In January 2014, a report by experts at the London School of Economics and Political Science suggested that, despite the widespread adoption of costly e-rostering systems, hospitals were still losing £71.5m annually from their payrolls as a result of poor staff scheduling (Hockley and Boyle, 2014).

Fast-forward to 2019, spanning a turbulent period for the NHS that has included the fallout from the Francis report, Carter review and EU referendum. Today, NHS Improvement (2018) enthusiastically endorses e-rostering as “a pivotal function in healthcare delivery because it ensures staffing resources are appropriately allocated to provide a high-quality and efficient health service”. As a result, the recent NHS Long-Term Plan states that, by 2021, all clinical staff working in the NHS will be deployed using an electronic roster (NHS England, 2019).

Shortly after Hockley and Boyle’s report was published, Nursing Times published an article I had written – Drake (2014) – in which I acknowledged the benefits of e-rostering, but also highlighted a number of challenges created by the new systems (Box 1). Five years on, given the almost-universal adoption of e-rostering in the NHS, it seems appropriate to ask: have these dilemmas been resolved? And if so, how? Moreover, given a challenging healthcare environment, relentless workforce shortages and rapidly changing technology, what might be expected from e-rostering in the future?

This article takes stock of what has changed since 2014, whether old dilemmas have been resolved and which new ones have emerged.

Boundary dilemma solved?
Healthcare workforce planning and scheduling should be a single integrated process that is driven by care outcomes. Unfortunately, due to its complexity, the process was traditionally split into requirement planning, staff scheduling and re-allocation. In practice, demand changes constantly due to fluctuating patient flows and varying levels of acuity. As noted in Drake (2014), “current models of nurse rostering assume a static target while, in practice, that target changes frequently and unpredictably.”
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The situation has now changed – providers of e-rostering solutions have enhanced them by integrating acuity measurement systems, which are synchronised to hand-held devices, giving ward managers and nurses greater transparency about staffing level requirements than ever before. North Staffordshire Combined Healthcare Trust notes that its e-rostering system “gives real-time visibility of staffing levels across wards in relation to patient numbers and acuity; it responds in real time to roster changes and gives visibility of staffing changes and the impact on patient safety, on redeployments and on usage of temporary staff” (Murray, 2017).

Clearly, the boundary dilemma has been resolved – this technological challenge has generated a vital workforce planning enabler.

What do we mean by flexibility?

In 2014, I suggested that a technological resolution of the boundary dilemma might lead to “contracts comprising a specified number of hours that trusts may call upon at short notice, where all nursing hours are on-call hours” (Drake, 2014). This has not yet been the case but there are signs that, with the help of e-rostering, working practices are beginning to change. Such early signs can be found, for example, in the regionalisation of staff banks (Ford, 2017) and the development of dedicated teams, such as the responsive workforce team at Derbyshire Community Health Services Foundation Trust (Nursing Times, 2015). At a recent roundtable discussion, Mil Miljevic, product management director at e-roster provider Allocate Software, suggested that “the workforce of the future is going to require much more flexibility. It will be more integrated, less fragmented and more mobile” (Moore, 2017).

Regrettably, the term ‘flexibility’ often means different things to employers and employees. As the consultancy firm Time-wise (2018) observed: “one complication in the NHS is the use of the term ‘flexibility’ in projects to improve productivity and efficiency, often led by the use of technology. While this kind of ‘flexibility for cost-cutting’ can sometimes overlap with ‘flexibility for work-life balance’, it doesn’t always do so”.

For employers, flexibility is the capacity of the workforce to respond quickly to changes in service demand; for employees, it is rostering practices designed to give them greater control over when, where or how they work. The resolution of the boundary dilemma through technology has produced ‘just-in-time’ rosters, in which staff have little or no control over shifts. This exacerbates both the empowerment dilemma and the fairness dilemma.

Work-life balance

In 2014, NHS leadership adviser Sir Stuart Rose said “leadership, motivating staff and creating a culture where people are empowered to do things differently are crucial to the success of any organisation” (Department of Health, 2014). Such empowerment requires processes that increase staff autonomy and self-determination.

For nurses, the roster lies at the heart of achieving a tolerable work-life balance and, for many, it is where empowerment must begin. However, as the NHS Long Term Plan acknowledges, inflexible and unpredictable working patterns make it increasingly difficult for staff to balance their work and personal life commitments (NHS England, 2019).

“E-rostering systems must become both more intuitive and more intelligent”

Moreover, the results of the 2017 NHS staff survey suggest that e-rostering has, so far, done little to improve opportunities for staff-oriented flexible working – only 51.5% of nurses reported being satisfied with their opportunities for flexible working in 2015, and 52.1% did so in 2017. Many of those who left the NHS said they would stay if they were offered more control over their working lives (NHS England, 2019).

In shift-based environments, work-life balance is affected by three elements:
- Variability and/or predictability of the roster;
- Amount of staff input into the roster;
- How far in advance staff are notified about their shifts on the roster.

The problem for many NHS staff is not simply a lack of flexibility, but too much variability – something over which they have no control. As a result, 80% of nurses who work for agencies do so because it gives them more control over their shifts (Time-wise, 2018).

Sadly, for many nurses, e-rostering still symbolises managerial desire for control and monitoring. This view is supported by an analysis of roster policies in 47 trusts (Drake, 2017), in which productivity and monitoring were two of the trusts’ most commonly specified objectives. Interestingly, the most commonly specified objective was fairness.

Reconciling flexibility and fairness

While many systems claim to produce ‘fair’ rosters, none define the term, the assumption being that fairness equates to all staff being allocated a similar number of unsociable shifts and having a similar number of requests granted. This narrow, uni-dimensional perspective of fairness is then enforced by a handful of simple measures, such as the number of approved requests per person or rule as a percentage of shifts worked. Who decides what is fair? Are fairness and flexibility to be imposed from above or negotiated from below?

FlexAbility in Nursing is a collaborative project involving Birmingham Women’s and Children’s Foundation Trust, Nottingham University Hospitals Trust, University Hospital Southampton Foundation Trust and the Time-wise Foundation. Begun in 2017, its aim is to improve the degree of input nurses have into their schedule and its approach is to “create a team-based rostering process, which encourages open discussion and negotiation of all work-life balance needs, not just childcare” (Time-wise, 2018).

Box 1. The five dilemmas of e-rostering in 2014

- The ‘boundary dilemma’: staff rostering and staff requirements are managed as separate processes. What are the implications? How can this be resolved?
- The ‘empowerment dilemma’: rosters are regarded either as a symbol of managerial control or an instrument of staff empowerment. How can these views be reconciled?
- The ‘constraints dilemma’: how can roster rules be codified in software without making rostering rigid?
- The ‘robustness dilemma’: if auto-rostering can deliver more-robust rosters, why do many ward managers choose not to use it?
- The ‘fairness dilemma’: is it possible to define and standardise ‘fairness’ in a ward environment? If so, can e-rostering deliver it?

Source: Drake (2014)
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The opportunities for collaboration with staff that are provided by e-rostering make it a fundamental enabler of such initiatives. However, to fulfil this potential, e-rostering systems must become both more intuitive and more intelligent. It is time for manufacturers to tackle both the constraints dilemma and the robustness dilemma.

A wider usability issue
Drake (2014) noted that "one of the most important contributions of e-rostering is that it requires trusts to make rostering rules explicit. This introduces greater transparency to how rules are set and ensures that staff and managers understand the constraints that shape the roster". However, while the use of smartphones to book time off work has become intuitive, other aspects of current e-rostering systems remain obscure and difficult to use. For example, the workings of rules engines and the manipulation of the rules (or constraints) remain shrouded in mystery within the technology.

Many ward managers struggle to use the auto-roster function of the systems, but according to Maria Nicholson, head of workforce insight at NHS Professionals, they are still "held to account when they have had no training and support" (Stephenson, 2016). Even if ward managers have received technical training, circumstances on a ward often change faster than the rules can be updated. Inevitably, these rules are left untouched, simply because staff do not have the skills and/or time to change them.

Eventually, the daily ward environment ends up bearing little relationship to the rules programmed into the e-rostering system and ward managers find themselves fighting against the system, rather than using it. They avoid the auto-roster function, preferring to use the system manually – highlighting what I referred to as the robustness dilemma. Today, the constraints dilemma and the robustness dilemma of 2014 have merged into a more-general issue of usability.

Empowering staff
If staff are to be genuinely empowered and team-based rostering such as that proposed by the FlexAbility in Nursing project is to be successful, e-rostering systems must facilitate a collaborative approach to workforce planning. By working together on ‘what if’ scenarios, staff would be empowered to develop work patterns that would give them an optimum work-life balance, while simultaneously meeting the needs of the service.

To achieve this, staff need to fully understand the rules that govern their roster. They need to know how these rules interact, how they can be modified and, crucially, what they mean for their own roster. Existing e-rostering systems, which are based on static rules engines, require significant expertise and experience, which makes them difficult for all but specialist staff to understand, thereby impeding wider collaboration.

Recognising a usability skill gap beyond e-rostering, the final report of the Topol review on preparing the healthcare workforce for a digital future recommended that Health Education England established “a new NHS Digital education programme to oversee the implementation of a national digital education strategy for both the generalist and the specialist workforce” (HEE, 2019). However, extensive training of already-stretched clinical staff will be both difficult and expensive. Given the speed of technological change, it may also be pointless. Perhaps it is the e-rostering systems that need to be smarter, not the members of staff who are using them.

Intelligent e-rostering
Currently, two of the hottest topics in healthcare are artificial intelligence (AI) and predictive analytics (HEE, 2019) – these are defined in Box 2, along with other relevant technological terms. The NHS Long Term Plan recommends that AI be used to help “in applying best practice, eliminate unwarranted variation across the whole pathway of care, and support patients in managing their health and condition” (NHS England, 2019).

There are, however, significant barriers to the deployment of AI across the NHS, namely data quality, information governance and a lack of expertise. As the Topol review observes, “capability must be developed within the NHS to identify and understand algorithmic bias” (HEE, 2019). This means that staff procuring AI products will need significant support during evaluation and purchasing. However, it is in less-glamorous areas, such as e-rostering, that the immediate impact will be seen (Heitmueller, 2017).

Today’s e-rostering solutions work adequately, assuming all conditions under which decisions can be made are known ahead of time. Unfortunately, in complex, fast-moving staffing environments, this is simply not feasible.

The next generation of systems will dynamically adjust nurse staffing ratios according to each patient’s needs, as determined by intelligent algorithms. At the same time, these intelligent rostering systems will be ‘trained’ using historic roster data so they ‘learn’ how the ward works under different circumstances and can adjust the rules accordingly. As the ward changes, so will the number and types of rules. The new systems will optimise rostering, making it more efficient while also empowering staff. This is intelligent rostering.

Data is the key
The key to intelligent rostering is data. Alison Leary, chair of healthcare and workforce modelling at London South Bank University, notes that “this kind of modelling allows a lot of flexibility for people to put in what they know about their environment, ward and patients, and hopefully come out with an optimum caseload” (Stephenson, 2015).

Box 2. Glossary of technological terms
- **Artificial intelligence (AI):** the ability of computer systems to perform tasks that usually require human intelligence
- **Big data:** extremely large data sets that can be analysed to reveal patterns, trends, and associations
- **Cloud:** data centres available to many users over the internet
- **Machine learning:** application of AI to enable systems to automatically learn and improve from experience, without being explicitly programmed
- **Predictive analytics:** advanced analytics used to make predictions about unknown future events
- **Open-source software:** software for which the original source code is made freely available and may be redistributed and modified
- **Rules engine:** an application that manages decision processes using pre-defined logic to determine outcomes
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According to Allocate Software, its HealthRoster system schedules over a million NHS staff in more than 300 organisations (Bit.ly/AllocateHealthRoster). Every shift, request, leave, sickness, overtime, redeployment, rule breakage and bank duty is captured, along with the date each roster was opened, closed, changed, published and finalised. That data is increasingly stored in the cloud rather than on trust-owned servers.

The amount of data acquired is staggering – and it increases as each new roster is planned, approved and worked. It is this data that must be used to ‘train’ tomorrow’s intelligent rostering systems. Increasingly, big data will enable hospitals to accurately forecast patient demand, pull in the correct clinicians, anticipate point-of-care needs and optimise the rostering process.

To work optimally, a predictive staffing model needs to combine a wide variety of data, such as staff competencies, demographics, historical trends, holidays, geography, seasonal conditions, waiting times, patient patterns and acuity levels. Unfortunately, so far, initiatives have focused on individual factors. As Cooke and de Montfort (2018) noted, “healthcare is a complex adaptive system and predictive analysis needs to understand the interactions of multiple factors. This is now possible but very rarely undertaken ... In the NHS there is a perception that this cannot be achieved, even though many other sectors are doing so”.

Time for open-source algorithms

For intelligent rostering to be realised, at least three things need to happen:

- Today’s rules engines must evolve into machine-learning systems;
- Large volumes of data must become accessible;
- The quality of that data must be fit for purpose.

Possibly the biggest challenge in moving from static rules engines to machine-learning systems is commercial.

In its code of conduct for data-driven health and care technology, published in 2018 and updated in February 2019, the Department of Health and Social Care outlined 10 principles (Bit.ly/DHDataDriven-Code). Principle 7 states: “Show what type of algorithm is being developed or deployed, the ethical examination of how the data is used, how its performance will be validated and how it will be integrated into health and care provision”. However, rules engines – and, importantly, the algorithms that drive them – remain the closely guarded intellectual property of the e-rostering system providers.

The confidentiality surrounding e-rostering systems is in stark contrast to the huge amount of published research in the field of nurse rostering algorithms over the last 40 years. At events such as the International Nurse Rostering Competition, researchers strive to develop increasingly sophisticated algorithms to solve ever-more complex rostering problems; Ceschia et al’s (2015) article provides an example of this.

Commercially, the skills required to create intelligent rostering algorithms are scarce and expensive, and they change rapidly. Perhaps it is time for e-rostering providers to open up their algorithms, make them open source and, effectively, crowd-source their development. As Oliver Harrison, chief executive of Alpha Health, noted: “it’s essential to build systems that are independent of any specific supplier or solution. These must be scalable, so that new sets of records can be added ... Most importantly, the technology must be simple enough to empower staff” (Harrison, 2018).

At the very least, machine learning demands intense cooperation between the company developing the algorithm and the user providing the data. For example, Ultromics recently unveiled a machine-learning algorithm that had been ‘trained’ using 120,000 images to analyse echocardiograms to detect signs of disease. It was offered to NHS trusts free of charge in recognition of the role the NHS played in its development (Hughes, 2018).

NHS big-data initiative

The data science skills needed to make sense of huge volumes of information are no less scarce than those required to develop e-rostering algorithms (Noveck, 2017). However, beyond this skills shortage, the key challenges of any big data project are:

- Retrieving data from systems;
- Linking systems together;
- Confirming the quality of that data;
- Presenting it in ways that staff can use effectively.

In this regard, e-rostering has some advantages. The last decade has seen a consolidation in system suppliers: 10 years ago, six companies were providing first-generation e-rostering systems to the NHS but, by 2015, Allocate’s HealthRoster system was used by over 80% of e-rostered trusts. As a result, a substantial amount of NHS rostering data is held on similar systems – and increasingly on the cloud – making a future big-data initiative easier and faster.

Big-data initiatives are already being conducted at the Data Analytics Learning Laboratory, set up by the NHS Business Service Authority, and the NHS Digital data innovation laboratory. The data-quality team at NHS Digital currently assesses the quality of selected NHS data using four metrics – namely, coverage, completeness, validity, and the use of default values – to produce its quarterly Data Quality Maturity Index (Bit.ly/NHS-DigitalIndex). That team, or a similar one, could be quickly deployed to assess the quality of historical roster data and recommend changes to data structures where necessary.

As Noveck (2017) suggested: “regardless of the platform the NHS adopts, it needs to convene the different bodies already undertaking data analytical work, to compare research agendas, share learning, and identify gaps in its needs for data science skills”.

QUICK FACT

52.1% Percentage of NHS staff survey respondents happy with their opportunities for flexible working in 2017
Leadership challenge
There is perhaps a fourth, rather more mundane, challenge to be overcome before intelligent rostering can come to fruition: that of strategy and leadership. As the Topol review notes, “for new digital healthcare technologies to reach their full potential and deliver significantly better patient outcomes without the need to increase resources, the whole health and care system will need to anticipate and plan for the future (HEE, 2019).

After more than a decade of piecemeal adoption of e-rostering systems, the announcement in the NHS Long Term Plan that all NHS clinical staff will be rostered electronically by 2021 (NHS England, 2019) is a welcome, if belated, statement of intent. However, to date, much of the strategy underpinning the growth of e-rostering has been developed by system providers working with individual trusts, rather than by the whole health and care system. This has implications for future system functionality, integration and cost.

If, as stated in the NHS Long Term Plan, the service is to “make the most of the NHS pound” (NHS England, 2019), it is time for the NHS to take ownership of the strategy. Some companies may be reluctant to open up their algorithms, while individual trusts may be hesitant to share their data, but if intelligent rostering is to be achieved, both must be prepared to compromise.

Conclusion
People live longer and the demand for healthcare grows in line with the increase in age-related long-term conditions. The workforce is also changing. Many staff experience burnout, while others choose to leave the health service earlier in their career. Millennials joining the health professions do so with different expectations and aspirations than their older colleagues. Meanwhile, most staff seek a manageable work-life balance through flexible careers. As a result, the staff shortages that drove the initial growth of e-rostering systems have escalated alarmingly. In response, rostering systems have become increasingly sophisticated; unfortunately, this sophistication has led to ever-increasing complexity, making systems inaccessible to staff who do not receive in-depth – and expensive – training.

For staff, empowerment requires some control over their roster, something that is impossible if the rules and algorithms driving it are hidden behind impenetrable technology. Ironically, the solution may be to increase the level of technology by moving to machine learning and predictive analytics – in short, by making systems even smarter.

Clearly, there are challenges. The original roadmap to today’s rostering systems was developed primarily by technology companies working with individual trusts. In future, the NHS must take an approach that encapsulates the whole health and care system to ensure trusts and system providers are more transparent and open to collaboration.

The adoption of e-rostering in the past decade means the foundations of intelligent rostering systems have been laid. Many trusts now roster on a common platform with similar data structures – something that may prove to be crucial for the NHS and how it is resourced.

In my 2014 article, I concluded that “today’s systems, despite their limited functionality, are the forerunners of much more sophisticated systems that will change forever how nurses work” (Drake, 2014). Box 3 summarises where we are today in relation to e-rostering dilemmas.

Today’s e-rostering systems have reached a much higher level of sophistication, but if they are to bring about real change in how nurses work, they must do more: they must become intelligent. NT

Box 3. Dilemmas of e-rostering: where are we today?

- E-rostering systems, which are projected to roster all NHS clinical staff by 2021, have become increasingly sophisticated, but this sophistication has led to ever-more complexity, making systems unusable by staff without in-depth training.
- For nurses, ‘flexible working’ means a tolerable work-life balance, but the results of the NHS staff survey suggest that e-rostering has yet to empower staff to achieve this.
- Staff empowerment requires more control over rosters, but the rules and algorithms that govern rosters remain hidden behind impenetrable technology; the solution may be intelligent rostering driven by machine learning and predictive analytics.
- Today’s rostering systems were developed by technology companies selling to individual trusts; in future, the NHS must take an approach that covers the ‘whole health and care system’ to ensure algorithms are transparent and trusts share data.
- Many trusts already roster on a common platform with similar data structures, so the foundations of intelligent rostering have been laid – but who will provide the leadership?

References
Harrison O (2018) Why Data Sharing Fears could be Catastrophic for the NHS. med-technews.com, 5 May.

For more on this topic online
- Using data to show the impact of nursing work on patient outcomes. Bit.ly/NTOutcomesData