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Algorithm for comorbidities, associations, length of stay and mortality (ACALM)

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“The dream is personalized medicine and the ability to create a mechanism whereby using the data in big data groups such as ACALM, patients can be evaluated according to their characteristics and with a high degree of certainty, we can deliver patient-specific diagnostic and management options for their needs holistically.”

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Over the past few decades, the concept of evidence-based medicine has developed with randomized controlled trials taking over as the gold standard underpinning clinical guidelines that are closely followed by doctors today [1–5]. In parallel, over the last 20 years, the growth of computerization has rapidly transformed healthcare in developed countries [6–10]. We now live in a medical environment where details of patients' histories, outcomes have been recorded for a variety of purposes ranging from hospital payments, physician billing, monitoring, insurance and in some cases for research purposes [11–13]. The value of the multidimensional information recorded was and is still unknown and therefore underutilized. Medicine is entering a new era – a digital era – where personalized medicine will be the norm using insights from such data [14,15].

Only a decade ago, data had to be collected and analyzed, often not in quantities large enough to show something that has not been done before. One needed grants, pharmaceutical funding etc., to run clinically impacting randomized trials and/or the status of a professor to run clinically relevant registries.

These challenges bore the idea of utilizing data which had been collected for other purposes rather than collecting data specifically for every project which is practically onerous. The compilation of the first algorithm for comorbidities, associations, length of stay and mortality (ACALM) dataset took almost 2 years of painful manual coding using a range of skills in IT and other self-taught skills but resulted in a dataset of 250,000 patients. A quarter of a million patients for medical research in 2007 was almost unheard of. We quickly went to work to utilize the research dataset by looking at diabetes, Alzheimer's disease, dementia and other psychiatric conditions [16–21].

All our research holds the same amalgamation code underpinning everything. Talking of coding, the process took 2 years the first time, 2 months when further hospitals collaborated, 2 weeks subsequently and now approximately 2 days.

ACALM actively explored associations including the suggested associated pathophysiology between breast cancer and cholesterol in mice [22]. A conclusive association in humans was not present at that time and utilizing ACALM, we found a significant association between high cholesterol and breast cancer in 664,000 women [23]. There was widespread media interest in this work including, a report in the TIME magazine postulating potential treatment strategies to tackle this association, including statins [24]. This was a turning point for ACALM because overnight we became internationally known. In 2016, we extended this research and showed that high-cholesterol patients in the four most common cancers in the UK, namely breast, prostate, colorectal and lung had significantly improved long-term mortality pointing to further investigation of the potential role of lipid lowering therapies, such as statins in their management [25,26].

Subsequently, ACALM development became easier and collaborations happened at a faster rate including finding acceptability among the medical and scientific community regarding the methodology. Big data in my view is the

concept of amalgamation of available data for a variety of purposes as opposed to collection of data for a specific purpose [16,27]. Second, the analysis of the available data using a variety of strategies including machine learning could lead to findings that are not possible to think of otherwise. Traditionally in medicine, we always tried to answer a preset hypothesis with a carefully designed study. Now we generate hypotheses from the results of big data analyses, and in future I am sure, we will in real time be able to integrate research and clinical practice into one seamless entity with advanced technology [16,27]. One of the main areas where this would be particularly helpful is in the fields of cancer and cardiovascular disease which combined contribute to the majority of deaths in the developed world [27,28].

When 67-year-old patient A walks through the hospital door with hypertension, diabetes, high cholesterol, strong family history of breast cancer and dyspnoea with a 2-month history of weight loss, what is their diagnosis, what is their treatment, how will they do and how can we optimize their quality of life and avoid unnecessary hospital admission? Comparing characteristics of patient A with millions of patients before and their outcomes using real-time machine learning algorithms and treatment has the potential to answer a lot of the above questions while also adding one more patient to the database for increased accuracy which can be used when patient B walks through the door. Adding more points of data such as laboratory tests, imaging and other profiling factors such as weight/height/demographic, for example, would lead to increased granularity which will allow for better prediction. The technology is already available, we see evidence of it every day when we undertake a Google search and find advertisements related to our search and in the media we have recently seen examples of the potential for harm from this type of technology as the Cambridge Analytica data scandal [29].

The ACALM algorithm has now been expanded to not only evaluate information cross-sectionally but also to follow patient journeys through longitudinally which gives us the ability to develop disease and patient group specific risk scores on a scale not seen previously. In the UK, our studies have highlighted the ‘weekend effect’ – a phenomenon where patients admitted to hospitals outside of normal working hours and at weekends have worse long-term outcomes in spite of adjustment across a number of conditions such as acute coronary syndrome, heart failure, atrial fibrillation [30–34]. We were also the first to show the role of weekend discharge from hospital having a significant impact on long-term mortality in a 1 million patients over 14 years [30–34]. We are currently undertaking research looking the impact of weekend effect in individual conditions and particularly in cancer, access to imaging and related conditions such as palliative and supportive care. We have shown that marital status has a significant impact on long-term outcomes in patients with cardiovascular events such as acute coronary syndrome as well as risk factors such as hypertension, diabetes and hyperlipidemia [35,36]. I think our finding showing that married patients having better outcomes is a proxy for psychosocial support mechanisms present in relationships manifesting as improved outcomes. In fact, the impact of mental health on physical health is something we have investigated thoroughly, showing that mental health cannot be taken lightly and clearly more needs to be done [37–39]. More research is required evaluating mental health and psychosocial issues in patients with cancer and we are actively working on this at the moment. Our long-term aim is to evaluate the combined impact of cancer and cardiovascular disease [28]. I am convinced that the two biggest killers in the developed world interact with each other in ways we do not know and there are many more findings like the association between breast cancer and cholesterol that ACALM and big data research can uncover in due course.

The dream is personalized medicine and the ability to create a mechanism whereby using the data in big data groups such as ACALM, patients can be evaluated according to their characteristics and with a high degree of certainty, we can deliver patient-specific diagnostic and management options for their needs holistically. In order to get there, ACALM needs to grow much bigger with multiple facets and harness technology from Silicon Valley giants and perhaps collaborate with other big data networks.

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