Avoiding
Medical Errors
and Adverse Events

How to expand precision medicine by improving patient safety

SIEMENS
Healthineers

Executive overview

Whenever people act and make decisions, mistakes happen – in healthcare as elsewhere. According to the World Health Organization (WHO), approximately 43 million adverse events happen worldwide each year in the healthcare sector. Statistically, roughly two-thirds of these are due to human error and would therefore tend to be avoidable.[1]

Patient safety is an important indicator of healthcare quality. Enhancing and guaranteeing patient safety should be a high priority for healthcare providers. Adverse events, or injuries as a result of medical care, lead to direct harm and waste, and have spillover effects on patient confidence in the healthcare system. Moreover, money spent on having to repeat diagnostic tests or counteract adverse events is unavailable for other purposes.

The past decade has seen rapid growth in awareness and understanding of medical errors, with an energetic patient safety movement promoting safer healthcare through "healthcare systems" solutions. Avoiding medical errors and increasing safety enables healthcare providers to increase value. Value will be at the heart of care delivery. Reducing costs without sacrificing outcomes will require dedicated teams working collaboratively across the full continuum of care.[1]

Healthcare delivery and diagnostic processes are becoming increasingly complex. Just as care delivery is a collaborative activity, improving safety will also require better-coordinated care, collaboration, and a widespread commitment to change among healthcare professionals, healthcare organizations, patients and their families, researchers, and policymakers.[1]

At all levels, a willingness to openly admit mistakes and learn from them is important. Every mistake represents an important opportunity to identify ways of improving the system and avoiding medical errors in the future. This requires an open error culture without blame. In other words, continuous education and training can help to improve patient safety and reduce medical errors in two ways: (1) By keeping staff up to date and allowing them to practice important skills, and (2) by enabling staff to recognize mistakes and learn confidently from them with the support of training courses and seminars, enabling the changes necessary to achieve an improved culture of patient safety.[1]

Introduction

"To err is human, but to persist (in the mistake) is diabolical."[2] This ancient Roman quote ascribed to the Roman philosopher Seneca, among others, should be understood as a plea for a constructive error culture.

This is particularly applicable to healthcare, where a high risk of error is prominent and prevalent. Treatment decisions often have to be made in conditions of great uncertainty, little time, or both. In addition, healthcare delivery is an increasingly complex process. It often involves many participants and multiple stages, which creates numerous sources of error from diagnosis to aftercare (see box entitled "Types of medical error"). What is more, when it comes to diagnosing and treating sick people ostensibly small errors can have serious (non-compensable) consequences – which can go as far as avoidable death.

Not every incidence of harm results from an error, and not every error leads to harm. This is why, in its groundbreaking publication "To Err Is Human: Building a Safer Health System," the Institute of Medicine (now the National Academy of Medicine, NAM) distinguishes between errors and adverse events.[3]

- An **error** is defined as the failure of a planned action to be completed as intended, or the use of a wrong plan to achieve an aim. Errors depend on two kinds of failures:
  - Either the correct action does not proceed as intended (an error of execution)
  - Or the original intended action is not correct (an error of planning)

- **Adverse events** are defined as injury caused by medical management rather than by the patient's underlying disease or condition. Not all, but a sizable proportion of adverse events are the result of errors.

- **Preventable adverse events** are errors that do result in injury. For example, if a patient has surgery and dies from postoperative pneumonia, it is an adverse event. If analysis of the case reveals that the patient developed pneumonia because of poor hand washing or instrument cleaning techniques by staff, the adverse event was preventable. However, the analysis may conclude that no error occurred and the patient would be presumed to have had a difficult surgery and recovery (not a preventable adverse event).

In order to improve patient safety, it is important to analyze more than just the serious adverse events. Errors that don't result in harm are also an important opportunities to identify system improvements and avoid medical errors going forward.

According to the National Academy of Medicine, medical errors and their root causes can be categorized into four different types, as outlined in Table 1.[3]

Table 1: Medical errors and their root causes

Diagnostic	Error or delay in diagnosis, failure to employ indicated tests, use of outmoded tests or therapy, failure to act on results of monitoring or testing.
Treatment	Error in the performance of an operation, procedure, or test, error in administering the treatment, error in drug dosing and/or administration, avoidable delay in treatment or in responding to an abnormal test, inappropriate (not indicated) care.
Preventive	Failure to provide prophylactic treatment, inadequate monitoring or follow-up of treatment.
Other	Failure of communication, equipment failure, other any other failure.

Contents

1. Reasons to read: Why we need to talk about medical errors

Preventing errors and improving safety is a critical step in improving quality of care.

Patients expect healthcare providers to provide optimal care in the form of a cure or an improvement in the patient's mental or physical condition. Diagnoses should be correct, and therapies should be safe and not cause harm. These justified expectations are shared by healthcare professionals. For reasons of professional ethics if nothing else, doctors and nursing staff want to avoid harm and treat patients successfully. To achieve this, besides specialist knowledge and experience, they primarily need a safe, well-organized environment and functioning safety systems that help them to avoid errors.

A look at other industries shows that errors can be largely avoided even in a high-risk environment. Errors can be prevented by designing systems that make it hard for people to do the wrong thing and easy for them to do the right thing. Some high-risk industries have focused very successfully on building safe systems in the past decades. Between 1990 and 1994, for example, the aviation industry reduced airline fatalities to less than one-third of the rate experienced in the middle of the century.[3]

Headlines about serious treatment errors, as well as scientific studies, suggest that there is still much potential for improvement in the healthcare industry; seizing it is in the best interest of patients, healthcare providers, payers , and society in general. Medical errors should always be reduced to the unavoidable minimum because they are one of the most obvious and costly problems in the hospitals.

- Errors lead to increased hospital costs, as shown in a study conducted at two U.S. teaching hospitals. Preventable adverse drug events, resulting in average increased hospital costs of USD 4,700 per admission, led to extra costs of about USD 2.8 million a year for a 700-bed teaching hospital. If these findings are generalizable, the increased hospital costs alone of preventable adverse drug events affecting inpatients are about USD 2 billion for the U.S as a whole.[3]

- Errors are costly in terms of opportunity costs: Money spent on having to repeat diagnostic tests or counteract adverse events is unavailable for other purposes. Purchasers and patients pay for errors when insurance costs and payments are inflated by services that would not have been necessary without error.[3]

- Errors can lead to high claims for compensation and drive up premiums for corresponding insurance cover.

- Errors are costly in terms of a loss of patient trust in the system and diminished satisfaction among both patients and healthcare professionals. Patients who experience a longer hospital stay or disability as a result of errors pay with physical and psychological discomfort. Healthcare professionals pay with a loss of motivation that comes from not providing thee best care possible.[3]

- Errors create costs for employers and society in general: These relate to reduced staff productivity, reduced school attendance, and lower levels of population health.[3]

Without a dedicated focus on improving safety and avoiding errors, medical errors will likely worsen as healthcare delivery and diagnostic processes continue to increase in complexity. Just as care delivery is a collaborative activity, improving safety will also require better coordinated care, collaboration, continuous education, and a widespread commitment to change among healthcare professionals, healthcare organizations, patients and their families, researchers, and policymakers.

"Errors can be prevented by designing systems that make it hard for people to do the wrong thing and easy for people to do the right thing."

William C. Richardson, Institute of Medicine (U.S.)[3]

2. Evidence: A closer look at medical errors in different countries

Medical errors are among the leading causes of death and represent a serious financial burden, not just in high-income countries. For a long time, medical errors were a quantitatively and qualitatively under-researched phenomenon with rather poor data. Medical reports or death certificates rarely state clearly whether there were any diagnostic or therapeutic errors. Likewise, official death statistics do not yet record errors as an independent category or official cause of death. Underlying disease and the age of patients often make it difficult to identify medical errors and their effects.[3]

However, there is increasing recognition of the fact that medical errors are not only an ethical problem, but also an economic one. Cost pressure is rising in healthcare, new value-based reimbursement models are being introduced, and patients are becoming increasingly independently minded and well informed. Against this backdrop, policymakers, payers, and providers are devoting more attention to the issue and analyzing it more closely.[4]

An increasing number of hospitals have started introducing in-house error reporting systems in recent years. Some voluntarily report adverse events to neutral institutions, such as the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), or CIRSmedical (Critical Incident Reporting System), an anonymous reporting and learning system of the German medical profession. The improved data situation has led to stronger and more targeted research into medical errors.[5]

The findings of the various studies and reports suggest that this is a serious and above all global health problem that does not just affect high-income countries such as the U.S., Australia, and the EU. Indeed, it is also an issue in emerging countries with their growing populations and expanding middle classes that are placing greater demands on healthcare services.
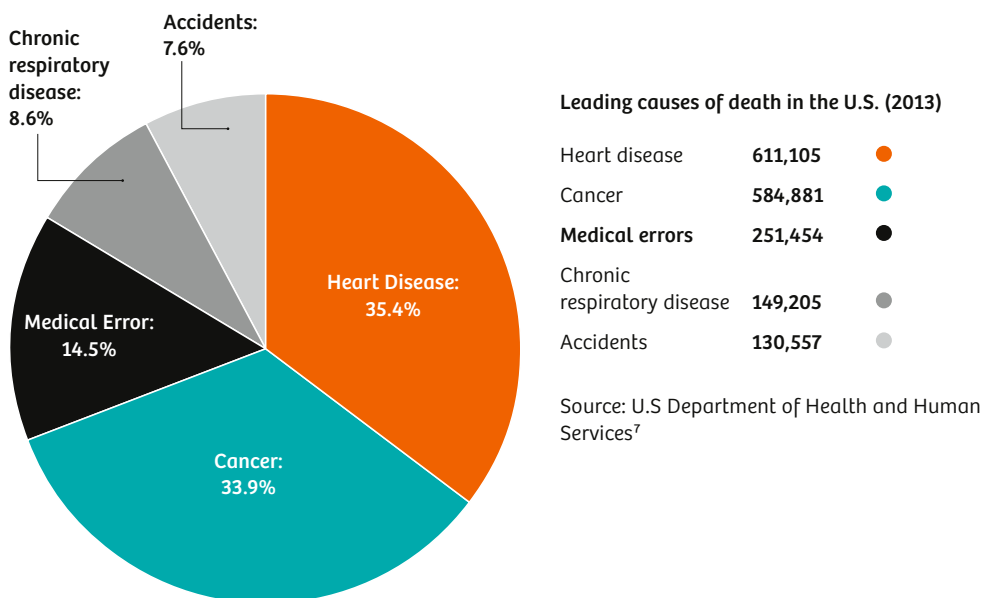
2.1 United States

In addition to having the highest per-capita health expenditure in the world, the U.S. is also one of the pioneers in the scientific analysis of medical errors. The NAM report "To Err Is Human," published in 2000, is still regarded as a standard reference on this topic.[3]

Its authors concluded that between, 44,000 and 98,000 people in the U.S. die each year as a result of preventable medical errors, and that considerably more are adversely affected by treatment that should have been therapeutic. The figures are based on two studies from the 1990s, one conducted at two hospitals in Colorado and Utah, and the other in New York. When extrapolated to a total of over 33.6 million admissions to U.S. hospitals in 1997, the results of the study in Colorado and Utah implied that at least 44,000 Americans die each year as a result of medical errors. The results of the New York study suggest that the number may be as high as 98,000.[3]

A more recent study of medical errors based on data from 2000 to 2008 estimates that errors may even account for as many as 251,454 deaths annually in the U.S., making medical errors the third leading cause of death after cancer and heart disease. Published in 2015, this study implies that far more Americans die from preventable adverse events within a hospital (251,454) than from accidents outside the hospital (130,557).[6,7]

Fig. 1: Medical errors are among the top 5 causes of death

Chronic respiratory disease: 8.6%

Accidents: 7.6%

Heart Disease: 35.4%

Medical Error: 14.5%

Cancer: 33.9%

Leading causes of death in the U.S. (2013)

Heart disease	**611,105**	●
Cancer	**584,881**	●
Medical errors	**251,454**	●
Chronic respiratory disease	**149,205**	●
Accidents	**130,557**	●

Source: U.S Department of Health and Human Services[7]

However, not every medical error leads to the death of the patient. The Joint Commission has maintained a database of "sentinel events" since 1995. A sentinel event is a patient safety event that results in death, permanent harm, or severe temporary harm, with intervention required to sustain life. As can be seen in Table 2, a recent analysis of the data shows that about half of the reported sentinel events were fatal.[8]

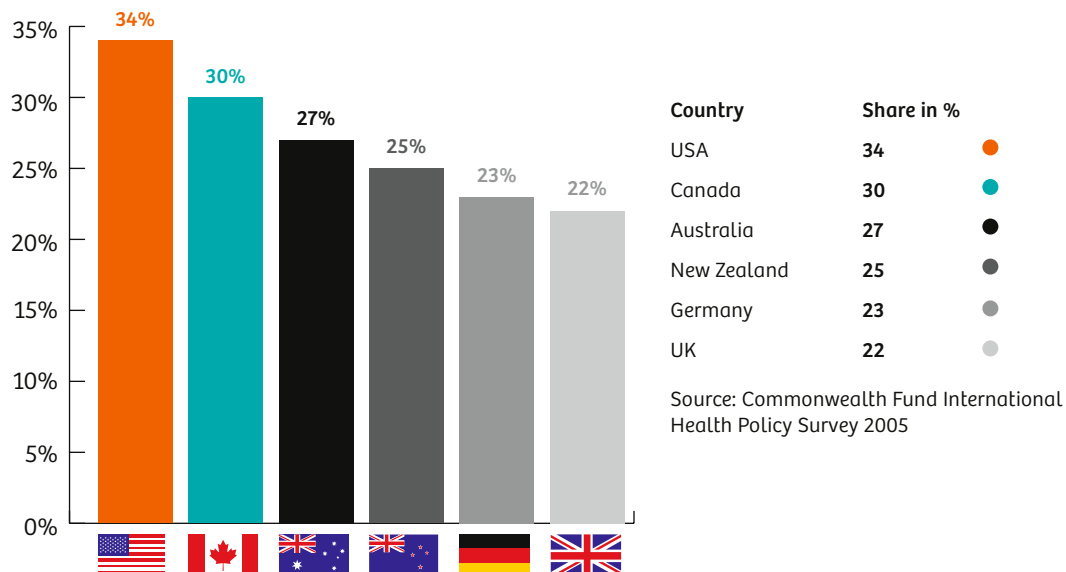## Table 2: Results of reported sentinel events (2005 – 2017)

52%		**Patient death**
25%		**Unexpected additional care**
10%		**Permanent harm, permanent loss of function**
6%		**Severe temporary harm**

Source: The Joint Commission[8]

Obviously, the number of errors far exceeds the number of deaths recorded in the studies cited. In a Commonwealth Fund survey (see Fig. 2) in six countries from 2005, 34 percent of the U.S. patients surveyed stated that they had been affected by medical errors (medical mistakes, medication errors, or test errors) within the past two years. This is far more than in Germany or the U.K., for example.[9]

One possible reason for this could be the degree of organization of the various healthcare systems. The Commonwealth Fund study shows that the risk of error nearly doubles if a patient is in contact with four or more physicians than with just one.[9] Relevant information can be lost across too many sites of care. This risk is more likely to occur in competitive healthcare systems, such as the one in the U.S., which have multiple treatment options and a high proportion of out-of-pocket payments; it is less likely to occur in countries like the Netherlands and Germany, where family doctors play an important role in all medical issues.

Fig. 2: Patients who have experienced a medical error

Country	Share in %	
USA	34	🟠
Canada	30	🟢
Australia	27	⚫
New Zealand	25	⚫
Germany	23	🔘
UK	22	⚪

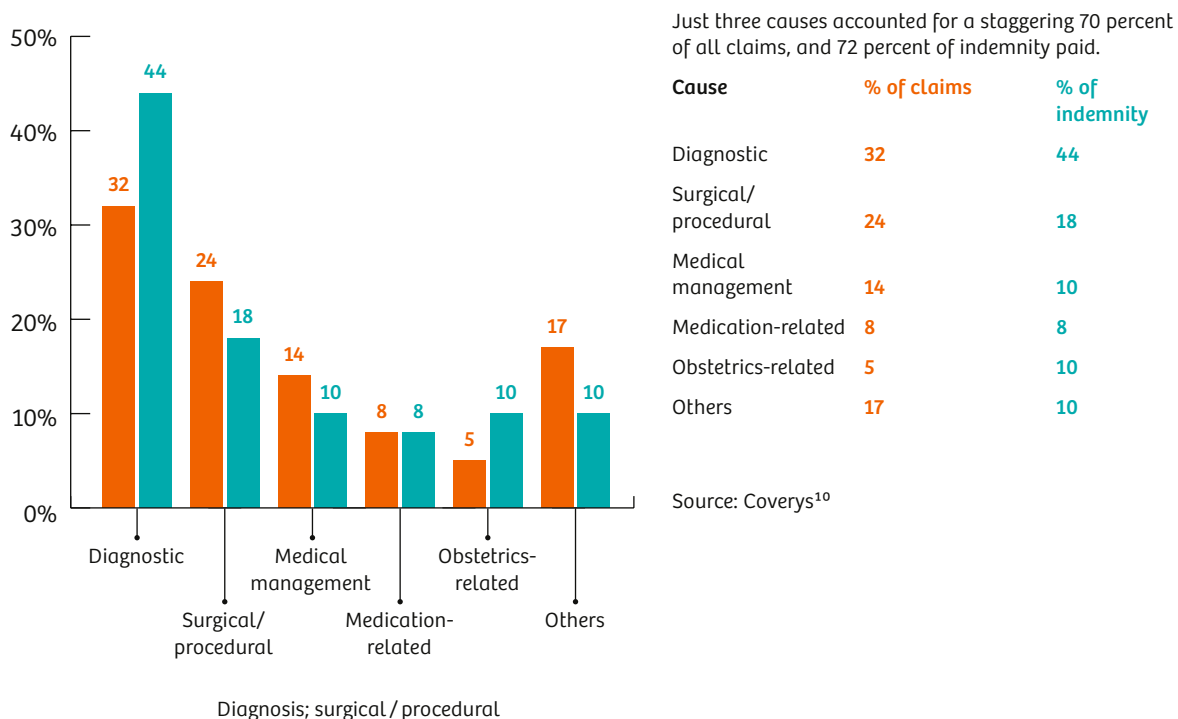Source: Commonwealth Fund International
Health Policy Survey 2005

Besides surveys and evaluations of hospital data, malpractice claims also provide information on the severity and frequency of medical errors. Errors related to diagnosis are the largest source of medical malpractice claims, according to a report published by malpractice services provider Coverys. At 32 percent, diagnosis-related claims outnumber all other reasons for malpractice lawsuits. Surgical or procedural claims were the second most common reason at 24 percent, while medical management claims came in third at 14 percent. About 36 percent of the diagnosis-related claims involved the death of the patient.[10]

The Agency for Healthcare Research and Quality (AHRQ), a Federal U.S. agency investing in research to improve diagnostic safety, arrives at similar conclusions. According to an AHRQ-sponsored report, most patients will experience at least one diagnostic error in their lifetime.[11]

1 in 3 medical malpractice claims are diagnosis-related.[10]

As shown in Figure 3, just three causes, including diagnosis-related, accounted for 70 percent of all claims, and 72 percent of indemnity paid between 2012 and 2010.[10]

Fig. 3: Leading causes of claims (2012 – 2016) in the U.S.

Just three causes accounted for a staggering 70 percent of all claims, and 72 percent of indemnity paid.

Cause	% of claims	% of indemnity
Diagnostic	32	44
Surgical/ procedural	24	18
Medical management	14	10
Medication-related	8	8
Obstetrics-related	5	10
Others	17	10

Source: Coverys[10]

Diagnosis; surgical / procedural

2.2 Germany and Europe

In Germany, the topic of patient safety is increasingly gaining support and acceptance at all levels of the healthcare system. However, valid data is scarce. In 2005, representatives of the healthcare professions, their associations, and patient organizations formed the Action Alliance for Patient The APS wants to see an improved database. To date, a uniform view of data and processes in the German healthcare system has been lacking. "Medicine and care in Germany are at a very high level. However, there is still room for improvement when it comes to handling errors," says APS chairman, Professor Matthias Schrappe, MD.[12]

Data from the Medical Service of the National Association of Statutory Health Insurance Funds (MDS) provide an indication of more or less error-prone specialist areas and areas of responsibility in Germany. On behalf of the health insurance companies, MDS experts check controversial cases to establish whether medical errors occurred. With regard to the various areas of responsibility, the MDS evaluations show that errors mainly occur in surgical treatment and during medical assessments, while other critical areas such as diagnosis, [patient] information (explaining the medical condition/treatment), and emergency management are only very rarely the subject of damage claims.[13]

In Germany, as in the U.S., errors in the area of surgery and interventions, medical assessment, and care account for over 70 percent of all medical errors. (see Fig. 4).

Fig. 4: Types of medical errors by area of responsibility in Germany

Source: MDS, 2016
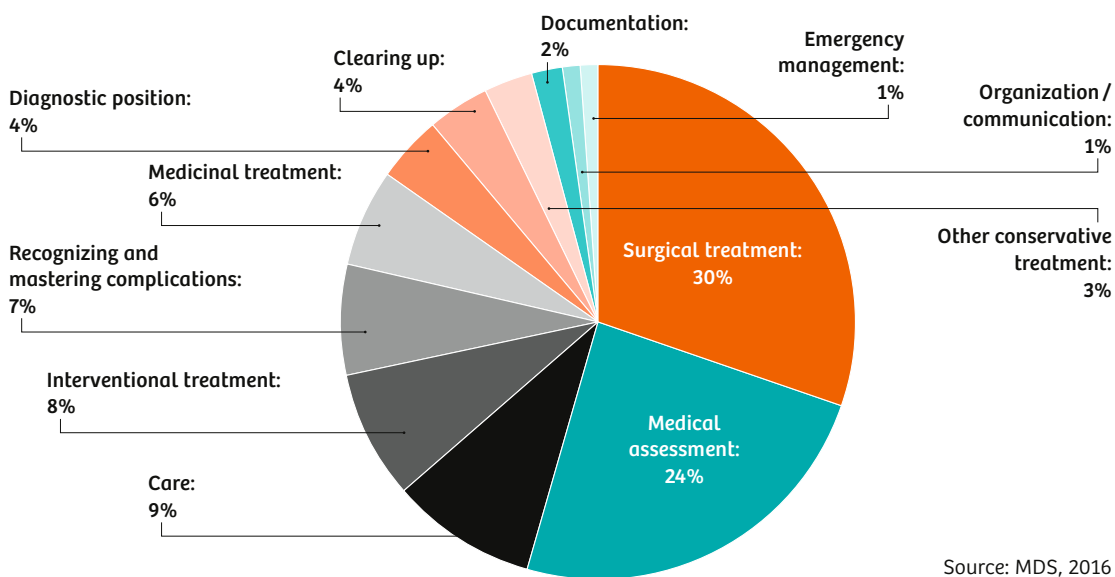
Overall, the number of allegations clearly exceeds the number of confirmed cases across all disciplines. According to MDS, orthopedics and trauma surgery are by far the most frequently affected by disputes, with almost 5,000 allegations/claims and around 1,200 confirmed cases. By contrast, in other areas such as internal medicine and cardiology, neurology and vascular and general medicine, the number of confirmed cases (in 2016) was well below 100.[13]
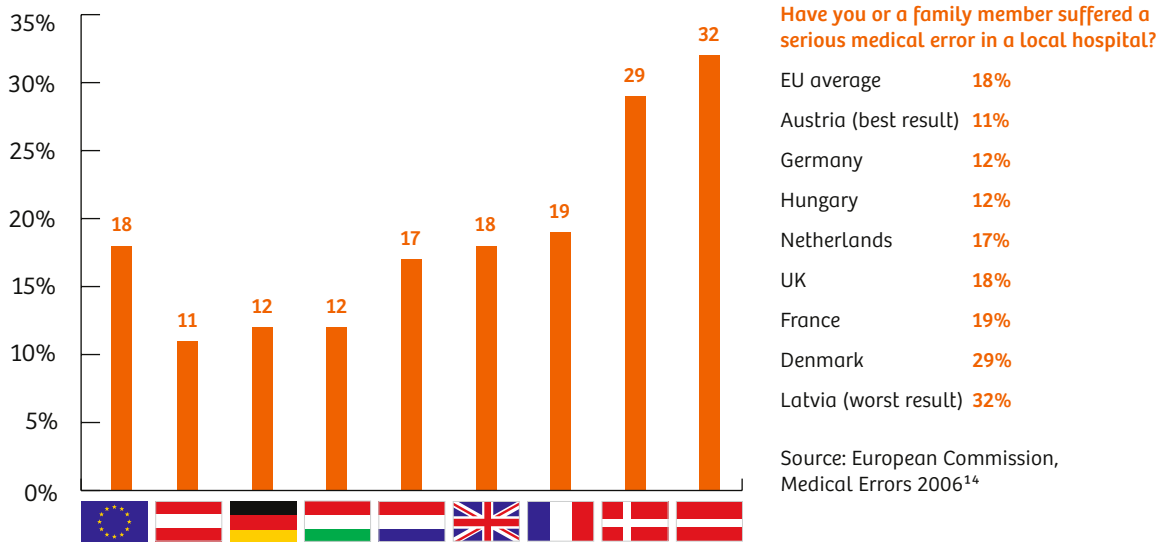
15,000 potential treatment errors are submitted to experts in Germany for examination each year. About two thirds concern inpatients.[13]

"Medicine and care in Germany are at a very high level. However, there is room for improvement in the handling of errors."

Professor Matthias Schrappe, MD
Aktionsbündnis Patientensicherheit – Action Alliance for Patient Safety (Germany)[12]

Compared with other European countries, Germany also gets good scores for patient safety in an EU study. In 2005, the European Commission, carried out its first systematic study on the problem of medical error at EU level. Its key findings showed that: Europe's citizens appear to be well aware of the existence of medical errors, with 78 percent indicating that they had at least read or heard about them. This awareness is not widely based on concrete experiences, since fewer than one in five respondents said that either they or a family member have personally encountered a medical error in a hospital. Although the occurence differs widely across the European countries studied, the results can be seen as indicating a need for improvement in this sector (see Fig. 5).[14]

Fig. 5: Medical errors in Europe

Have you or a family member suffered a serious medical error in a local hospital?

EU average	**18%**
Austria (best result)	**11%**
Germany	**12%**
Hungary	**12%**
Netherlands	**17%**
UK	**18%**
France	**19%**
Denmark	**29%**
Latvia (worst result)	**32%**

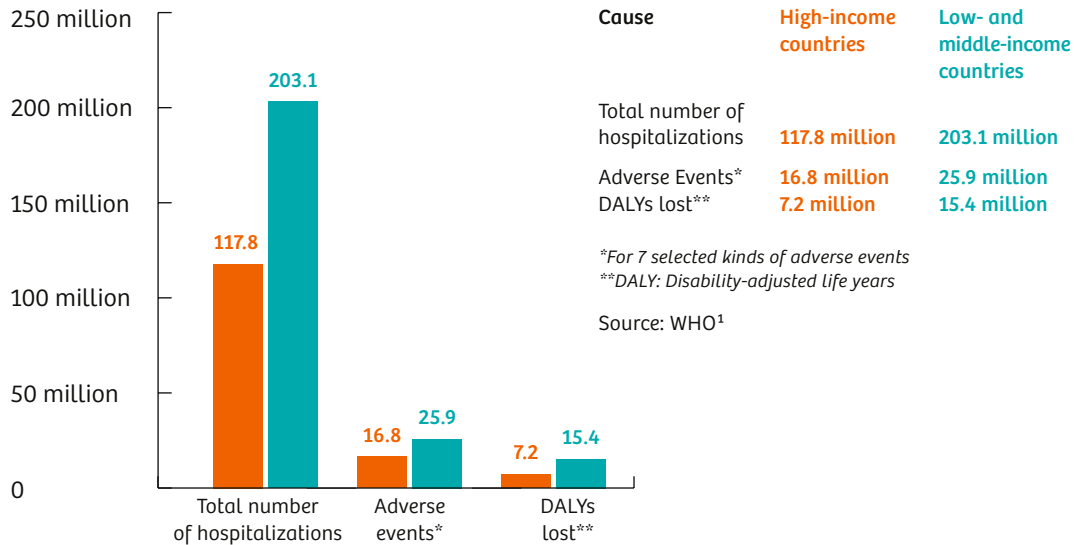Source: European Commission, Medical Errors 2006[14]

Percentage of people who say that they or their family members have suffered damage as a result of a serious medical error in a local hospital.

2.3 A comparison of high-income and low-income countries

Many policymakers have considered patient safety primarily as an issue for high-income countries (HIC), where most of the population has access to basic healthcare. Meanwhile, in low- and middle-income countries (LMCs), the lack of access to healthcare services itself poses a serious health risk. Nevertheless, medical errors are not limited to rich nations. They affect the most diverse countries and healthcare systems, as a study by the WHO shows.[1]

The WHO estimates that 421 million hospitalizations worldwide annually result in around 43 million adverse events per year, which in turn correspond to the loss of 23 million healthy life years. LMCs account for around two-thirds of lost disability-adjusted life years and these numbers will likely grow (see Fig. 6). The findings suggest that improving global health will not only require better access to care, but also a substantial increase in efforts to improve the safety of the healthcare systems that people access worldwide.[1]

Fig. 6: Medical errors impact health in low- and middle-income countries

Cause	High-income countries	Low- and middle-income countries
Total number of hospitalizations	**117.8 million**	**203.1 million**
Adverse Events*	**16.8 million**	**25.9 million**
DALYs lost**	**7.2 million**	**15.4 million**

*For 7 selected kinds of adverse events
**DALY: Disability-adjusted life years

Source: WHO[1]

3. Strategy

To err is human, but many errors are preventable. Sources of error are as varied as healthcare providers, their patients, medical procedures, and organizational processes. Processes and risks in emergency rooms or intensive care units differ considerably from those in ophthalmology or pediatric wards, or at a rehabilitation clinic.[3]

The strategies that are required and feasible for patient safety differ in their details. Individual concepts for avoiding medical errors must therefore be jointly developed and implemented locally by the people involved. However, most errors are caused by a number of fundamental factors that can be found across departments, companies, and even industries. In particular, these include a lack of – or insufficiently practiced – knowledge and skills, time pressure, work-overload (often caused by staff shortfalls), inadequate communication, and faulty or incomplete documentation.[3]

On this basis, fundamental recommendations for dealing with medical errors can be derived which will help improve patient safety regardless of patient group, specialty, company size or the political or social conditions.

Improve coordination for care delivery
Poorly coordinated care puts patients at risk for events such as medication errors, lack of necessary follow-up care, and diagnostic delays. Like so many preventable errors in healthcare, these risks come down to a failure to communicate. Providers, including multiple specialists, must inform one another at every step in the care process of the patient's condition, medication regimen, and medical history. Tools such as checklists and safety huddles can help providers to communicate effectively at every stage of the patient's care. Communication training and leadership support are also essential.[15]

Improve communication and collaboration within teams
Care delivery relies on teamwork. Team training for healthcare employees can help to significantly reduce patient mortality and reduce medical errors. Team training aims to improve team-based knowledge, skills, attitudes, and problem-solving interactions. It focuses on developing coordination, cooperation, communication, leadership, and other team skills. Team members train in specific roles while performing specific tasks and interact or coordinate to achieve a common goal or outcome.[16]

Create motivation to learn
Some popular treatments from earlier times would now be considered serious medical errors. In the medical field in particular, the state of knowledge is constantly and rapidly developing. This applies, for instance, to the fields of rare diseases, mental illnesses, and cancer treatment. Staying up to date at all times is a challenge for healthcare professionals. As well as giving staff access to training and further education, healthcare providers must also motivate and support their learning – for instance, with new digital formats (e-learning) and organizational measures (scheduled time for learning). As William Marella, Executive Director of Operations and Analytics at ECRI Institute, says: "Most important? Foster a culture that truly values learning."[17]

Seize the opportunities of digitalization

In diagnosis and treatment, modern and efficient medical technology can make a significant contribution to optimizing processes, increasing patient safety, and preventing errors. New digital technologies such as artificial intelligence (AI), big data, and robotics are enabling significant progress in diagnostic imaging, methods for evaluating large amounts of data (e.g., DNA-based tests), customized medication and implants, and minimally invasive surgical procedures.[18]

The enormous volumes of data now at our disposal often require the use of AI in everyday clinical practice. As well as processing existing information, AI can also learn by recording symptoms, analyzing X-rays, making initial diagnoses, proposing suggested therapies / treatments, and automating standardized workflows – all in a very short time.[18]

Acceptance for deploying these types of technologies is growing: According to a PwC survey, 41 percent of Germans are generally open to treatment by AI. In China, the humanoid robot Xiaoyi ("little doctor") passed the Chinese medical approval test with exceptionally high scores in November 2017. In preparation for the exam, the robot had been fed around one million medical images, 53 medical books, two million medical files, and 400,000 medical articles and reports.[18]

Digital tools for communication, documentation, and collaboration, such as digital patient records, can also reduce errors. The introduction of technical innovations should always be accompanied by training. E-learning, apps, and digital simulations open up new scope for education and training. [18]

Introduce IT-assisted error reporting

Evaluations from various hospitals show that the number of reported errors increased significantly in the years after IT-based reporting systems were introduced. Of course, this was not because more mistakes had been made, but because recording and documenting them had been made easier. Ideally, the digital systems should be very user-friendly and web-based, and offer the option of reporting errors anonymously. A central error database makes it possible to identify anomalies more quickly, analyze interrelationships, and thus effectively eliminate sources of errors.[15]

Allow for uncertainty

Successful treatment begins with an accurate and timely diagnosis. However, this is the stage at which expensive and serious mistakes often happen. A team-based approach in which doctors are encouraged to discuss clinical cases with others is an effective tactic to avoid medical errors and improve diagnostic accuracy. A culture in which doctors know that it is okay be unsure about a diagnosis and to seek help should also be encouraged to improve patient safety and avoid wasting resources.[17]

Cultivate an open culture of error tolerance
Many patient safety experts point out that full disclosure of adverse events, without blame, can reduce medical errors. Yet many organizations, still have a blame culture in which healthcare professionals are afraid to report errors because of they are concerned about liability or worried that their colleagues will consider them incompetent. This leads to underreporting and means that the expected learning from adverse events and near-misses does not occur on a broad scale.[19]

Therefore, a key recommendation made by the Institute of Medicine in the U.S., the Department of Health in the U.K., and a consortium of healthcare professionals in the Netherlands is to cultivate a more open culture and reflective attitude toward errors and adverse events.[19] Continuous education and training can help to bring about the necessary change in mindset.

"Most important? Foster a culture that truly values learning."

William Marella, ECRI Institute[17]

Practices that ensure safety at high-reliability organizations

High-reliability organizations (HROs) are high-risk organizations that manage to be safe and reliable, such as nuclear power plants and naval aircraft carriers. "HROs are agile, adaptable learning systems that respond well to the unexpected," says Kathleen Sutcliffe, Bloomberg Distinguished Professor at Johns Hopkins University. Their high levels of safety and reliability are based on five practices:[20]

1. A preoccupation with failure: HROs are alert to any failure, however small, because deviations can result in tragedy. HROs are always aware of what could go wrong.

2. A reluctance to simplify: Complexity is a given in HROs, and they do not go for easy answers when a problem arises.

3. Sensitivity to operations: Frontline workers are in a better position to recognize problems than executive leadership, and HROs welcome their input on how to improve.

4. Commitment to resilience: In an ever-changing environment, HROs continually look for potential problems and innovative solutions.

5. Deference to expertise. Expertise matters more than authority for HROs, which recognize that on-the-ground workers may well know more than their leaders.[20]

4. Key takeaways

1. Patient safety culture is an important measure of healthcare quality. There is a growing recognition of the need to establish a hospital culture focused on patient safety.

2. A critical component of a comprehensive strategy to improve patient safety is to create an environment that encourages organizations to identify errors, evaluate causes, and take appropriate action to improve performance going forward. Building safety into care processes will reduce errors more effectively than blaming individuals.

3. External reporting systems are one of the tools that can enhance our understanding of errors and the underlying factors that contribute to them.

4. Communicating accurate and timely diagnoses to patients is an important aspect of providing high-quality care. Errors in diagnosis can severely hamper efforts to deliver excellent care.

5. A willingness to keep learning and to change habits is essential. Healthcare providers should help their employees to pursue continuous education and training by providing them with suitable programs.

Expanding precision medicine by reducing medical errors

Precision medicine helps to improve patient outcomes, reduce waste, and create more value with every healthcare dollar spent.

Precision medicine starts with diagnostic accuracy. Siemens Healthineers supports healthcare providers with best-in-class imaging and laboratory results. AI-enabled applications help to reduce unwarranted variations. For example, without AI, biovariabilities can be a source of error and inefficiency in MR imaging.

At the same time, precision medicine helps to personalize treatment when it matters, for instance, by enabling more effective and less physically demanding personalized cancer therapies. Finally, precise images and diagnostics help to guide treatment for better outcomes, with one example being cutting-edge robotic imaging for minimally invasive procedures.

5. References

1. WHO. The global burden of unsafe medical care: analytic modelling of observational studies. 2013. Available from: http://qualitysafety.bmj.com/content/22/10/809.long. Last visited: May 2018.

2. www.wortbedeutung.info/Irren_ist_menschlich/.

3. Institute of Medicine (US) Committee on Quality of Health Care in America; Kohn LT, Corrigan JM, Donaldson MS, editors. To Err is Human: Building a Safer Health System. Washington (DC): National Academies Press (US); 2000. Available from: https://www.ncbi.nlm.nih.gov/books/NBK225182/ doi: 10.17226/9728. Last visited: May 2018.

4. The U.S. non-profit organization accredits hospitals worldwide according to defined quality standards: www.jointcommission.org.

5. www.cirsmedical.de.

6. Mackary MA, Daniel M. Medical error - the third leading cause of death in the US. BMJ. 2016; 353:i2139.

7. Xu J, Murphy SL, Kochanek KD, et al. Deaths: Final Data for 2013. Natl Vital Stat Rep. 2016; 64(2):1-119.

8. The Joint Commission. Summary Data of Sentinel Events Reviewed by The Joint Commission. January 2018. Available from: https://www.jointcommission.org/assets/1/18/Summary_4Q_2017.pdf. Last visited: May 2018

9. The Commonwealth Fund. International Health Policy Survey of Sicker Adults in Six Countries 2005. Available from: https://www.commonwealthfund.org/publications/surveys/2005/nov/2005-commonwealth-fund-international-health-policy-survey-sicker. Last visited: May 2018.

10. Hanscom R, Small M, Lambrecht A. A dose of insight: A data-driven review of the state of medication-related errors & liability in American healthcare. 2012-2016. Available from: https://www.coverys.com/PDFs/Coverys_White_Paper-A_Dose_of_Insight.aspx. Last visited: May 2018.

11. Agency for Healthcare Research and Quality. Improving Diagnostic Safety. 2015, Available from: https://www.ahrq.gov/professionals/quality-patient-safety/diagnostic-safety/index.html. Last visited: May 2018.

12. Aktionsbündnis Patientensicherheit e.V. (ed.). Aus Fehlern lernen (Learning from Mistakes). January 2008. Available from: www.aps-ev.de/wp-content/uploads/2016/10/Aus_Fehlern_lernen_0.pdf. Last visited: May 2018.

13. Statistisches Bundesamt, Bundesärztekammer, Statista 2018. Gesamtzahl der Ärzte in Deutschland im Zeitraum von 1990 bis 2017. (Total Number of Physicians in Germany in the Period 1999 to 2017). Available from: https://de.statista.com/statistik/daten/studie/158869/umfrage/anzahl-der-aerzte-in-deutschland-seit-1990/. Last visited: May 2018.

14. European Commission. Special Eurobarometer: Medical Errors. January 2006. Available from: http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_241_en.pdf. Last visited: May 2018.

15. ECRI Institute. Top 10 Patient Safety Concerns for Healthcare Organizations 2018. Available from: https://www.ecri.org/EmailResources/PSRQ/Top10/2018_PSTop10_ExecutiveBrief.pdf. Last visited: May 2018.

16. Hughes AM, Gregory ME, Joseph DL, et al. Saving lives: A meta-analysis of team training in healthcare. J Appl Psyschol. 2016; 101(9):1266-304.

17. Arndt R. Diagnostic errors pose greatest patient safety risk. Modern Healthcare. March 12, 2018. Available from: http://www.modernhealthcare.com/article/20180312/TRANSFORMATION01/180319987. Last visited: May 2018.

18. Lange K, Hammesfahr J. Roboter – die Ärzte der Zukunft? (Robots: The Doctors of Tomorrow?), Ärzte Zeitung. August 17, 2018. Available from: https://www.aerztezeitung.de/praxis_wirtschaft/medizintechnik/article/963930/kuenstliche-intelligenz-roboter-aerzte-zukunft.html. Last visited: Aug 2018.

19. Wagner C, Smits M, Sorra J, et al. Assessing patient safety culture in hospitals across countries. Int J Qual Health Care. 2013; 25(3):213-21.

20. Harvard Business Review Analytic Services. Transforming Health Care Delivery to Increase Value. November 2017. Available from: https://hbr.org/sponsored/2017/11/transforming-health-care-delivery-to-increase-value. Last visited: May 2018.