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[1] Introduction

The exponential growth and development of science and technology has changed the way the world addresses problems, particularly in the healthcare industry. Considering the critical nature and integral role this industry plays in our health and well-being, it is important that such technology is constantly revised and kept up-to-date with the latest advancements.

This report aims to gain an insight into the implications that science and technology has had, and continues to do, on advancements in the health sector. It addresses any social, moral or ethical issues that arise due to the implementation of new technologies and the legal implications that follow.

[2] History of Technology in the Health Sector

Technology has had an enormous impact on the world and the way we live, work, eat and sleep. Scientific research and innovation has driven technological advancements in all fields and industry. The health care industry in particular has taken advantage of such advancements in science and technology.

The 1960's saw the introduction of healthcare information systems for administrative and financial purposes. Mainframe computers were installed in large hospitals for centralised data processing. Medicare and Medicaid were introduced to help those who struggle to provide the income for medical costs.

The minicomputer debuted in the 1970's as hospital growth expands the healthcare environment. Medicare and Medicaid expenditures increase and there is a need for healthcare cost containment. Computer networks were created and utilised by mini-computers in healthcare. The implementation of new information systems saves money in the health industry.

During the 1980's, Personal Computers (PC) were introduced to the world, along with Local Area Networks (LANs) and Wide Area Networks (WANs). This was to facilitate the need for financial and clinical information on demand. Data processing was decentralised, and clinical information systems expanded.

The World Wide Web (WWW) was unveiled in the 1990's. Hardware costs are dropping, and the Internet is prolific. Healthcare organisations begin to take advantage of the Internet and there is a growing implementation of clinical applications. However, there is a lack of adoption of Electronic Medical Records (EMRs).

The 2000's utilise the Internet to a greater extent as wireless technology floods the market. Personal Digital Assistants (PDAs) are introduced to make it even easier to access information. Unfortunately, healthcare organisations struggle to implement EMRs. Furthermore, due to the large amounts of data now being stored, there is a resurgence of mainframe computers in order to handle enterprise wide applications.

Finally, 2010 to present day. Technology is advancing at an alarming rate. Technologies such as cloud computing and smart devices are being implemented to refine and build upon older technology. Bar codes and Radio Frequency Identification (RFID) tags are used to uniquely identify patients and provide access to patient health information. (Anon., 2014)

The reach of technological innovation continues to grow, changing all industries as it evolves. In healthcare, technology is increasingly playing a role in almost all processes, from patient registration to data monitoring, from lab tests to self-care tools. (Review, 2014)

[3] Advancements in Health

There has been myriad of technological advancements within the healthcare industry which as a result, has had a big influence on the industry as a whole. The following section describes some of the major and more recent technologies.

[3.1] Electronic Health Records (EHRs)

An Electronic Medical Record (EMR) is the standard format for medical and clinical data gathered in one providers office. An Electronic Health Record (EHR), however, encapsulates all external data to provide a more comprehensive patient history. The records can only be created, managed and consulted by authorised providers and staff in health care organisations. These records allow organisations to track data over time and identify patients who are due for preventative visits and screenings. Furthermore, they allow healthcare professionals to monitor how patients measure up to certain parameters like vaccinations and blood pressure readings. (HealthIT, 2017)

To put the magnitude of your Electronic Health Records into perspective, they include the following information;

- Administrative, Financial & Billing Data
- Patient Demographics
- Progress Notes
- Vital Signs
- Medical Histories
- Diagnoses
- Medications
- Immunisation Dates
- Allergies
- Radiology Images
- Lab & Test Results

(HealthIT, 2017)

[3.2] Telehealth Services

Telehealth is the remote exchange of data between a patient and their clinician via the use of telephone lines or wireless technology. This allows clinicians to assist in their diagnosis and monitoring. Patients with long-term conditions can sometimes have mobile home units that are used to measure and monitor vital signs such as temperature and blood pressure. Data collected via the home units is transmitted to a telehealth centre where it is monitored by a health professional. The data is then compared to parameters set by the individuals clinician and an appropriate response is made.

There are real benefits for both the patient and the clinician. It allows the clinician to proactively involve themselves with the wellbeing of their patient, while managing interventions to help improve their patients' quality of life. Furthermore, the patient has more control and understanding of their health conditions. A study carried out by the 'Whole System Demonstrator' programme found a 15% reduction in visits to

Accident & Emergency (A&E), a 20% reduction in emergency admissions and a 45% reduction in mortality rates due to the introduction of telehealth services. (TSA, 2017)

[3.3] Sensors & Wearable Technology

Recent advances and development in telecommunications, micro-electronics and sensor manufacturing has opened up new possibilities for wearable technology. The production of micro-circuits and controllers with the integration of wireless and sensor technology has produced discrete wearables such as watches and bands.

This technology plays a crucial role in health and wellness monitoring. By combining physiological sensors with activity monitors, disorders can be detected early, facilitating timely medical interventions. Furthermore, many sensors and wearables have been developed for safety monitor. This includes the detection of falls, seizures and heart attacks in older people and susceptible individuals. The devices can then send a message alert via the Internet to an emergency response team. Additionally, like telehealth services, this technology provides a cheap and easy means for home rehabilitation for physiotherapy, heart disease and ageing individuals. (Innovatemedtec, 2017)

[4] Benefits of Technology

Technology has provided several passive benefits for the health industry, opposed to the major advancements mentioned above. The following section highlights such benefits.

[4.1] Cutting Costs

Most people assume that medical technology is an expensive luxury. However, use of the right technology can in fact reduce the overall cost of medical treatment and ultimately improve patient outcomes. One major improvement that reduces expenditure is improving and expediting diagnosis. In the past, to make a diagnosis, a clinician may have conducted a biopsy which is time consuming and requires multiple appointments. This means lots of money is spent on staff, equipment and consumables. In contrast, newer technology allows ‘virtual pathology; where diagnostic tests are performed on the patient in real time.

Furthermore, technology has advanced disease prevention. For example, DNA Sequencing technologies have the potential to reduce the overall cost of treating a patient. This enables more personalised therapies which reduces drug waste and any associated time costs. Doctors can sequence a patient’s genome in order to select the specific therapy that will be the most cost effective. (Robin Lee, 2013)

[4.2] Increased Diagnostic Accuracy

Newer diagnostic technologies are able to detect smaller and milder abnormalities in humans. These technologies play an important role in the healthcare work system and more specifically in the diagnostic process. See Appendix A. New imaging techniques can detect such abnormalities which are symptoms of the early development of terminal illnesses such as cancer. This allows doctors to administer treatment for the prevention of these illnesses as early as possible. (LTH Tan, 2002)

Research shows that there are several opportunities to reduce diagnostic error through electronic clinical documentation. A reduction in such errors would ultimately prevent time and resource wastage, but allow for a more accurate diagnosis. For example, maintaining a dynamic patient history would carry forward information for recall. This would avoid repetitive patient querying and recording, while minimising copying. Furthermore, it would provide helpful feedback that would upstream to clinicians, therefore facilitating learning from the outcomes of diagnostic decisions. A study documented in the New England Journal of Medicine discusses several more of these opportunities. See Appendix B for the full table. (Care, et al., 2015)

[4.3] Speed of Workflow

One major technology that has increase the speed of workflow in health environments is the implementation of 2D Barcodes. Patients are provided with a lightweight bracelet with a printed barcode that uniquely identifies them. This provides a quick, accurate method of data entry, allowing time to be spent increasing efficiencies instead of manually entering data. Some of the benefits include; inventory control; material tracking and patient validation. (barcode, 2012)

Another technology increasing time efficiency is the aforementioned implementation of Electronic Health Records. Six studies were conducted to measure the time efficiency increase due to EHRs and the use of bedside terminals and computerised systems. They reported a reduction in documentation time when using a computer. The relative time differences ranged from -2.1% and 45.1%. Considering the magnitude of the upper bound, it is clear that such technology has caused a drastic decrease in time spent, and therefore, an increase in the speed of workflow. (Lise Poissant, 2005)

[5] Moral, Social & Ethical Issues

A vast industry such as healthcare, to no surprise, raises lots of moral, societal and ethical issues. This section covers some of the more major and controversial issues raised due to the advancements made in the industry.

[5.1] Privacy & Confidentiality

Electronic Health Records contain sensitive information that should be private to the patient and therefore should be kept secure. They contain information such as billing data, medical history, vital signs and allergies.

Organisations that either store or access EHRs must conform to The Data Protection Act (1998) which declares that information is used fairly and lawfully, kept safe and secure and is used in a way that is relevant and for the stated purposes. (gov.co.uk, 2017) In order to preserve confidentiality, it is important to ensure that only authorised individuals have access to the information. Such authorised individuals are required to authenticate themselves via a two-tier approach using biometric methods such as palm, finger and retina scanning. The information is also distributed about a hierarchy of access levels that are granted to these individuals relative to their role in their organisation. For example, a nurse and a receptionist have access to different information that is relevant to their role. This ensures that access is kept as strict and tight as possible. (Laurinda B. Harman, 2012)

[5.2] Diagnosis & Treatment Prioritisation

The high cost of manufacturing and implementing new diagnostic technologies means they must be used selectively. Such availability problems cause controversy regarding who should get to use them. This raises lots of questions such as;

- Should we treat everybody equally, irrespective of their social status?
- Should 'important' people such as doctors and government be prioritised?
- Smokers. Are they entitled to treatment at all, if its ultimately their choice?
- Is age a factor? Children, Adults, Elderly. Who do we treat first?

These are just a few of the controversial issues that are raised relating to society, morals and ethics. Nurses rely on principles of justice. To make decisions, they use certain rules to determine which factors should count. For example, gauging their urgency based on how life-threatening an ailment is.

Another rule of justice is the protection of safety to patients and nursing personnel which is applicable to everyone. The attention to the safety of patients is strengthened by the obligation not to harm. Therefore, this covers both short-term and long-term problems. In the short-term, this prevents immediate harm such as drug error. It also prevents long-term permanent problems such as back injuries. (Amy Haddad, 2008)

[5.3] Increasing Life Expectancy

The industrial revolution brought forth advancements in science and technology which led to a significant reduction in the amount of deaths. It helped increase food production and distribution; improve public health via clean water and sanitation; and newer medical technology such as vaccines and antibiotics. Today, the problem is every growing worse. As of November 2017, the world population is estimated to be 7.6 billion.

As a result, more problems were introduced into the already over-problematic industry that is healthcare. We see a rise in age-related chronic illnesses such as heart disease, cancer and diabetes. This warrants a need for specialised health care workers and long-term healthcare. Ultimately, costs increase and the drain on resources does too. (Technologies, 2015)

The question we then need to ask ourselves is, should we continue to spend time and money treating older individuals, merely to preserve their existence? Is it fair that a retired, elderly person should take the hospital place of a young, aspiring individual? Numerous controversial issues are raised and question our morals and ethics.

[6] Legal Implications of Technology in Healthcare

Working as a computer or systems specialist, it is important to be aware of current legislation affecting computing professionals. The following section outlines 3 major pieces of legislation and describes the implications they have on individuals working in the field.

[6.1] Health and Safety at Work Act (1974)

Circa 1974, approximately 8 million employees had no legal safety protection at work. The HSW provides the legal framework to promote, stimulate and encourage high standards of health and safety in places of work. It protects employees and the public from work activities. (rbkc.gov.uk, 2017)

Some of the employers' responsibilities are as follows;

- To provide a safe place of employment and working environment
- To provide and maintain safety equipment
- To ensure materials used are properly stored, handled and transported
- To provide written safety policy/risk assessment documentation

Likewise, employees also have responsibilities enforced by a Local Authority Environmental Health officer. Employees must;

- Take care of their own health and safety, and that of other persons
- Co-operate as instructed with their employers
- Not interfere with anything provided in the interest of health & safety

The aforementioned responsibilities are particularly important in computing within healthcare given the nature of the industry. Health and Safety Executives can carry out inspections in organisations to ensure that they meet the standards. If a company failed to meet the minimum standards, both the employers and employees can face prosecution leading to fines in the Magistrates Court and jail in the Crown Court.

[6.2] Computer Misuse Act (1990)

The Computer Misuse Act is designed to protect computer users from threats such as cyber-attacks and theft of information. This includes offences such as hacking, accessing computer systems without authorisation and spreading malicious software.

Unauthorised access includes the modification of software and date, changing passwords or other settings to prevent other users from access a system and interfering with the normal operation of a system to its detriment. Even if an attacker attempts to penetrate a systems security but is unsuccessful, they can still be prosecuted using this law. (swa.org.uk, 2008)

Therefore, it is important that healthcare organisations ensure their online systems and databases have very tight security and preventative measures for such attacks.

[6.3] Data Protection Act (1998)

The Data Protection Act controls how personal information is used by organisations, businesses and the government. It defines a number of 'data protection principles', some of which are;

- The data is used fairly and lawfully
- Kept for no longer than absolutely necessary
- Kept safe and secure

- Used for limited, specifically stated purposes

Stronger legal protection exists for more sensitive information like sexual health, criminal records and political opinions. (gov.co.uk, 2017)

The Information Commissioner's Office (ICO) is responsible for enforcing the DPA and penalising those who breach it. Over the last 10 years, they have increased the number of fines issues for DPA related offences. In fact, the total fine for major offences increase by £2,957,500 in 7 years (from 2010). Appendix C illustrates the rise in thousands of pounds since 2010. (itgovernance, 2017)

[7] Author's Personal Experience

I personally have experienced both the positive and negative impacts of technology in the health sector.

One of the positive impacts is the advancement of sensors and wearable technology. I've had an Apple Watch since they were first released, and recently upgraded to the latest model, the Series 3. The watch comes in 38 or 42mm variants, is very light, waterproof and has some serious technology for it's form factor. It has a dual-core processor, built in Wi-Fi and Bluetooth, GPS, a barometric altimeter, heart rate sensor, accelerometer, gyroscope, ambient light sensor and 8GB of storage. Not only is it great as a customisable watch, but it has lots of other real-word applications too. I personally use mine every day at the gym. It tracks all my workouts. The duration, heart rate over time, calories burnt, distance and stores all this on my phone where it is archived and visualised. This functionality also integrates with 3rd party developers' apps such as MyFitnessPal. This is an iOS app that is used for tracking your calorie and macro-nutrient intake. The pedometer readings from the watch automatically updates MyFitnessPal and alters my daily calorie value. I've also created a custom face for use at the gym that has a stopwatch, a timer, the current time, the workout app and my currently playing music with controls. This is just one of the major uses I get out of wearables like the Apple Watch. (Apple, 2017)

Unfortunately, some of the technology has a negative impact due to poor implementation, particularly in administration. My local doctors' surgery released an online appointment booking and management site called 'EMI Patient Access'. Its goal was to provide patients with the ability to book their appointments online instead of having to endure the arduous morning call queue on the phone, only to find out there are no appointments left. Although it's intentions were good, it immediately failed, with no acknowledgement why. It simply didn't work, error messages were displaying information that there were no appointments, even though the displayed calendar showed none.

These are just two examples of a positive and a negative impact that technology has had on my life. There are lots more, but ultimately, it has had a greater positive effect that it has negative.

[8] Conclusion

In conclusion, the advancement of technology is going to continue to shape the future of the health care industry. As the world population continues to increase and

the number of patients grows, our reliance on technology to provide quicker and more accurate treatment and diagnosis increases. Moral, social and ethical issues will continue to cause controversial decisions to be made. Furthermore, as the technology becomes more sophisticated, even more sensitive data will be stored electronically. This means that security and data protection will be paramount and more of a concern that it currently is.

To summarise, although the implementation of technology has some negative implications on the health care industry, it has ultimately had a very strong impact on the effectiveness of our diagnosis and treatment of illness.

[9] Glossary of Terms

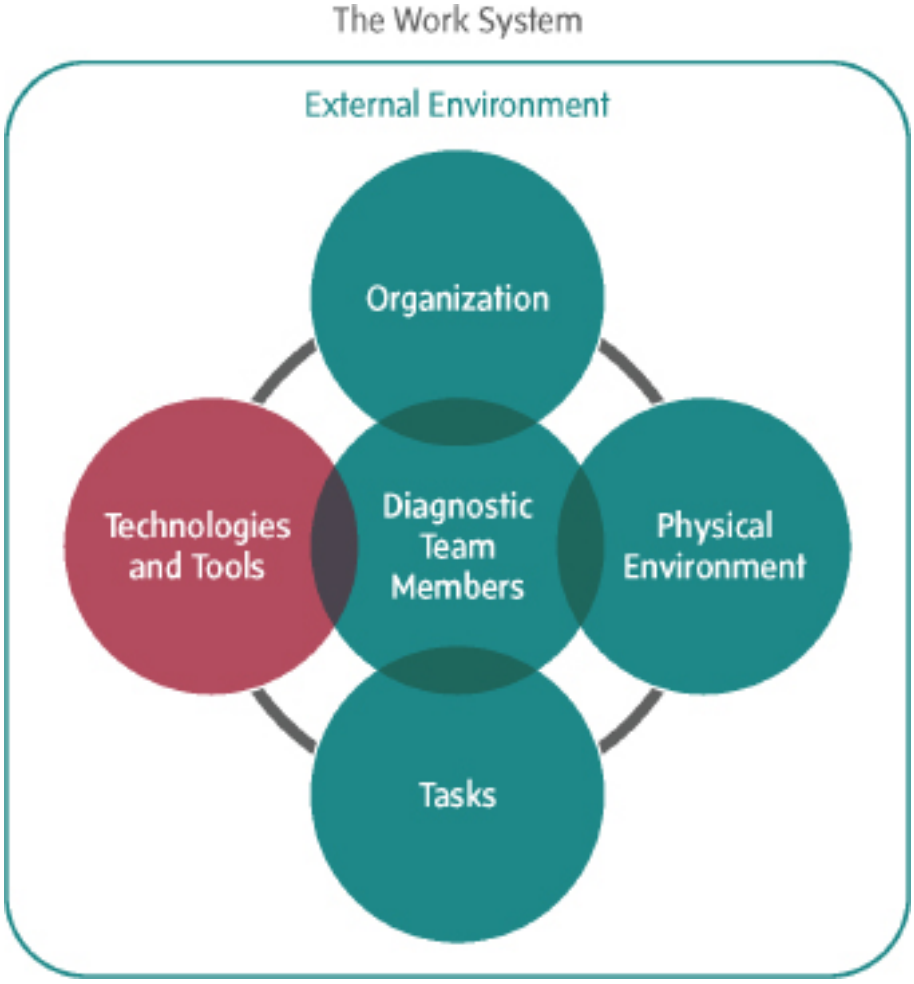
Term	Definition
2D	Two-Dimensional. Having or appearing to have length and breadth but no depth.
Accelerometer	An instrument for measuring the acceleration of a moving or vibrating body.
Apple	A manufacturer of computers and consumer electronics that is the world's most valuable company. Due primarily to the iPhone, Apple became the most profitable company in 2014. Apple was founded in a garage on April Fool's Day 1976 by Steve Wozniak and Steve Jobs.
Barometric Altimeter	The aneroid altimeter is calibrated to show the pressure directly as an altitude above mean sea level, in accordance with a mathematical model atmosphere defined by the International Standard Atmosphere (ISA).
Biometrics	The measurement and statistical analysis of people's physical and behavioural characteristics. The technology is mainly used for identification and access control, or for identifying individuals that are under surveillance.
Bluetooth	A standard for the short-range wireless interconnection of mobile phones, computers, and other electronic devices.
Clinician	A doctor having direct contact with patients rather than being involved with theoretical or laboratory studies.
DNA	Deoxyribonucleic Acid. A self-replicating material which is present in nearly all living organisms as the main constituent of chromosomes. It is the carrier of genetic information.
DPA	Data Protection Act (1998). An act of the United Kingdom (UK) Parliament defining the ways in which information about living people may be legally used and handled. The main intent is to protect individuals against misuse or abuse of information about them.
EHR	Electronic Health Records. Similar to an EMR, except it goes beyond the data collected in the providers office and includes a more comprehensive patient history.
EMR	Electronic Medical Record. A digital version of a paper chart that contains all of a patient's medical history from one practice

Genome	The haploid set of chromosomes in a gamete or microorganism, or in each cell of a multicellular organism.
GB	Gigabyte. A unit of information equal to one thousand million (109) or, strictly, 230 bytes.
GPS	GPS, which stands for Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.
Gyroscope	A device consisting of a wheel or disc mounted so that it can spin rapidly about an axis which is itself free to alter in direction. The orientation of the axis is not affected by tilting of the mounting, so gyroscopes can be used to provide stability or maintain a reference direction in navigation systems, automatic pilots, and stabilizers.
HSE	The Health and Safety Executive. The UK government body responsible for enforcing health and safety at work legislation.
HSW/HASAW	Health and Safety at Work etc Act 1974. An Act of Parliament is the main piece of UK health and safety legislation. It places a duty on all employers "to ensure, so far as is reasonably practicable, the health, safety and welfare at work" of all their employees.
ICO	The Information Commissioner's Office. In the United Kingdom, is a non-departmental public body which reports directly to Parliament and is sponsored by the Department for Digital, Culture, Media and Sport (DCMS).
iOS	An operating system used for mobile devices manufactured by Apple Inc.
LAN	Local Area Network. A group of computers and associated devices that share a common communications line or wireless link to a server.
Mainframe Computer	A data processing system employed mainly in large organizations for various applications, including bulk data processing, process control, industry and consumer statistics, enterprise resource planning, and financial transaction processing.
mm	Millimetre. one thousandth of a metre (0.039 in.).
MyFitnessPal	MyFitnessPal is a free smartphone app and website that tracks diet and exercise to determine optimal caloric intake and nutrients for the users' goals and uses gamification elements to motivate users.
PDA	Personal Digital Assistant. A palmtop computer that functions as a personal organizer but also provides email and Internet access.
Pedometer	An instrument for estimating the distance travelled on foot by recording the number of steps taken.
Physician	A person qualified to practise medicine, especially one who specializes in diagnosis and medical treatment as distinct from surgery.

Processor	Referring to the letter 'P' in the acronym 'CPU'. This is a Central Processing Unit. Sometimes referred to simply as the central processor, but more commonly called processor, the CPU is the brains of the computer where most calculations take place.
WAN	Wide Area Network. A geographically distributed private telecommunications network that interconnects multiple local area networks (LANs).
Wi-Fi	A facility allowing computers, smartphones, or other devices to connect to the Internet or communicate with one another wirelessly within a particular area.
WWW	World Wide Web. The World Wide Web (abbreviated WWW or the Web) is an information space where documents and other web resources are identified by Uniform Resource Locators (URLs), interlinked by hypertext links, and can be accessed via the Internet.

[10] Appendices

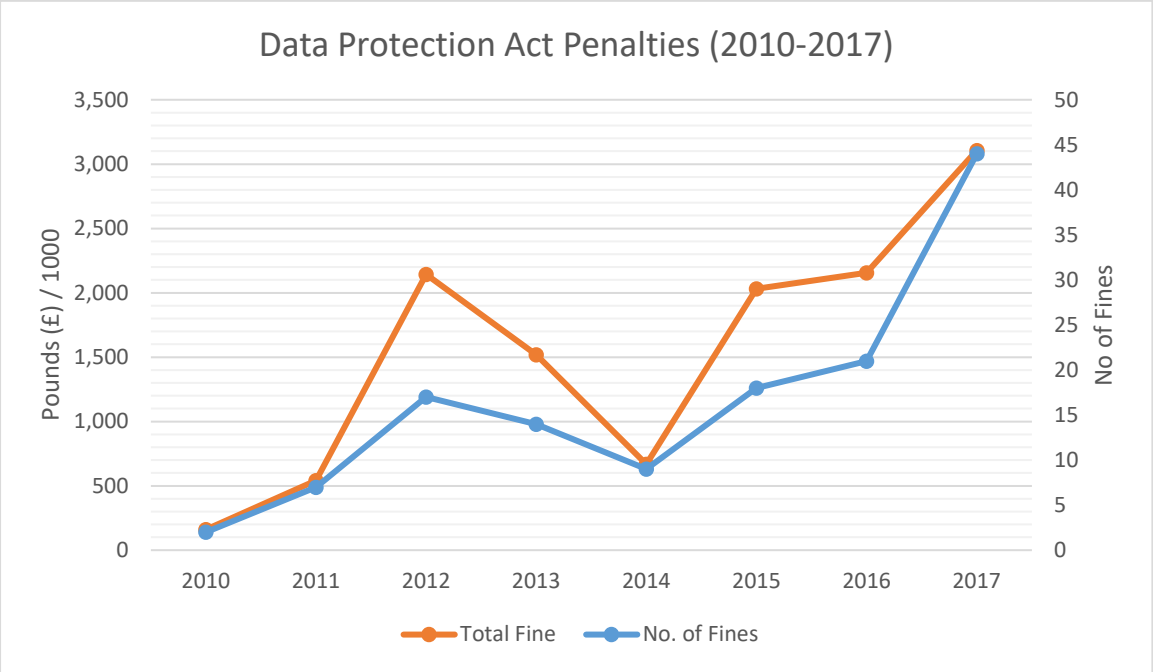
[10.1] Appendix A – Healthcare Work System Diagram



[10.2] Appendix B – Opportunities to Reduce Diagnostic Error

Role for Electronic Documentation	Goals & Features of Redesigned Systems
Providing access to information	Ensure ease, speed, and selectivity of information searches; aid cognition through aggregation, trending, contextual relevance, and minimizing of superfluous data.
Recording and sharing assessments	Provide a space for recording thoughtful, succinct assessments, differential diagnoses, contingencies, and unanswered questions; facilitate sharing and review of assessments by both patient and other clinicians.
Maintaining dynamic patient history	Carry forward information for recall, avoiding repetitive patient querying and recording while minimizing copying and pasting.
Maintaining problem lists	Ensure that problem lists are integrated into workflow to allow for continuous updating.
Tracking medications	Record medications that the patient is actually taking, patient responses to medications, and adverse effects in order to avert misdiagnoses and ensure timely recognition of medication problems.
Tracking tests	Integrate management of diagnostic test results into note workflow to facilitate review, assessment, and responsive action as well as documentation of these steps.
Ensuring coordination and continuity	Aggregate and integrate data from all care episodes and fragmented encounters to permit thoughtful synthesis.
Enabling follow-up	Facilitate patient education about potential red-flag symptoms; track follow-up.
Providing feedback	Automatically provide feedback to clinicians upstream, facilitating learning from outcomes of diagnostic decisions.
Providing prompts	Provide checklists to minimize reliance on memory and directed questioning to aid in diagnostic thoroughness and problem solving.
Providing placeholder for resumption of work	Delineate clearly in the record where clinician should resume work after interruption, preventing lapses in data collection and thought process.
Calculating Bayesian probabilities	Embed calculator into notes to reduce errors and minimize biases in subjective estimation of diagnostic probabilities.
Providing access to information sources	Provide instant access to knowledge resources through context-specific “infobuttons” triggered by keywords in notes that link user to relevant textbooks and guidelines.
Offering second opinion or consultation	Integrate immediate online or telephone access to consultants to answer questions related to referral triage, testing strategies, or definitive diagnostic assessments.
Increasing efficiency	More thoughtful design, workflow integration, and distribution of documentation burden could speed up charting, freeing time for communication and cognition.

[10.3] Appendix C – Data Protection Act: Increasing Monetary Penalties



[11] Version Log

Version	Description	Date
1.0	First Draft (Start)	21/10/2017
1.1	First Draft (Completed)	10/11/2017
1.2	First Revision	28/12/2017
2.0	Second Draft (Completed)	

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