A healthcare professional in a green uniform is examining an elderly patient's ear with an otoscope. The patient has white hair and is wearing a green garment. The professional is focused on the task, and the scene is brightly lit.

CHAPTER 2 CLINICAL CARE

Over the coming decade in Europe, we will see a shortage of doctors and nurses, an ageing population and a growing epidemic of respiratory diseases. This will pose a formidable challenge for the future of curative medicine.

It is expected that by 2020, the estimated shortage of healthcare workers, including physicians, nurses, dentists, pharmacists and physiotherapists, in Europe will amount to 1,000,000, leading to an absence of coverage of 15% of the necessary care [1]. The latest demography report of the European Commission shows that Europe's population is becoming older and more diverse (fig. 1).

Another visible development in the population is the rapid rise of the "oldest old", *i.e.* the share of those aged 80 years and above. It is around 4% now, but will rise to 12% by 2060. The growing share of the over 80 year olds will put a strain on the provision of services for the elderly, mainly in health and long-term care.

A formidable challenge for curative medicine will be the shortage of doctors and nurses to deal with an ageing population and this growing epidemic of respiratory diseases (table 1).

FUTURE SHIFTS

Attracting more healthcare workers is required, as strong relationships have been demonstrated between quality of care and nurse staffing and qualifications [4]. Other measures include shifts from hospital to home care, and from physician care to nurse care and self-management. Interestingly, improving

Table 1. Common non-malignant chronic respiratory diseases.

Asthma
Bronchiectasis
Chronic obstructive pulmonary disease
Hypersensitivity pneumonitis
Interstitial lung disease
Pneumoconiosis
Post-tuberculous lung disease
Pulmonary circulatory disease: pulmonary embolism, pulmonary hypertension and cor pulmonale
Pulmonary eosinophilia
Rhinitis
Sarcoidosis
Sleep apnoea syndrome

Reproduced with permission from the publisher [3].

quality of care is also effective, because catastrophic events resulting from poor care quality usually require disproportionately large use of resources, such as prolonged critical care [5]. Sleep disorders and obesity, treatment of lung cancer and infections, and tuberculosis will remain significant challenges. While mortality due to cardiovascular disease and stroke has been decreasing, the mortality due to

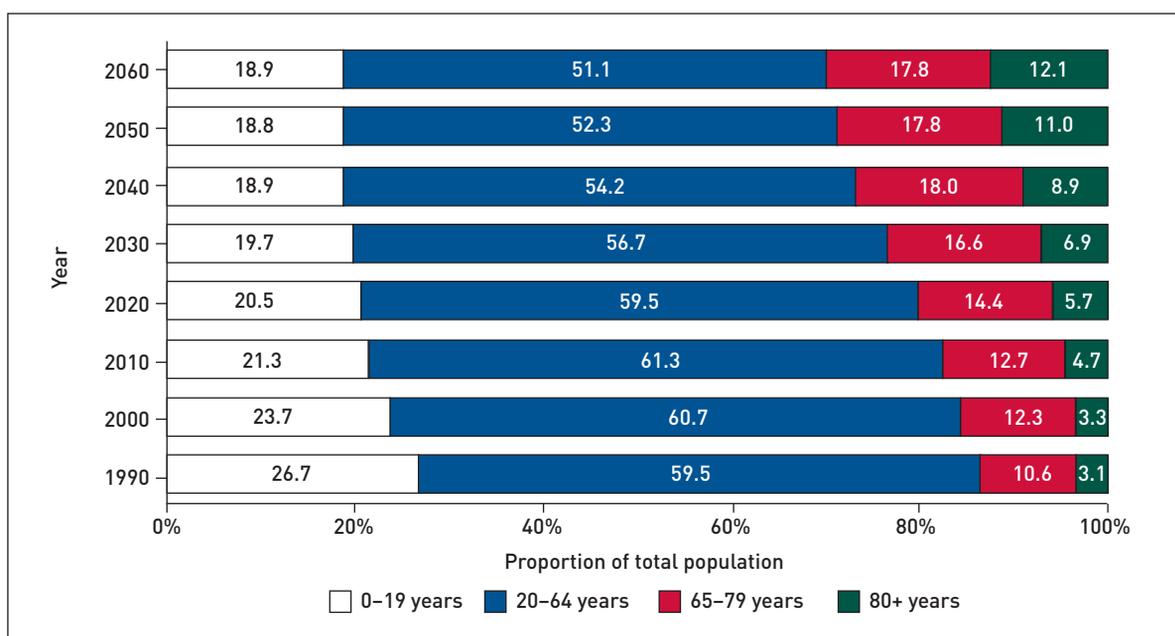


Figure 1. Division of European Union population by age group. Reproduced with permission from the publisher [2].

chronic obstructive pulmonary disease (COPD) has been increasing during the past three decades (fig. 2), indicating that COPD in particular, and chronic respiratory diseases in general, will become the diseases of the next decades [6].

Robust and simple methods for screening for sleep apnoea will be required. From a paediatric point of view, the microbial colonisation of the gut opens up new approaches to improving newborn health [7], and a cure for cystic fibrosis *via* a single compound or intervention may become feasible and is the goal of current research [8].

In the field of respiratory intensive care, acute lung injury (ALI) and acute respiratory distress syndrome (ARDS), as well as sepsis, have a prominent role for acute critical care specialists. Mortality from ALI/ARDS and sepsis is high and has not been seen to decrease over time. The main areas for future investigation and clinical implementation are related

to: early application of different clinical, diagnostic procedures and therapies, *e.g.* non-invasive ventilation in the ward and in critical care units; better haemodynamic management in high-risk patients; identification and treatment of sepsis and septic shock; use of imaging techniques at the bedside, *e.g.* electric impedance tomography and lung ultrasound; and monitoring of sedation and application of early physical and occupational therapies.

AFFORDABILITY

Another formidable challenge will be the affordability of healthcare, as care for chronic respiratory diseases is costly, because of the requirement for expensive therapies, such as long-term medical and oxygen therapy, therapy for exacerbations of disease, which often require hospitalisation, and end-stage therapies such as rehabilitation, lung volume reduction surgery and, particularly, lung transplantation [9, 10]. Conversely, healthcare systems are already overstressed in most European countries, where healthcare costs have now risen to 10.5% of the gross domestic product (GDP) on average. The latter corresponds to about 28–29% of the fiscal income of those countries [11]. Healthcare expenditure is expected to reach 16% of GDP in Europe by 2020.

The costs are expected to rise further, because of the increasing costs associated with the ageing population in most European countries [12]. This situation is likely to become problematic in the next decades, although even higher healthcare costs may be cost-effective, and generous welfare and healthcare systems may remain affordable, if combined with strong incentives to work longer, as in the Scandinavian countries [13]. Thus, a high degree of social protection is sustainable if it is intelligently designed. Economic models have shown that even much higher fractions of GDP may be cost-effective by 2050. In addition, the willingness to pay for healthcare amongst the general public has been shown to be very high (F. Vandenbroucke, ERS Summit, Leuven, 2011; oral presentation).

CLINICAL CARE MODELS IN THE NEXT DECADE

Accessibility

Care for chronic diseases will necessitate new modes of approach such as integrated care, multidisciplinary care, clinical pathways, self-management [14], teleconsulting, telemonitoring [15] and rehabilitation [16].

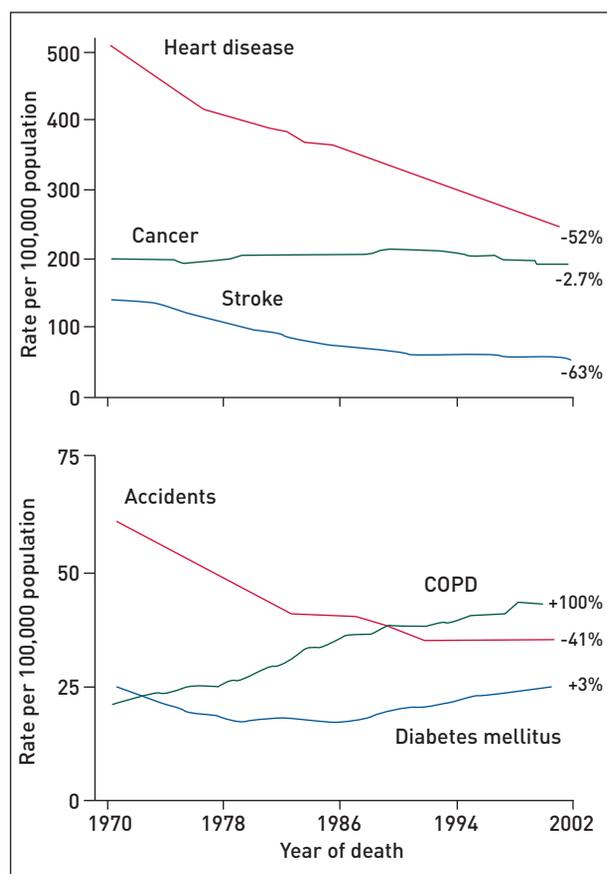


Figure 2. Evolution of mortality due to various diseases over the past 30 years. Reproduced with permission from the publisher [6].

For the latter four modalities, there is evidence of an effect on outcomes, but accessibility of these services remains dismal. It is estimated that less than 5% of the eligible patients actually have access to rehabilitation [17].

Integrated care models

In the broadest sense, integrated care is a concept bringing together inputs, delivery, management and organisation of services related to diagnosis, care, rehabilitation and health promotion [18]. The use of managed clinical networks, multidisciplinary teams and collaborative efforts across the lines of healthcare should be stimulated and funded (fig. 3). Moreover, management of comorbidity is a major challenge often overlooked by evidence-based diagnosis and treatment using disease-specific clinical guidelines [20].

COPD is one of the most common chronic diseases worldwide [21] and a common cause of hospitalisation. An analysis of the economic cost of COPD in the UK shows that 54% accrues from hospitalisation; a further 32% is equally divided between scheduled care and drug treatment [22]. An integrated care pathway with flexible shared care arrangements between primary care and hospitals, facilitated by information technologies, has an enormous potential to decrease hospital admissions in COPD patients.

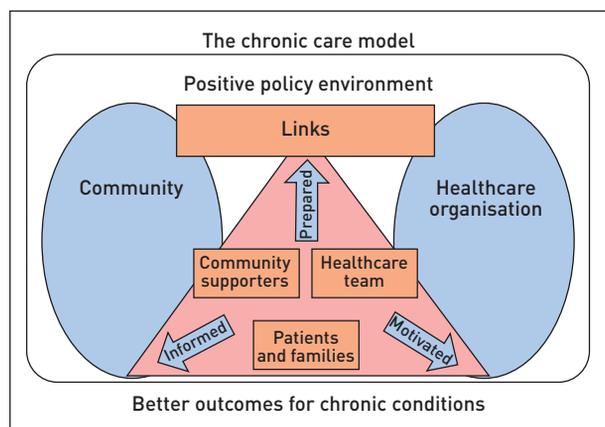


Figure 3. Diagram of the integrated care model proposed by the World Health Organization's Innovative Care for Chronic Conditions initiative. Interplay between the roles of patient/carer, healthcare/public health and community services is needed. Reproduced with permission from the publisher [19].

The multidisciplinary team as a crucial component of patient care

For many subspecialties of respiratory medicine, such as respiratory critical care, sleep medicine and thoracic oncology, the major innovation for further improving care will be the implementation of a coordinated and strategic cooperation between team members and among different units in the development of diagnostic and clinical management strategies.

However, when managing complex patients, optimal systematic care often breaks down owing to barriers such as a lack of communication between teams, disjointed transfers between services, unnecessary or time-consuming re-evaluations and transitional pauses in time-dependent circumstances, and significant variability in patient care practices.

The importance of multidisciplinary care teams will need to be further developed: this is crucial [23]. The care of many respiratory patients, e.g. those with thoracic tumours, and the critically ill and injured, has become increasingly complex, so that optimal management not only relies on the talents of highly coordinated multidisciplinary teams, but also requires shared responsibilities across a continuum of longitudinal care involving numerous specialties and departments.

Pulmonary rehabilitation programmes as a way to reduce hospitalisation

Patients with chronic respiratory disease are heavy users of healthcare resources and social services worldwide. Pulmonary rehabilitation has become recognised as central to the comprehensive management of patients disabled by chronic respiratory disease, including children who survive with respiratory impairment [24]. Furthermore, such programmes can reduce healthcare costs as a result of a reduction in the number of hospital admissions and the length of hospital stay. However, pulmonary rehabilitation as a practice in Europe is very inhomogeneous and, even within single countries, there are great variations in its use.

Comprehensive rehabilitation in the primary care setting should be a priority, since it can manage large numbers of symptomatic “moderate” COPD patients. A strong recommendation for the future is to establish accessible pulmonary rehabilitation programmes,

in order to deliver remote support to patients with chronic respiratory disease in an affordable way. There is a need to optimise the availability and quality of pulmonary rehabilitation in Europe, especially since rehabilitation is acknowledged as cost-effective for these patients, *i.e.* those with moderate advanced COPD. Concerted efforts are needed to encourage healthcare delivery systems to provide this therapy and make it affordable.

Palliative care for patients with non-malignant disease

The development of palliative care as a specialty in its own right has led to great improvements in the care of patients with end-stage disease and, in particular, those with malignant disease. A great inequality in access to services currently exists between patients dying with malignant and non-malignant respiratory disease. This is in part due to lack of resources, which constrains the wider availability of palliative care programmes in the healthcare system. A study by GORE *et al.* [25] showed that COPD patients were generally better provided for in terms of aids and appliances, but very few had received counselling and none had received help from specialist palliative care services (fig. 4).

In the period leading up to death, only 2–3% of those dying from non-malignant disease access specialist palliative care [26]. Across Europe and the developed world, most people with chronic respiratory disease

die in hospital, although it is known that few would make this choice. There is a need to change our practice to allow both curative care and palliative care to run side by side, and for patients with non-malignant respiratory disease to be referred to specialist palliative care services at a time when specialist palliative care teams can still be of help.

The use of an integrated care pathway can aid health professionals in providing better end-of-life care to patients, independent of their diagnosis, by providing tools for communication and symptomatic relief, and with involvement of the whole multidisciplinary team. The use of non-invasive ventilation has revolutionised care for patients with moderate to severe COPD who develop type 2 respiratory failure during exacerbations, with many patients now surviving such episodes. However, across Europe, around one-third of patients who die in hospital from COPD receive non-invasive ventilation during their last hospital admission and in some of these patients, the intervention is perhaps inappropriate [27]. There is a need to improve communication with patients about their diagnosis and prognosis, even during the final stages of the disease in those with non-malignant respiratory diagnoses, and greater support from specialist nurses and palliative care teams is required.

Hub and spoke methodologies to optimise care in complex cases

These methodologies will be particularly suited to conditions that require either complex diagnostics in a limited number of cases and are common, like sleep disordered breathing, or that require specific and expensive pharmaceutical treatment best administered in centres equipped to study rare conditions. Examples are neuromuscular disease, interstitial lung diseases and pulmonary hypertension. New treatment approaches for pulmonary hypertension have revolutionised this field and are rapidly following from the development of both knowledge about the disease and new biological treatments [28, 29].

Disease management programmes

COPD is a relatively new target for disease management or integrated care programmes, whereas asthma has long been a focus for such programmes, and can provide a template for respiratory disease management [30]. A major difficulty when developing disease

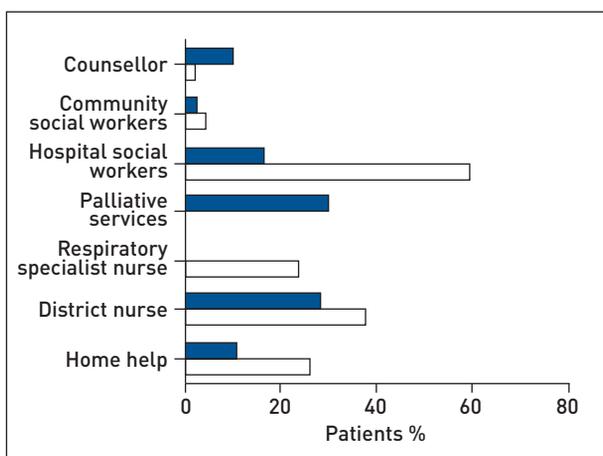


Figure 4. Services provided to patients with severe chronic obstructive pulmonary disease (white box) versus non-small cell lung cancer (blue). Reproduced with permission from the publisher [25].

management programmes in an area that has not previously been targeted is determining the outcomes that need to be monitored. In this area, experience in asthma management may provide direction for the management of other chronic respiratory diseases. Healthcare providers that manage patients with chronic respiratory diseases must use a variety of outcome measures to guide therapy.

Commonly used measures of pulmonary function are spirometry, lung volumes, gas transfer, peak expiratory flow and, occasionally, airway hyperresponsiveness. To use them effectively, clinicians must be aware of the information provided by these measures and the limitations of their use. Outcome measures related to quality of life provide information about a patient's level of everyday function. Further research is required

to better understand the relationship between these outcome measures, so that disease management programmes can be successfully implemented in future for COPD management.

Rare and orphan lung diseases

As a result of a growing awareness about orphan lung diseases (table 2), in the coming years there will be an apparent increase in the prevalence of, and mortality from, rare pulmonary diseases, in particular pulmonary fibrosis and other interstitial lung diseases [31], as well as pulmonary hypertension [32]. Currently, networks for the management of rare and orphan pulmonary diseases are starting to form, being mostly based on networks already existing in individual European countries. This is an

Table 2. Estimated prevalence (per 100,000) in Europe of some of the rare pulmonary diseases or diseases commonly affecting the lung.

Disease	Estimated prevalence
Acute respiratory distress syndrome	30
Idiopathic pulmonary fibrosis	27
α_1 -Antitrypsin deficiency	25
Systemic sclerosis	16
Sarcoidosis	15
Dermatomyositis, polymyositis	14.8
Bronchopulmonary dysplasia	13
Cystic fibrosis	12
Small cell lung cancer	10
Tuberous sclerosis	8.8
Combined variable immune deficiency	7.5
Wegener granulomatosis	6.6
Primary ciliary dyskinesia	5
Congenital lobar emphysema	4.5
Acute interstitial pneumonia	3.8
Hereditary haemorrhagic telangiectasia	3.5
Mesothelioma	2.7
Langerhans cell histiocytosis	2
Idiopathic or heritable pulmonary arterial hypertension	1.5
Interstitial pneumonia with anti-synthetase antibodies	1.5
Hypereosinophilic syndromes, including pulmonary eosinophilia	1.5
Agnesia of the trachea	1
Churg–Strauss syndrome	1
Goodpasture disease	0.64
Birt–Hogg–Dubé syndrome	0.5
X-linked agammaglobulinaemia	0.5
Atrophic polychondritis	0.35
Congenital dyskeratosis	0.1
Lymphangiomyomatosis	0.1
Alveolar lipoproteinosis	0.1

Infectious diseases are excluded from this list. Data are from www.orpha.net

encouraging development as, particularly for rare and orphan diseases, large-scale trials on a European scale are urgently needed for improved care [33].

Technology as an integral part of care pathways

Telemedicine is a potentially important way to monitor lung function at home, and it is very likely that some of the new non-invasive lung mechanics techniques will be miniaturised and become part of the routine evaluation of patients, signalling when their clinical condition deteriorates.

Use of activity monitoring, symptom diaries using telemedicine, and “physiological plasters” to remotely monitor patient key symptoms will become more prevalent in future. Telemedicine can also be useful in the follow-up of patients undergoing interventions such as home rehabilitation. This may increase patient access to this evidence-based therapy, and thereby alleviate what is currently one of the major problems in its implementation.

HOME CARE, TELEMEDICINE AND SELF-MANAGEMENT

Home care

Home care includes different aspects of care provided within the home of the patient. For example, home care can refer to episodic, often post-exacerbation care provided intermittently, palliative and end-of-life care, and chronic care, and it also includes home medical equipment (oxygen, nebulisers, non-invasive and invasive ventilation, *etc.*). Chronic bronchial diseases, such as COPD and bronchiectasis, with chronic infection will require more developed programmes of home care or home hospitalisation. Home care services can have very positive effects for patients with respiratory disorders, especially paediatric and geriatric patients. Telemedicine can be considered as an extension of home care, as it allows the patient to stay at home while remaining connected with healthcare professionals in order to ensure adequate monitoring of his or her condition.

In the field of respiratory medicine, telemedicine has shown some promising effects, especially for monitoring COPD and asthma patients. In the next 5–10 years, there is therefore potential to increase and improve the use of home care and telemedicine, to form

a valuable part of the disease management process and supplement conventional delivery techniques. In that respect, it will be crucial to ensure that new technologies are introduced adequately, so as to balance benefits and problems. However, in order to achieve this, appropriate training for healthcare workers will be necessary [34]: more information can be found in the Medical education and training chapter.

In the past years, efforts to provide a more integrated respiratory care have led to a shift from secondary to primary care, and to nurse-assisted home care. In such integrated care schemes, the role of the specialist nurse has become prominent. For the respiratory profession, producing clear clinical practice guidelines and protocols and delivering appropriate training to specialist nurses will be of utmost importance [3, 35, 36].

Self-management and the empowered patient

In future it will be essential to adopt an integrated and holistic patient-centred approach to long-term chronic conditions, such as respiratory diseases, encompassing disease prevention and promotion of lung health, early diagnosis, monitoring and education, coordination of hospital and community-based care and implementation of evidence-based guidelines.

Specialist consultation clinics should be considered in order to improve both the self-management of chronic conditions and the communication between the medical professional and the empowered patient. These models will include increased patient involvement in directing treatment, greater use of patient-reported outcomes, and evaluations of efficacy of treatment by patient reports *via* the internet, mobile phones and other interactive modes of communication, *etc.* At all times there also needs to be accessible, accurate and reliable patient information. Validated asthma control tests would further improve the potential for self-management.

NEW AND FUTURE TREATMENTS, DIAGNOSTICS AND TECHNOLOGIES IN RESPIRATORY MEDICINE

New medications and vaccines in respiratory medicine

Several new drugs are now in development for asthma and COPD, but it is unlikely that many of these will have advantages over existing therapies, in the

sense that they will bring about more symptomatic improvement, but unfortunately no real significant disease modification. Disease modification must be the focus of future research actions in COPD.

For respiratory infections, no new families of antibiotics are in the pipeline; therefore, strategies such as monoclonal antibodies acting against different strains of multi-resistant bacteria must be developed. Eradication of tuberculosis will require a much greater effort than is currently being delivered (fig. 5). Strong political influence is needed to foster the development of new formulations of antibiotics. Pneumococcal vaccination has proved to be beneficial. Further development of vaccines against respiratory bacteria and viruses will be needed. New insights into the antimicrobial response will help in the development of new strategies for fighting infection.

Clinical algorithms

For respiratory infections, excellent clinical algorithms need to be developed to include continuous care and integrated care, in order to prevent frequent unnecessary use of antibiotics.

Algorithms for the medical intensive care unit are also essential. Algorithms are intended to be used as general guidelines, and this approach could reduce

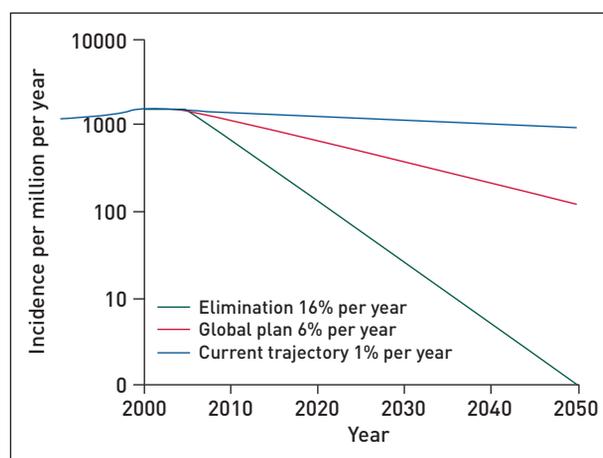


Figure 5. Full implementation of the global plan (and reaching the 2015 UN Millennium Development Goal) induces a 6% decline of incidence per year (red line), compared with the current trajectory of 1% per year (blue line); total elimination by 2050 would require a reduction of 16% per year (green line). Reproduced with permission [37].

mistakes in hectic moments when decisions are made. The standardisation of most activities in the acute critical care setting is vital in order to achieve the optimal management of diagnostic, therapeutic and clinical procedures.

Role of guidelines

Guidelines are an important tool for clinical management that should be subjected to a comprehensive evidence-based approach. A proper guideline programme leads to optimal management of respiratory disease, with improved outcomes and a reduction in health inequalities across Europe and globally. An important goal for the future will be the production of truly multidisciplinary guidelines, which is particularly important in patients (especially the elderly) with multiple chronic conditions. Guidelines need to be inclusive and produced in collaboration with the relevant stakeholders, such as patients and their organisations (W. Wedzicha, ERS Summit, Leuven, 2011; oral presentation).

To remain relevant, it is essential that guidelines are widely disseminated and updated regularly. Furthermore, guidelines need to be assessed in view of cost-effectiveness, and a structure for the management of the guideline programme needs to be set up. Such a structure for guideline management would include the following elements: establishing a steering group; appointing a technical team; prioritising the order of guideline development; developing and focusing the clinical and research outcomes; and establishing specific guideline development groups. In view of the growing complexity of guidelines it is crucial to, in future guidelines, include sections with summaries for lay people, discuss the role of new technology, and ensure guidelines answer clinicians' questions.

Registries

Registries constitute invaluable resources in medical research. Patient registries are valuable sources of medical and family history data and serve as a central information source where researchers can obtain data for analysis. Registries are needed to evaluate treatment on a group level, and for follow-up reports, long-term follow-up, national and international collection of data, building of consortia and increasing possibilities for funding on national and international levels.

Organ donation

The need for donor organs by far exceeds their availability. The shortage of donor lungs is the main reason why only relatively few lung transplantations are performed every year, despite the high effectiveness of this life-saving method in end-stage lung diseases (fig. 6).

For the next decade there is a need to promote and better coordinate organ donation within Europe, to promote the use of donation after cardiac death, extension of donor criteria, use of marginal donors, and most importantly, to further develop and extend the use of *ex vivo* lung repair [39–41].

Personalised medicine and targeted therapy

The concept of predictive and personalised medicine is a lifelong, individually tailored healthcare approach to the detection, prevention and treatment of disease based on an individual's peculiarities and genetic profile. The philosophy behind personalised medicine is that every patient has a unique biology and so predictive and personalised medicine deals with individual diversities and the complexity of the human body, taking into account environmental or external influences, such as lifestyle factors.

Personalised medicine is becoming relevant in the treatment of lung cancer [42, 43] and may have relevance for other lung diseases, like pulmonary fibrosis, asthma and pulmonary hypertension, but

disease-related basic research aimed at searching for biomarkers is needed to achieve personalised and patient-specific treatments for lung diseases. In these cases, treatment decision is based on an analysis of biomarkers of response and resistance to cytotoxic drugs. Targeted therapy will be the way to provide personalised treatment, by selecting therapeutic agents according to a target that has been identified on the patient's own tumour.

Multimodal treatment

Multimodal treatment is particularly relevant for lung cancer treatment: for the same stage disease, different modes of treatment apply, *i.e.* surgery, radiotherapy, chemotherapy and therapy with biological agents. The main treatments are, so far, (neo)adjuvant chemotherapy for early lung cancer, radiochemotherapy for stage III lung cancer, and stereotaxic radiotherapy (lung nodules and brain metastases). Further studies are required to improve the multimodal treatments that are used today and to develop new integrated approaches, *e.g.* anti-tumoural vaccination after surgery, tyrosine kinase inhibitors as adjuvant treatment, and local treatment combined with chemotherapy for oligometastatic disease. The role of positron emission tomography/computed tomography scan technologies with new markers has to be defined in the early assessment of treatment efficacy.

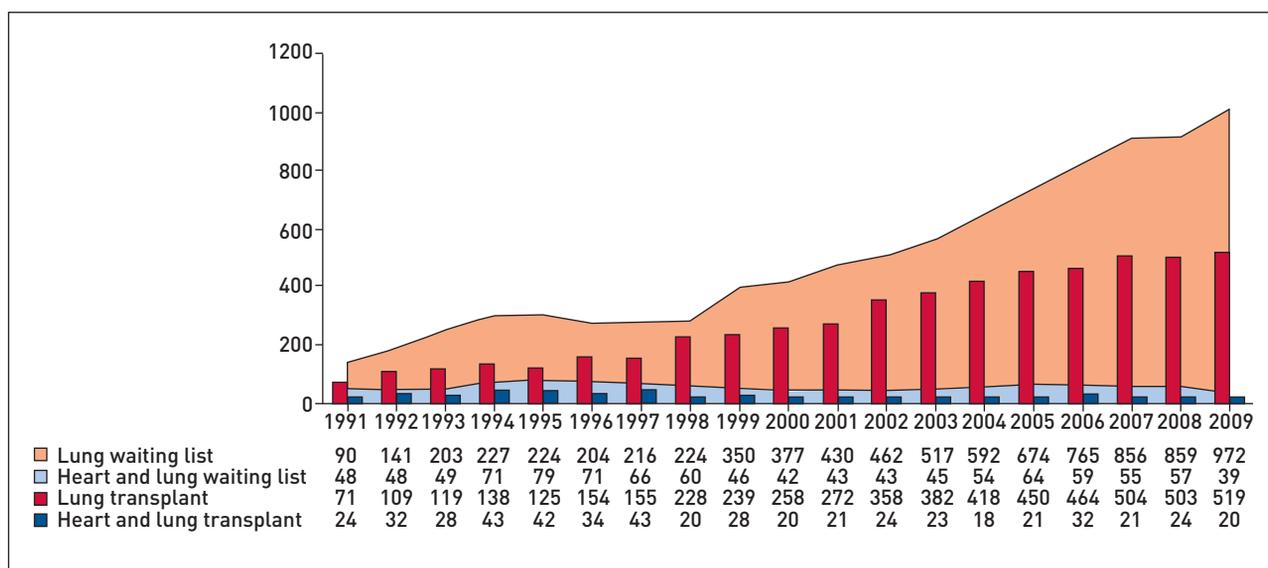


Figure 6. Dynamics of the Eurotransplant heart and lung transplant waiting list and transplants, and lung transplant waiting list and transplants, 1991–2009. Reproduced with permission from the publisher [38].

Diagnostic methods

There are a range of new diagnostic technologies that need to be evaluated and incorporated with our approaches to identifying and managing respiratory diseases. These include:

- Volatile compounds in exhaled air, and the electronic nose could be developed for differential diagnosis and detection of bacterial and viral infections in the airways [44].
- Metabolic imaging techniques to assess localised disease activities in the lungs [45, 46].
- Non-volitional methods of measuring lung function, such as impedance oscillation techniques, and use of “visiology” (the combination of imaging and physiological measurement), which can now be computerised and made relatively “user friendly”.
- Sensitive imaging techniques for the diagnosis and monitoring of childhood lung diseases.
- Non-invasive assessment of chest wall movement.
- Bioinformatics to help understand the complexity of asthma phenotype heterogeneity.
- Cystic fibrosis newborn screening and improved lung function testing to identify and treat infections at the earliest stage.
- Non-invasive biomarkers for early signs of irreversible (or reversible) inflammation in asthma, cystic fibrosis, primary ciliary dyskinesia, interstitial lung disease and chronic lung disease of prematurity, e.g. exhaled biomarkers in air and breath condensate.
- More specific molecular methods for identifying different strains of bacteria, viruses and fungi, e.g. *Pseudomonas* in cystic fibrosis and in the immune-compromised child.

Technological innovations

Technological innovations spanning the entire spectrum from diagnosis, treatment and management of respiratory diseases will have a key role and be an essential component in ultimately improving the quality of life and reducing hospitalisation of patients living with respiratory disease. Some examples are listed below, but many of these will still require extensive validation before they will be incorporated in clinical practice:

- Video-assisted thoracic surgery resulting in less post-operative pain and early recovery from operations with equal safety and efficacy of the procedures [47–50]. Future developments from these achievements will directly lead into robotic surgery and telesurgery.
- Laser energy as a surgical tool. Laser resections save a large amount of lung tissue that would be unnecessarily resected together with the neoplastic tissue in standard stapler resections. This technique significantly increases the number of metastases that can be resected in a given patient.
- Endoscopic techniques on the refinement of tissue procurement for diagnostic purposes.
- Novel intrabronchial delivery techniques of medication.
- Bronchial thermoplasty for severe asthma patients.
- Novel drug therapies and novel indications of drug therapy, e.g. tyrosine kinase inhibitors in lung disease other than lung cancer, biological treatments for asthma, COPD, cystic fibrosis and interstitial lung disease.

RECOMMENDATIONS FOR FUTURE CLINICAL CARE

General

- To address the shortage of healthcare workers in Europe (over 1 million by 2020), it will be essential to attract more healthcare workers, including physicians, nurses, dentists, pharmacists and physiotherapists.
- Improving quality of care will be an effective way to focus resources and avoid unnecessary uses of, for example, critical care.
- There is a need for robust and simple methods for screening, *e.g.* for sleep disorders, lung cancer, COPD and other chronic respiratory conditions, including infectious diseases.
- The role of guidelines in clinical management needs to be enhanced. Guidelines need to be inclusive and multidisciplinary.

Future shifts

- A shift from hospital-centred medicine to home care, and from physician care to nurse care and self-management, will be inevitable.
- Extensive use of modern technology (internet phones and application software) to improve patient access, patient information and disease monitoring will lead to cost savings.

Accessibility

- Accessibility to remain a key challenge in managing chronic respiratory disease. Tools and systems need to be activated across the health system to change the current dismal state of affairs.
- There is a need to optimise the availability, accessibility and quality of pulmonary rehabilitation in Europe, especially since it is acknowledged as cost-effective in patients with moderate or advanced COPD. Presently, less than 5% of eligible patients have access to rehabilitation.
- Improved access to end-of-life care, in particular for patients with non-malignant respiratory disease, is needed. Greater support from specialist nurses and specialist palliative care teams is required. Studies show that in the period leading up to death, only 2–3% of those dying from non-malignant disease access specialist palliative care [26].

Affordability

- To face the growing pressure on healthcare systems in Europe, governments must be efficient when allocating budgets for healthcare and these should be set at slightly above the GDP growth level to ensure a competitive and efficient system.
- Higher healthcare costs may be cost-effective, and generous welfare and healthcare systems may remain affordable if combined with strong incentives to work longer, as in the Scandinavian countries.
- More procedures need to be incentivised, such as lung function tests and tobacco dependence treatment, with obvious benefits, such as early detection.

Applications of existing tools

- Educational training programmes and guideline development will need to adapt to the emergence and application of new technologies for the benefit of patients.
- Experience in asthma management may provide direction for the management of other chronic respiratory diseases.

Future care models

- Integrated care models: the use of managed clinical networks, multidisciplinary teams and collaborative efforts across the lines of healthcare should be stimulated and funded.
- Multidisciplinary care teams are crucial for the optimal management of complex conditions, and will need to be further developed.
- The focus of chronic care models on advanced chronic conditions needs to be shifted toward addressing people in the early stages of chronic disorders. The ultimate aim should not be solely to manage disease, but to improve the prognosis of chronic disorders.

New treatments, diagnostics and technologies

- Personalised and targeted medicine for lung cancer and other lung conditions will see further breakthroughs.
- For the next decade there is a need to promote and better coordinate organ donation within Europe, to promote the use of donation after cardiac death, extension of donor criteria, use of marginal donors and, most importantly, to further develop and extend the use of *ex vivo* lung repair [39–41].
- Strong political influence is needed to foster the development of new formulations of antibiotics. Further development of vaccines against respiratory bacteria and viruses will be needed.
- Further studies are required to improve the multimodal treatments that are used today and to develop new integrated approaches, *e.g.* anti-tumoural vaccination after surgery.
- Many technological innovations for diagnosis and treatment are expected to reach the clinic following validation, such as video-assisted thoracic surgery, sensitive imaging techniques, use of tracer gases, regenerative medicine (*e.g.* in lung transplantation), nanoparticle-based carriers of inhalational drugs or bioactive compounds, personalised medicine (especially for lung cancer), bronchoplasty, laser energy as a surgical tool, and metabolic imaging techniques.

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