3.2	7 (14%)	1.4
Norway	975 (17%)	18.5	375 (NA)	7.5
Portugal	1005 (10%)	9.0	262 (27%)	2.5
Slovakia	550 (NA)	10.0	97 (NA)	1.7
Slovenia	90 (3%)	4.5	22 (13%)	1.1
Spain	2350 (29%)	15.0	1125 (41%)	2.4
Sweden	1874	19.5	286 (33%)**	2.9
Switzerland	889 (7%)	11.0	442 (NA)	5.5
Turkey	3117 (NA)	4.0	976 (NA)	1.2
United Kingdom	5017 (4.2%)	8.0	976 (19%)	1.6

**Approximated*
***Number of trainees who are members of the National Organisation, but membership is not mandatory*

There is some evidence of ongoing feminisation of the workforce, with the proportion of female trainees and specialists being higher than in the past. The survey found that only 9% of orthopaedic specialists were female but 20% of trainees were female. This may reflect an increasing number of females being appointed to training programmes but this is not the full explanation. Retention of females in an orthopaedic career is lower than for males and the reasons for this seem to be many. However trauma and orthopaedic surgery is still not a popular career choice by female

medical graduates, even though the proportion of females in the workforce is slowly increasing.

Concerning the requirements during training for courses attended, surgical procedures performed, research performed and leadership training, only one country set minimum requirements across all four domains. 40% of countries set minimum requirements in only one, or none, of these areas. When minimum requirements for surgical procedures performed existed, these varied from 300-1800 across the residency period. 80% of countries had some sort of final examination at the end of training whilst the rest relied on interim examinations or had no such formal assessment. The entry requirements to training also varied substantially and there was no consistency – ranging from a simple application through an interview selection process with or without an entrance examination.

The requirements for the training of specialists is delegated to individual countries and each country deals with this differently, even though specialist status is then recognised across Europe. Responsibility for the design and governance of training is delegated to Governmental or Hospital administrations (eg Austria, Belgium, Denmark, Portugal), Medical Professional Bodies (eg Croatia, Germany, Netherlands, Switzerland, UK) or Universities (eg Finland, France, Italy). Although politicians seem content with this laxity, which allows the required mobility of the workforce across national boundaries, the professional organisations have some concerns about the equivalence of standards and feel greater consistency is required. It is for this reason that the evolution of examinations and curricula is occurring with no central political drive. A few countries have published pathways revealing the total time to train an orthopaedic and trauma specialist after University graduation:

Table 2. Orthopaedic training pathways in selected European countries
Source: EFORT database

Country	Training Pathways
Germany	- Common trunk rotation 2 years - Specialised orthopaedic and trauma rotation 4 years (Head of department confirms successful completion of training) - Board exam (State Physician Chambers)
Netherlands	- Common trunk surgical training 1.5 years - 4 to 4.5 years of orthopaedic training (at least two training centres (one of them a university hospital) - 3 official national exams during the orthopaedic training - Virtual logbook, annual assessment and in the first year after each 3 months. Curriculum based on EPA's (entrustable professional activities). - Central national capacity planning - Government finances all costs of training
Spain	- 5 year programme that includes 'external' attachments (anaesthetics, vascular and plastic surgery) - Annual assessment of logbook and trainers feedback – no set numbers - Exam ? (in 2019 starting with EBOT exam as national exam)
UK	- Foundation training 2 years (medical registration occurs at the end) - Core Surgical Training 2 years - Higher surgical (T&O) training 6 years - CCT determined by exam, logbook, research, annual assessments and programme director sign off

Subspecialisation and Fellowships

After completion of specialty training, some European countries offer additional subspecialisation programmes and certificates (i.e. paediatric orthopaedics, hand surgery, spine surgery). There is no harmonized European program, however, and the type as well as content of such subspecialty trainings shows large variation.

5. Continuing Professional Development

Although lifelong learning is seen as a prerequisite for safe professional practice in all branches of medicine, the main driver for European regulation in this area is to facilitate mobility of the medical workforce by ensuring doctors from each member state are required to participate in effective Continuing Professional Development (CPD), including Continuing Medical Education (CME - education that continues beyond University and Professional qualification). Article 22 of the Professional Qualifications Directive (Directive 2013/55/EU) states 'Member States shall, in accordance with procedures specific to each Member State, ensure, by encouraging continuous professional development, that professionals are able to update their knowledge, skills and competence in order to maintain a safe and effective practice and keep abreast of professional developments'.

Member States are required to report to the Commission the measures they are taking to promote CPD and, under Article 56, 'to exchange information and best practices for the purpose of optimising CPD in their Member States'. Legislation on the requirements for individual doctors to participate, and to demonstrate that participation, is therefore devolved to the individual nations. There is therefore no common standard for CPD laid down in European Law, which refers to all Professions with the same loose directive, and each Nation has a free rein to interpret the requirements according to their own needs and to put in place any mechanisms they see fit to provide access to, monitor and administer CPD. The result is that different countries have taken different approaches and there is no unified professional standard that applies across Europe setting out the requirements for individual doctors. The Biomedical Alliance surveyed all European Nations in 2019 to identify the systems in place and how these are used in practice. They found 4 different situations –

- CPD is mandatory for all Professionals practising in a country (most common, eg France, Germany, Italy, the Netherlands)
- A voluntary CPD framework is in place (eg Spain, Portugal, Sweden)
- A voluntary framework may co-exist within a mandatory CPD requirement (eg UK, Norway)
- No formal CPD structure exists (least common situation – eg Albania, Bosnia).

Who initiates and polices CPD policy varies even more: the most common systems are that a Professional Association, the Ministry of Health or a Professional Regulatory Body are in overall charge. However, in some nations individual hospitals or Universities, national policy makers or the Ministry of Education may take the lead.

Participation in CPD is most commonly measured by a system of credits and most commonly these are measured by a points-based system, and the most common method of allocating points to CPD is that one point is awarded for each hour of participation. Some nations, however, simply require attendance at a specified number of events and some measure not the hours of participation but the learning outcomes achieved. Some countries recognise only external courses and meetings as valid CME, others require doctors to use a range of sources both externally and self-directed, accumulating points only for CPD that is relevant to their own clinical practice. Monitoring of participation is most commonly done by a Professional regulatory body, but in some countries the National Specialty Association or a Government Ministry are involved, whilst in others

self-regulation is encouraged. The Biomedical Alliance survey showed that a minority of European countries link the attainment of CPD requirements to review of the license to practice. Only the UK and the Netherlands have so far introduced a system of revalidation of the licence to practice, which occurs every 5 years and in the UK this is linked to annual whole-practice appraisals including CPD and clinical outcomes. In the Netherlands individual assessment but also appraisal of the department as unit is included in the revalidation process of the licence.

Allocation of points to learning experiences may be devolved to individual doctors if the system only recognises learning that is relevant to that doctor's field of practice. Whilst this system is open to abuse, it is backed up by legislation that threatens removal of the licence to practice if a doctor is found to be falsifying returns. Most commonly, however, events are allocated CME points by an accrediting body that awards points against published criteria and standards. Typically a surgeon practising in Trauma and Orthopaedic Surgery might have to accumulate 50 CME points in a year to satisfy their national requirements. As with all aspects of CPD, the accreditation varies between countries and can involve not only Professional associations and Government Departments but also Specialty Societies (European Respiratory Society accredits CPD in Respiratory Medicine, for example), Universities and public or private accreditation agencies. If we consider the delegates at a typical EFORT congress, therefore, some will have no requirement to obtain a CME certificate, some will be able to accredit all relevant education themselves, whilst others will need a certificate to show that the meeting has been assessed independently and judged against standards and awarded a certain number of credits. Some will come from a country where their own Government approved organisation has accredited the meeting. Some will require that the accreditation is by a specific body, such as UEMS, and others would accept accreditation by any of a number of accreditation agencies.

It is therefore not possible to provide a detailed description of CME in Trauma and Orthopaedics in Europe, as the systems and requirements are so variable. It may be valuable, however, to consider CME accreditation of the EFORT Congress, as the system chosen is not random but to meet the needs of the largest proportion of delegates, and that is accreditation through the European Union of Medical Societies (UEMS), which typically awards the 3 day congress with 18 CME points.

UEMS is the body representing the overarching Professional Medical Association of each country in Europe (whether or not they are part of the European Union). This already introduces variation, as in some countries there can be more than one body representing all doctors but only one will be part of UEMS. UEMS then has specialty sections, one of which is Orthopaedics and Traumatology (note however that the UEMS specialty Section 'Surgery' also has a specialist division 'Trauma surgery'). UEMS established the 'European Accreditation Council for CME' (EACCME), which is charged to facilitate and accredit CME. EACCME will receive online applications for accreditation of events and these are passed to representatives of its specialty sections who judge the application against standards derived from various consensus statements on CME. They award credits that can then be offered by the Congress organisers to all participants. As the largest accrediting body for CME in Europe, with national and international agreements with many nations, this satisfies the needs of a significant proportion of EFORT Congress attendees, but not all. The process is expensive, a cost that is shared by all delegates, and whilst the process is transparent, the decisions can be opaque. EACCME is one of many accreditation agencies in Europe and, as part of UEMS, has the ear of politicians in Brussels even though it is not itself an agency of the European Parliament. EFORT has links with UEMS through the national delegates that make up the Orthopaedic and Trauma Surgery specialty group. UEMS represents the overarching Medical Associations of each country, whereas the Biomedical alliance represents the European Specialty Associations (European Cardiology Society, European Society of Neurology etc, and including EFORT representing Orthopaedics and Traumatology). EFORT is represented in The Biomedical Alliance, which has a CME experts group monitoring the landscape of CME across Europe and currently has an interest in the accreditation of CME derived from a desire to have harmonious standards across Europe and to ensure that medical education is not used as a tool to derive commercial gain.

This perhaps leads to a final word on the provision of CPD and in particular its' sponsorship. CPD is expensive (but not as expensive as the complete absence of CPD!) and historically governments, employers and individual surgeons have been unwilling to meet the full costs themselves. However the medical device industry, and to a lesser extent in T&O the Pharmaceutical Industry, have been willing to step in and subsidise events in exchange for advertising (through booths and brochures) and access to delegates for conversations, satellite meetings at which their products are promoted, and dinners. However a series of legal rulings in the USA, where most of these multinational corporations are based, has resulted in the development by the Industry of a Code of Practice that is intended to ensure that Industry can only attend meetings that meet standards that ensure that money is not flowing to surgeons that could be seen as an unethical inducement to use a particular company's products, for instance by paying their air fare to attend a meeting in a tourist location and registering them for a meeting but inviting them to dinners to meet their own product champions. However, it is quite acceptable within the code for a company to set up its own educational meeting in a nice setting with their own product champions overtly promoting their own products. It is quite correct that we need industry to work with us and provide education and training on the products they make. Paradoxically however the effect of this change has been to significantly reduce Industry sponsorship of unbiased education, such as the congresses of National and cross-national associations (Kearney et al. 2019). Undoubtedly over the next few years an adjustment to the working relationship between doctors and industry will occur, hopefully establishing a harmonious situation where industry can use some of the profits they derive from the medical profession to feed back into the unbiased and evidence based education of that workforce.

6. List of Activities Needed

Undergraduate medical training:

- University education of medical students in Europe shows a large variety of training conditions and curricula. An increase in the overall number of graduates is a positive trend in order to meet possible future shortages of doctors.
- *Nevertheless, considering the big impact of musculoskeletal disorders and injuries on our societies, medical schools in Europe may currently not give sufficient instruction on these important areas.*

Postgraduate Specialty training

- Specialist training in Orthopaedics and Traumatology takes diverse forms both between and within countries – more and better European standardization is needed in order to harmonize quality of patient care. EFORT developed the first curriculum for musculoskeletal specialty training in Europe in 2015.
- *Effective measures are urgently needed to increase the number of female orthopaedic trainees as well as female orthopaedic surgeons.*
- *Harmonized European initiatives for subspecialisation could further improve the quality of care (e.g. fellowship programmes with cross-national exchange and accreditation).*

Continuous Professional Development

- There is a large variation in CPD- and CME-policies throughout Europe – harmonization of revalidation is necessary. Historical formats of CPD and CME sponsorship through medical device industry no longer meets compliance standards.
- *Nevertheless it is mandatory to develop new formats of financial support for unbiased education.*

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Section 6

Research in Orthopaedics and Trauma

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1. Summary

The societal needs for musculoskeletal healthcare delivery are increasing in Europe, due to the growing demand for life-long healthy motion. Innovative treatment solutions for musculoskeletal disorders, intended to improve the surgeon's armamentarium, are developed from solid safety and efficacy research, from the preclinical stage into the clinical environment then post-market evaluation. The role of different stakeholders, from industry to academic, and the landscape of European funding, is reviewed. Fostering translational research to increase the role of European industries, with the support of medical specialists, may efficiently create new solutions in this expanding field, from early hypothesis through to definitive clinical evidence.

2. Introduction

Orthopaedic and Trauma (O&T) specialists deliver care to meet the needs of musculoskeletal disorders (MSDs) that already affect a substantial proportion of European citizens, across national borders. Forecasts predict an increase in the need for treatment of patients with MSDs in Europe, already occurring in the present, but probably becoming exponential in the near future. Health system sustainability is a major concern for European healthcare in view of the demographics of the population, costs and societal challenges. Specifically in the field of MSDs, we face a diverse population with increasing demands. Our society requires more technologically supported healthcare to deal with wide ranging and complex problems that seriously impact mobility and the capability for independent life among our population. Requirements of effectiveness run in parallel with increasing safety concerns, which raise the threshold for acceptance of new solutions to enter the market. In the global context external competition, which frequently brings expensive and increasingly technological solutions, paradoxically coexists with the introduction of cheap solutions claiming similarity but without adequate evidence to confirm equivalent safety. Needless to say, incredible challenges to the optimization of musculoskeletal healthcare create unique research opportunities. This scenario has previously been seen in the evolution of the orthopaedic and trauma market, and strongly impacts on translational research. Financial support is certainly necessary, but the returns on investment can be very high, given the ever-expanding needs of society.

3. Do We Need O&T Research? Vision and Mission

European research and innovation in the field of O&T deserves deep reflection from the profession, in view of the current circumstances and opportunities (Lidgren et al. 2014). The needs are clearly perceived by medical specialists facing the daily challenges in our Hospitals imposed by the current O&T "epidemics", clearly described by the World Health Organization (WHO 2003), in both the young and aged populations:

- In the young population, road traffic injury is the leading cause of death for people between the ages of 15 and 29, with vast differences between EU countries.
- The acute treatment cost of trauma is higher than for any other disease group.
- In the aged population, 40% of people over the age of 70 years suffer from osteoarthritis (OA) of the knee.
- Independent life in the aged population is at risk, as 80% of people with OA have some limitation of movement, and 25% cannot perform routine daily activities.
- Patients aged over 65 years, especially women, consume a disproportionate share of hospital resources for trauma care, particularly due to fragility fractures.

In the face of this scenario, O&T research is certainly needed. The vision, in this context, is the extension of orthopaedic and trauma research to facilitate independent, active living for the young population suffering hazards and the aged population during the extended life expectancy seen as decades pass, aiming to reduce and narrow the spectrum of dependency. A clear mission for the Orthopaedic community is not only to deal with the daily management of this burden, but also to reduce the burden of these musculoskeletal disorders and trauma on European society. This mission requires the awareness of the European key decision and policy makers and society, but also the commitment of the profession to define and verify new solutions in order to diminish and manage efficiently and effectively the current and upcoming musculoskeletal burden.

How is O&T research structured?

Orthopaedic and trauma research is frequently considered in two categories: basic research, concerning the fundamentals of musculoskeletal science including epidemiological studies, and clinical research evaluating diagnostic and treatment options and the effects of treatment.

Translational research is the process which brings knowledge derived from basic research to clinical applications (so-called "bench to bed" research translation). As in other fields of Medicine, this is a complex process with many hurdles along the way, such as unexpected results, unexpected regulatory changes, or unexpected strategic decisions in academic institutions, industry, funders and in researchers themselves. This is a particularly complex area because evaluation and confirmation through evidence-based O&T research studies require many years, due to the long timescale over which the consequences of interventions in slowly remodelling tissues such as bone, cartilage and other constituents of the musculoskeletal system become apparent. Strong basic research is therefore necessary to orient clinical research towards scientifically feasible, safe and efficacious hypotheses. If the scientific foundations, including pathophysiology, are not solid enough, future research is more likely to fail.

The most efficient agents positioned to develop O&T research in Europe are those strong institutions already involved in the different steps of research, or more frequently, strong consortia formed by different players from industry, academia and clinicians converging to pool skills and resources. Industrial partners in Europe tend to foster applied research into specific solutions, while spin-off and small companies pivot around developing good ideas and market niches. However, industry involvement in wide-ranging clinical multicentre studies is not easy due to the cost and the complex requirements of these clinical networks.

Drivers of O&T research

Different factors and incentives may drive the direction and intensity of research. The "technology push" caused by the advancement of technology may point to new solutions, while the

"demand pull" of the market may foster investment and interest in other areas. On both sides, advances in basic science and the societal and professional demands certainly steer the strategies of institutions and industry. In the medical industry, and particularly in the orthopaedic medical industry, the development of new products and solutions is linked to predicted usage in clinical applications. This implies the significant influence that agent users (O&T specialists) and end users (patients) may have in determining the amount and direction of research and innovation in the field. In fact, many new solutions will continue to require extensive evaluation after first adoption, and feedback from clinical use may disclose both new problems and potential new uses, while surgeons may continue to seek other innovative applications and follow through further research. Furthermore, the need for multicentre clinical evaluation is frequently a barrier or delay to broadening many medical fields. In the O&T area, introduction of a new device to the market through CE-marking and commercial release and advertising has been the usual pathway. Multicentre research studies were most frequently launched as a means of post-market outcome evaluation and many surgeons participated in such post-commercialization research, parallel to the expansion of ongoing surgical use. This approach may have to change due to recent regulatory changes, as discussed below.

A major source of original ideas and research questions comes from the academic field, whether Universities or clinical services. Specialists in these areas know well the complex scenario of demands and needs, which shape the opportunities for research and innovation. However, the incentives are so different for the academic world and for industry that academics and clinicians are frequently productive of new ideas but unproductive in exploiting them. Good systems for technology transfer and intellectual property management are essential. Public–private partnerships should be improved. There are grounds for further collaboration in Europe between academic research departments and industry, taking advantage of the capability of clinicians and researchers to generate ideas based on their closeness to the clinical scenario, but also the capability of industry to recognise those ideas that could profitably be exploited. In fact, key innovations in history have been invented, prototyped and initially tested by users (von Hippel 1976), while producers developed engineering to improve reliability, manufacturing, marketing and sales. Finally, however, the user is also involved in the diffusion of information about the value of the innovation and its applications towards colleagues and end users, strengthening the case for close collaboration. Important players in the field of orthopaedic innovation and the early development of truly novel solutions are the small companies. Large firms are more likely to progress developed solutions to a second generation or bring about incremental improvements to new solutions by different means, which may include incorporating smaller companies or their patents into larger firms, refining product lines and expanding markets. The small companies are a key interface between clinician researchers and industry, and this collaboration is frequently seen behind success stories. Furthermore, clinical evaluation of new products requires the development of large networks, while independent clinicians can also provide adequate feed-back to further progress development and dissemination of the solution, if it is found useful. Of course, large studies also benefit from generating reliable information on cost-effectiveness, which may itself foster further developments. Due to the variable country-to-country cost allocation, such studies need to be launched as multicentre and international projects in Europe, which secondarily is also useful to guide the proprietary companies in their subsequent national marketing strategies. The final information about the true outcomes of a device can also be collected through means of large clinical networks that include registries. All this information forms part of the research validation of a product that is destined to reach society, and the benefits for the surgeon, the hospital, and society are available to orient decisions.

4. Orthopaedic Devices and Research

Devices are classified in Europe into four categories (Class I, IIa, IIb, and III), according to the risk associated with device usage, the amount of time that the device is in contact with the human body and the degree of invasiveness needed to deploy the device. A set of essential requirements has been designed to ensure the highest level of patient and user security, quite apart from the device performance. All medical devices must comply with these essential requirements, which require manufacturer registration, administrative and safety requirements. In addition, all medical devices must comply with a set of conformity assessment procedures, which is a scheme designed to regulate the level of scrutiny required to deem a medical technology or device safe, based on the level of its inherent risk to the user. The risk ranges from simple compliance with essential requirements for Class I devices to a requirement for the Notified Body's evaluation of full quality systems for Class III devices, the class which includes those higher-risk devices requiring clinical trials. If the product conforms to all of the applicable community requirements and all appropriate conformity assessment procedures have been completed, a CE mark is affixed to the product. Member States are not allowed to restrict usage of any such product unless evidence of non-compliance of the product is generated.

Until now, clinical trials concerning O&T devices and solutions are scarce, as such evidence was not originally required to obtain the CE-marked status before commercialization. Recent regulatory changes included the categorisation of orthopaedic hip, knee, and shoulder implants as Class III (EU Commission Directive 2005/50/RC). Class III implants require clinical trials, and such trials may therefore become more commonplace in order to obtain the required authorization for new implants. However, as the regulations incorporate more stringent evidence and testing requirements than previously, concentration of research efforts into fewer devices may also occur, limiting the possibilities for some proposals to be developed to an end-stage and come to the market. The consequences on research and innovation of the new medical device regulations (EU Regulation 2017/745) are still to be observed.

Research directly related to industry partners is even more heterogeneous in the O&T field, which is characterised by sub-markets at different stages in the product life cycle requiring variable amounts of resources. Evaluation may be required for new products, new manufacturing processes and new modes of practice. Patent data and literature studies may be used to try to clarify the trends of industrial research and innovation. However, in a global world, international patents may not identify the origin of relevant research but rather the registered head office location for the company. Previous analysis of patents and associated scientific literature on the appropriate medical devices was performed at the

beginning of the 21st century (Pammolli et al. 2005). It concluded that US patent counts and citations dominated the medical device field, more than doubling the number of non-US patents in 2005. Europe and Japan lagged far behind and indeed were experiencing a certain decline. The opposite was true for publications, however, where although the US impact factor was stronger, the number of medical device-related publications was increasing in Europe. The western European orthopaedic market represents about 20-25% of the world market, three-quarters of this accounted for by Germany, the United Kingdom, France, Italy and Spain. The role of the European orthopaedic device industry in market share is unclear, as the merging of industry compounds the whole picture. The role of European orthopaedic industry is limited nevertheless, with significant involvement in many companies of multinational parents headquartered outside Europe. This aspect also influences where industrial research can occur, and support of the European orthopaedic industry could be further stimulated by fostering research and collaboration throughout companies and institutions owned and based within Europe.

Many surgically implanted O&T devices undergo phase IV post-market prospective research funded by industry, and this voluntary approach to supporting research may be useful for the company, the hospitals and society. In the future, post-market research could increase our understanding of the long-term benefits and risks of O&T commercialized treatments and will also be required to maintain implants in the market. This research need is in part currently solved by strong collaboration with joint replacement registries, which contain data from all implanted systems in a country, fostered by the profession or by the national health care administration. In fact, even if a new technology becomes available, its real impact on healthcare only occurs once the dissemination of knowledge and confirmatory research provides positive support for this spread. Clinicians play the most significant role in such dissemination (van Merode et al. 2002). Key factors influencing this diffusion include the availability of trained personnel and the attitude of the O&T profession when data confirm the benefits, and these aspects strongly benefit from post-market research. Furthermore, technology assessment processes, government pricing policies and the cost of common alternatives may also be influenced by research data supplied by O&T specialists.

The current landscape of O&T research across Europe is difficult to analyse due to the fragmentation of information, some of it confidential or not publicly available. Fragmented information may result from industry-funded research, institutional or academic research. Furthermore, private funders may only require institutional recognition and acknowledgements in publications derived from research, but reports on detailed results that are never made public. On the other hand, public funding requires wide transparency and this may facilitate tracing research (amount of funds, declared programs, open access and other forms of widely distributed publication acknowledging the origin of funds).

While a significant amount of public funding in O&T research originates in local, regional and national bodies, the information on funding does not converge into unified European databases and data collection on funding allocations is often imprecise. Therefore, in order to obtain an overview of the level of high-quality publicly funded research in European O&T, a reference source that can be used is the European Commission's database on research (CORDIS). Another indicator browsed for this purpose is the database of European registered clinical trials (EUDRA-CT).

Focusing on European O&T related projects, search criteria included #Bone, #Musculoskeletal, #Orthopaedics, #Trauma (see Figure 1).

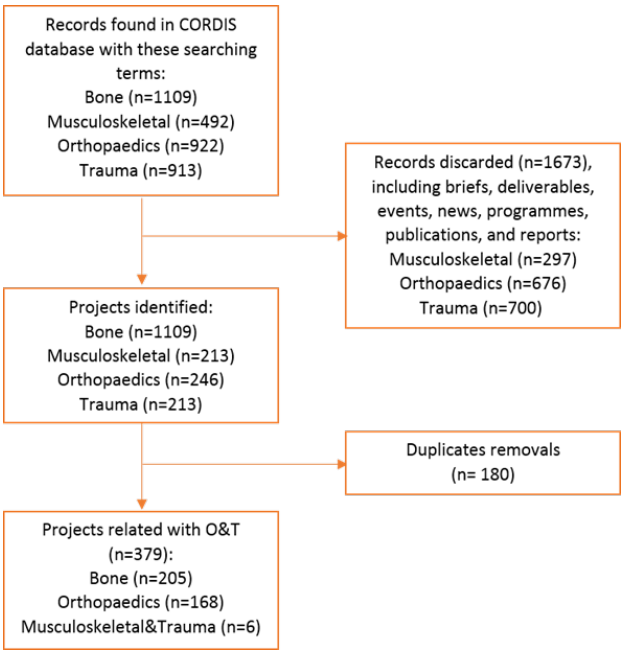

Figure 1. Flow diagram from CORDIS online database searching, 1982-2020.

The different topics that were related to O&T after manual filtering are displayed in Figure 2. Orthopaedic biomaterial development and implants are major topics attracting public funding.

When reviewing the O&T project topic distribution by area of interest (health, technology development, industrial processes, and transfer or knowledge/training), the results are seen in Figure 3. Projects in the Health axis are scarce, while training and technology development are preferred areas.

When the analysis is performed regarding the year and the program a project was funded by (Figure 4), technology development projects were preferred in earlier programs, while more projects in the O&T area more recently address training and knowledge transfer.

To better understand the evolution of EU funding and the share obtained by O&T related projects, health funding in the most recent programs, FP7 and H2020, is 4.77 billion € (in 1004 projects) and 3.64 billion € (in 914 projects) respectively (H2020 is not closed at the time of writing), while O&T funding in FP7 and H2020 can be estimated at about 321.45 million € (113 projects) and 248.21 million € (in 102 projects) respectively. Of note, O&T funding is not restricted to Health topics, but may also find support in Technology developments and Industrial processes, while a substantial amount of funding is offered for training and networking (17 projects in FP7, 68 projects in H2020).

The share of the O&T topics among the FP7 projects is about 0.44% of the total program funding (total of 113 projects), and the distribution among the FP7 subprograms is seen in Figure 5. The predominance is in the pillars for NMP (Nanoscience, Nanotechnologies, Materials and Production technologies) and PEOPLE (Marie-Curie Actions).

The share of O&T topics among the allocated H2020 projects (until 2019) was about 0.4% of the available funding (total of 103 projects), and the distribution among the H2020 pillar/thematic areas is seen in Figure 6. The predominance is for Excellent

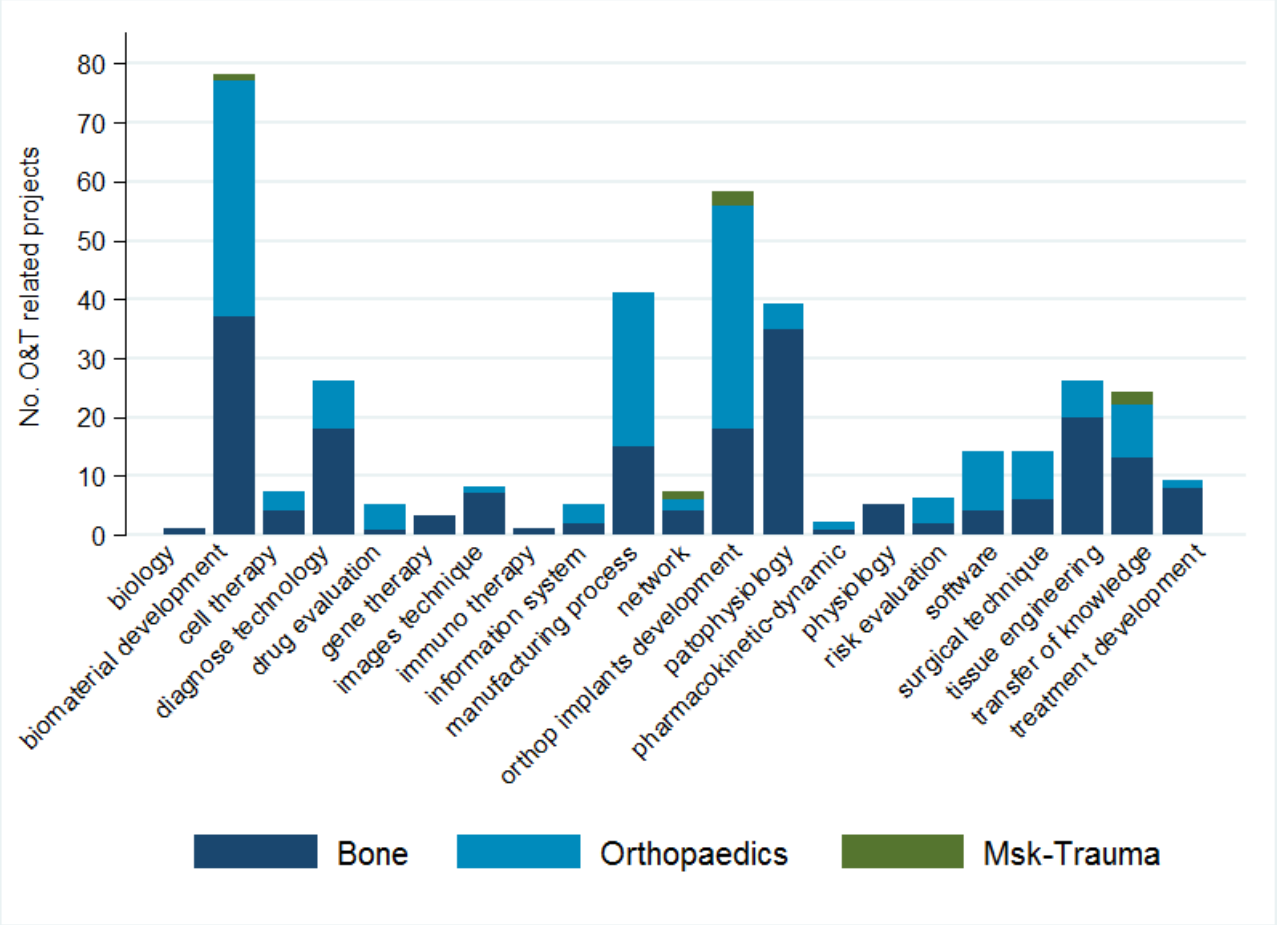

Figure 2. Topic distribution of the O&T projects (1982-2020), by CORDIS searching terms.

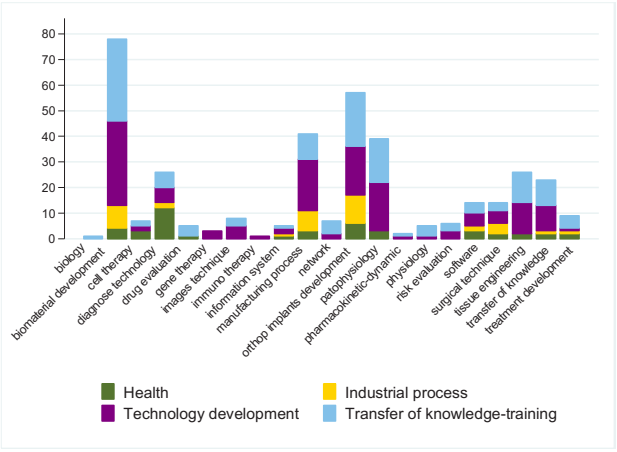

Figure 3. Topic distribution of the O&T projects (1982-2020), by area of interest.

science (that includes Marie-Curie actions), followed by Societal challenges (Health) and Industrial leadership (covering materials and nanotechnologies).

This overview of the presence of O&T research in EU funding programmes confirms that some competitive, early ideas from academic research receive public support, but this accounts for only a very small proportion of all the innovation and related research. It is frequently funded with lesser amounts by other public bodies (from local to national entities), while the extent of private funding is less well known. Furthermore, industries are rarely beneficiaries of these strategies, and their occasional contribution to academic public consortia may not represent a consistent or significant share of their research spending. Globally, the level of funding seems quite low, if we compare it to the annual budget allocated to the National Institute of Arthritis and Musculoskeletal Skin diseases (NIAMS), as part of the National Institutes of Health (NIH) in U.S.A. NIAMS receives about 1.5% of NIH allocated funds (NIH, NIAMS web page), in 2020 this representing about 41,000 million US dollars for NIH, and 600 million US dollars for NIAMS. The limited funding of O&T research in Europe is one barrier towards innovation in the O&T field.

Within the O&T profession itself, the current contribution is limited and there are apparent gaps in collaboration with basic academic researchers and industry researchers from the early stages of research and development. Clinicians, offering a pragmatic view and a clear understanding of the patients' and surgeons' needs, may foster efficient research planning and project development, thus avoiding the potential risk of a decrease of innovation in the specialty, particularly in view of the more complex scenario developing due to health economics and regulatory constraints. A potential opportunity is seen to further clarify and disseminate options and results through European research databases that may also be of benefit to industry and to academic networks. A major strength of the European O&T research landscape comes from its collaborative networks spanning different backgrounds and different European nations, and this is an activity where O&T specialists, led by EFORT, can predominate.

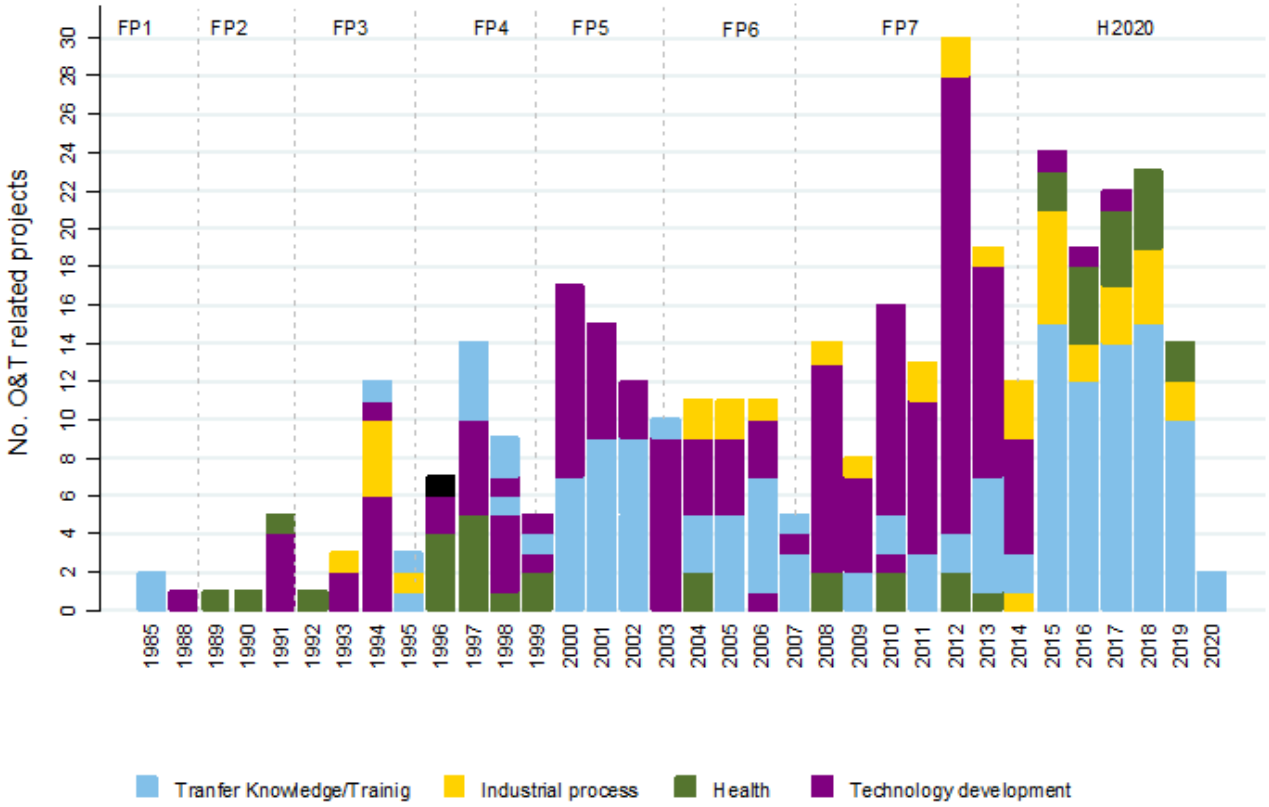

Figure 4. Year and program distribution of the O&T projects (1982-2020), by area of interest

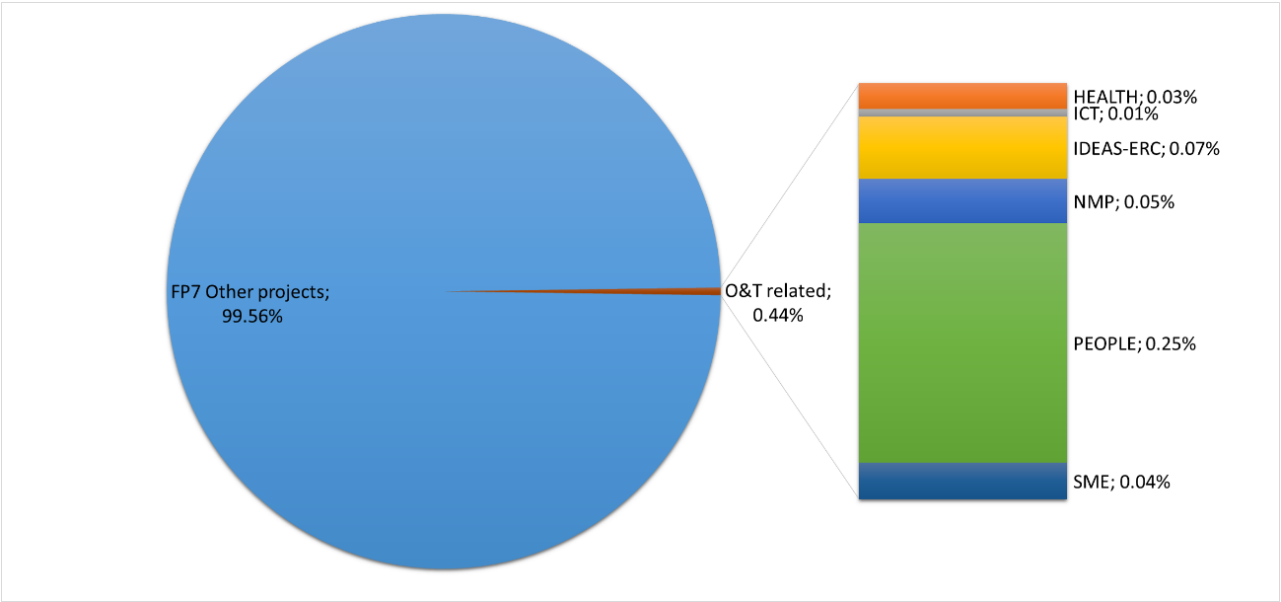

Figure 5. O&T funding in FP7 and distribution per pillar (2007-2013).

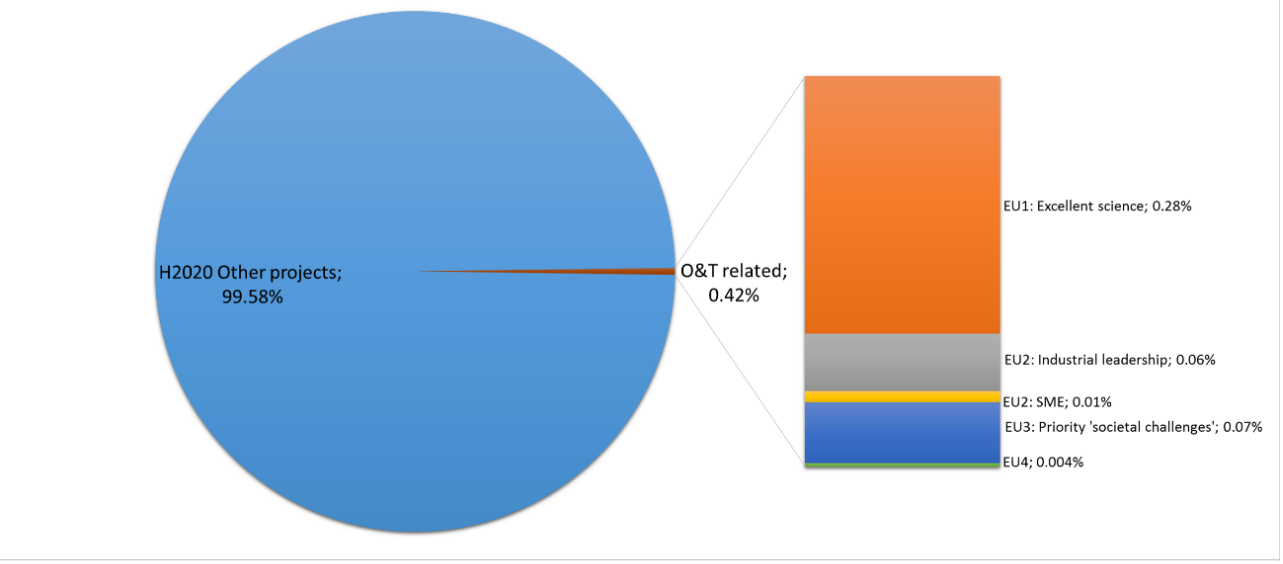

Figure 6. O&T funding in H2020 and distribution per pillar (2014-2020).

5. List of Activities Needed

- While the need to generate O&T research and innovation appears inevitable due to the state of musculoskeletal health and future requirements, the European landscape suffers from *very limited and scattered research funds*.
- Industry and academic-based O&T research offers opportunities to launch collaborative efforts that may *strengthen the output of European solutions to shape the future of musculoskeletal healthcare.*
- *Clinical research in the unique European multicentre, multinational model may provide a solid support to prove the safety and efficacy of innovative solutions, including orthopaedic and trauma devices.* O&T specialists, in collaboration with related European industries, are positioned to provide data and evidence of the highest quality.

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