A Review of Clinical Research Incorporating Artificial Intelligence Analyses

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Abstract: Artificial Intelligence is increasingly being used in medical research and certain clinical practice areas. This article examines selected literature to identify common themes with an idea to understanding the impact, concerns and opportunities afforded by such technology. Such research is markedly different from established research methodologies and so is challenging to assess and evaluate. The complexity of the analytics and applied statistics makes it difficult for many to understand and yet conclusions drawn can have a significant impact on clinical practice and policy, funding and recording practices. The key themes identified are those of accuracy, population bias, database limitations, cost- and time-savings, and the ability to use artificial intelligence to predict future events or outcomes. In addition, certain dangers are highlighted and a few recommendations made.

Keywords: Artificial intelligence, Machine learning, Delivery of health care, Deep learning

1. Introduction

Public health policies are informed by research into best practice and this is determined through evidence-based research. Research relies on the analysis of various kinds of data which is generated through carefully designed studies, but also through the provision of healthcare services where it is saved in a multitude of databases from pathology laboratories to funder systems and electronic health records. Vast quantities of information are now available for interrogation and new methods which increasingly rely on complex digital processes are impacting the health industry in a tangible way.

The technology behind the utilisation of data in this way is artificial intelligence (AI) which is a branch of computer science that enables computers to simulate intelligent behavior. Machine learning on the other hand is “the science of getting computers to learn and act like humans do, and improve their learning over time in autonomous fashion, by feeding them data and information in the form of observations and real-world interactions” [1]. This is a departure from rules-based programming that instead relies on the scripting of very detailed and complex algorithms to evaluate data. The computerised deep learning process that takes place makes use of neural network architectures to enable machine learning that improves analysis over time and with the expansion of the database. A key contribution of machine learning relies on its ability to uncover hidden relationships between data entries.

This article explores published literature to ascertain the extent to which AI is being used and accepted in current medical research, and also to determine the accuracy of such applications. Furthermore, an indication of the cost savings is a point of interest. These are thought-provoking questions which impact directly on the healthcare working environment but more importantly, as they are increasingly embraced and accepted within industry, so the need for non-IT professionals to have a working understanding of AI increases.

The Lancet [2] aptly states: “2017 has marked a step change for AI in health care… With this change, the skills required to understand the informatics of large datasets, and the insights that can be drawn from them, have become an essential pillar of clinical practice, alongside evidence-based medicine.”

The aim of this review is to present themes identified in healthcare research so as to understand the evidence- and financial-impact of the use AI interrogation in current clinical research.

2. Methods

The strategy used to guide the literature search identified articles published in English between 2013 and 2018. PubMed and Google Scholar were searched using combinations of relevant key words: machine learning, delivery of health care (and healthcare), and deep learning. Given that AI is a relatively new field, numerous variations in definitions and terminology abound and so very specific search terms were avoided. Figure 1 presents the search results. When the articles were reviewed and the definitions of in- and exclusion applied, the material identified was found not to be very numerical in nature, excluding the need for statistical analysis. This article therefore presents and discusses the key themes distilled.
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The research into AI and machine learning marks a clear
departure from standard research methodology in that
enormous amounts of data already exist. The data is
generally quantitative in nature but can also be qualitative. In
addition large image databases exist and these have been
used to draw conclusions via AI interrogation with a high
degree of accuracy. The use of machine learning in the
analysis and diagnoses of radiology scans is a particularly
successful application. Significantly though, no matter the
type of data, it must all be digitally labelled and curated in
order for it to be useable within the AI arena.

A second significant fact is that the database needs to be
very large and able to store information gained from
different kinds of studies and diagnostic tests.

Given these realities, it was not possible to evaluate the
evidence utilised in the identified studies, or to place them
within the accepted academic hierarchy of evidence. On
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complex, and difficult to understand and interpret by a
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and computer science underpinning these. Similarly, the
study designs and methodology used in each article are not
comparable with traditional research approaches designed to
assess clinical evidence.

4. Discussion

A number of themes were identified in the articles even
though the focus of investigation was diverse. The themes of
accuracy, bias, database limitations and cost- and time-
saving were uppermost. The ability of AI to predict future
trends also came to the fore.

4.1 Accuracy

The accuracy of AI analyses is completely reliant on data
quality, and if this is lacking, then so will be the results.
Furthermore the repetition of investigations through robust
testing should produce similar results, but if the data
available is limited, then the ability to test is affected and
levels of accuracy become difficult to determine. When
multiple results are evaluated, the research team must be able
to conclusively state that the AI is sufficiently accurate to be
useful when applied in the field. However, this particular
challenge results in an interesting paradox as the detailed
nature of AI analyses expose inconsistencies within the
database, resulting in it not being able to consistently
perform the task at hand. On the surface this appears to be a
problem of accuracy when in reality it speaks to
inconsistencies in the data.

4.2 Population bias

The fact that AI research relies on datasets introduces a
population bias by default as the population sample excludes
everyone whose results are not uploaded into the database.
Where health inequity or dual healthcare systems exist,
datasets could exclude significant segments of a population
which would skew results. Minority populations could either
be excluded, or their unique circumstances not captured
within the data. For example, an analysis of the Twitter stream
investigating public perception to certain vaccines
produced valuable information but its insights are limited to
Twitter users and are not necessarily generalisable to the
broader public [3].

4.3 Limitations of database

The limited nature of databases was found to impact on the
results, accuracy and transferability of conclusions drawn
from the data. Although the ability to predict clinical risk
(e.g. an asthma attack or cardiovascular event) by using
machine learning analyses of clinical data has shown
promise [4], [5], its usefulness has been diluted by
insufficient potentially relevant data. Digital information on
environmental, behavioural, genomic or cultural factors are
not often recorded and so not factored into the algorithm
applied to the data.

4.4 Cost- and time-saving

In instances where positive results were produced from the
algorithms, it was shown to deliver cost savings. In one
institution, the ability of an algorithm to successfully predict
objective remission with thiopurines reduced the need for a
pathology test which resulted in a cost saving of $75 000 [6].
In Japan, machine learning was successfully used to develop
a virtual health check-up which was able to predict
hyperuricemia amongst high risk individuals [7]. If
implemented in Japan, it will largely eliminate the need to
administer a serum test which could lead to a saving of around $408,960 per annum.

By extension, the analysis of additional datasets once an algorithm has been developed can be achieved with relative ease. The successful analysis of public sentiment to certain vaccines in Twitter data produced valuable information which was used to inform public health campaigns. These algorithms could for example be modified to examine sentiment in response to other public health initiatives such as the sugar tax.

It is clear that in instances where an algorithm extracts value from relationships between pieces of data, it can lead to cost savings in clinical practice and also be modified so as to identify other relationships of clinical significance. Large investments in time and expertise in the initial research lessons over time as the methodology is replicated in subsequent projects.

4.5 Ability to predict

Chronic diseases and comorbidities are an increasing problem in healthcare and any automated process to predict the need for intervention will help to manage conditions and avoid treatment in an advanced disease stage. In the literature analysed, a number of AI algorithms were designed to predict specific exacerbations (e.g. asthma attacks) or disease progressions (e.g. diabetic retinopathy) with varied levels of success. An examination of the challenges experienced highlighted the importance of quality, complete and well curated datasets, and the impact of the clinical complexity being investigated. The different machine learning approaches and statistical models currently available have been used to generate predictive risk models and the relative strengths of each have been contrasted. In some instances, these were successful and could be implemented within a clinical setting where improved care and cost savings could be realised. Others were inconclusive and instead areas of improvement were identified to ensure future progress.

As healthcare systems are required to meet the needs of growing numbers of people with increasing disease burdens, so the need for a reliable assessment tool that can generate a credible problem list from data routinely entered into an electronic health record becomes imperative. Additional tools like virtual health check-ups which are able to flag people with imminent health needs will enable qualified practitioners to act on high risk individuals timeously. As the ability of AI to predict outcomes and disease progression improves, so too will these tools, and their ultimate impact on health systems will be immense.

5. Conclusion

AI and machine learning tools interrogate existing databases and so traditional evidence based research methodologies, interventions and outcomes measures are no longer directly applicable. Each published article reviewed here adopted a unique approach to examine the chosen dataset so as to identify trends and draw conclusions around the accuracy, generalisability and transferability of the new methods of analyses across data. In essence, new standards and norms for future healthcare research are being established through such groundbreaking work.

Looking to the future, it is recommended that healthcare practitioners embrace the drive to ensure that data is collected in such a way that it can be used for machine learning. Furthermore, it is important that practitioners in the clinical space be trained to understand this new research field so that they can critically assess its usefulness, accuracy and applicability. There is a great danger that the lack of skills to evaluate and critique such information will lead to a manipulation of results in favour of secondary agendas. This would defeat the gains made and could cause great harm to public health. Ultimately however, clinical research cannot rely only on statistical analyses of databases. It must integrate these insights together with aspects of being human that cannot be assimilated into data fields as these are often critical and able to influence the overall interpretation of a study. A close, mutually respectful relationship must therefore exist between the programmer designing the algorithm, data analyst and clinician when AI is implemented in medical research.

6. Declarations

The authors declare that they have no competing interests

References


Author Profile

Sonya Reid received a B.A. and M.A. degree in English Literature from the University of Pretoria in 1992 and 1996, respectively. From 1996-2011 she worked in various communication and education posts, including Early Learning Development for hearing disabled and also orphans and vulnerable children. After qualifying as a Paramedic she worked in the pre-hospital space from 2012-2015. Since 2017 she has furthered her studies in Public Health and worked in Managed Health Care where she focuses on cost containment interventions, case management, disease programmes and the monitoring of health trends across different medically insured populations. She currently works for AfroCentric Health in Johannesburg, South Africa.

Dr. Vikram Niranjan, is a public health specialist whose research focus areas are public patient involvement, cancer research, quality of life, mix method studies, health promotion programmes, health promoting within schools, tobacco control and oral health. He achieved his doctorate with distinction and has received recognition as an academician and dentist. He has over 6 years teaching at dental school in India and supervising postgraduate and PhD students. He has been an international speaker at international conferences and has presented several papers at conferences. He is the winner of the “Outstanding Dentist of the Year - 2016" in India by Famdent organisation for his excellent clinical and dental public health practice.