

Artificial Neural Networks in Diabetes Healthcare Professional Education

- Effective Diabetes Education Now (EDEN)

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Across the UK, the NHS faces a common challenge – up-skilling hundreds of thousands of healthcare professionals¹ to care for 2.9 million people with diabetes² and ensuring a consistent level of care from across practices and CCGs. The costs of manually identifying and tracking diabetes training requirements are likely to be considerable, but artificial neural networks³ offer us a potential solution.

Key decision making areas for a neural network include determining *which* healthcare professionals (HCPs) need diabetes training, *when* action needs to be taken (e.g. when diabetes update training has lapsed) and *where* (e.g. where training is most needed geographically). In this article, we explore how this decision-making process can be automated, by utilising a computational model with some similarities to biological neural networks known as an artificial neural network.

Effective Diabetes Education Now (EDEN),⁴ plans to utilise neural networks to identify training needs. EDEN is a comprehensive training package developed by Leicester Diabetes Centre which aims to up-skill healthcare professionals to provide high levels of diabetes care, and reduce hospital admissions and referrals to specialist care. EDEN utilises a mixture of training needs analysis, taught courses, e-learning, and train the trainer approaches to up-skill diabetes healthcare professionals. We describe both how machine learning is playing an increasingly important role across diabetes and how we have utilised feed forward neural networks specifically in diabetes healthcare professional education.

Assessing Diabetes Training Needs

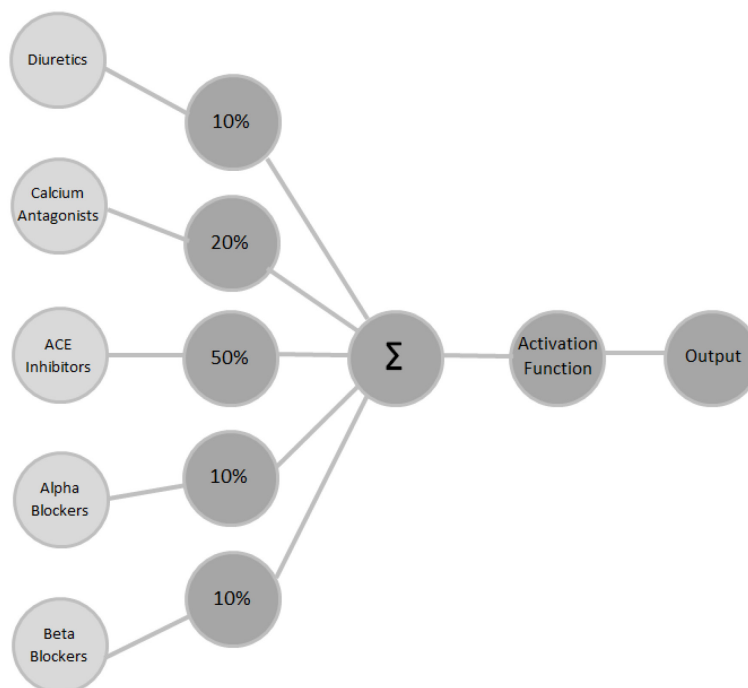
In order to assess diabetes training needs amongst HCPs, we collected data on HCPs' responses using questionnaires with multiple choice knowledge and confidence questions. Nearly 400 surveys have been collected to date from 139 practices across six CCGs. Participation has been voluntary and each CCG encourages as many healthcare professionals as possible to take part. HCPs are asked to indicate how confident they feel on a Likert scale in relation to 11 key diabetes competency areas when completing our knowledge and confidence survey. These responses to the 73 questions on the multiple choice survey were used as the raw input for a decision tree algorithm to process. Responses provided by Leicester City CCG HCPs, were analysed by the algorithm, looking for scores of less than two relating to course-specific questions, before checking if the individual had attended, and if not, whether they've booked before emailing them. Across the eight modules, a mean average of 18.9% of HCPs went on to attend the course, with the top four courses' response rates ranging between 23-27%. Given the pressures and demands on busy doctors and nurses' time, we are particularly pleased with these results, and hope to increase uptake further through the provision of e-learning for those who, particularly with staff shortages or difficulties arranging cover, cannot attend our full-day or two day face-to-face courses. For CCGs like Lincolnshire West, our system gathered together individual knowledge and confidence survey results to provide a colour-coded baseline of mean average knowledge and confidence levels across all participating practices to identify both strengths and weaknesses and to plan training provision. Sarah Dunderdale of Lincolnshire West CCG, who has utilised this training needs analysis, said: "The needs analysis enabled us to see graphically which of our practices needed support in developing

their capabilities. It was clear we had a lot of variation and enabled us to target training and actively seek participation in the right place.”

Use of neural networks in training needs assessment

We plan to implement a neural network approach to these algorithms where the decision as to whether to trigger an EDEN training recommendation is dependant not on a single knowledge area but scores in *multiple* clinical areas. When making a decision, there may be some indicators that are more clinically important than others, in relation to patient safety and other factors, and this is where neural networks come in. Siqueira-Batista et al. state that artificial neural networks “have been increasingly used in medical teaching, since they are a computer model extremely useful for solving complex clinical problems.”⁵ The diagram below shows a simplified example of the feed forward neural network we will use to make these kinds of decisions.

Fig.1 A Simplified Feed Forward Neural Network in Diabetes HCP Education (Blood Pressure Management Example)



The EDEN project uses a Training and Overview Database application (TOD) to determine diabetes training recommendations for healthcare professionals using algorithms. In the example above, the TOD has to decide whether to recommend training for a HCP. Fifty per cent of its decision whether to recommend a blood pressure management module is dependent on an individual’s score on the ACE inhibitors question, one of 73 questions in the multiple choice knowledge and confidence survey used by EDEN. A further 20 per cent is based on their score in relation to calcium antagonists and then equally dependant on a further three factors. TOD takes all the scores into account multiplying them by their associated weightings before making its decision on training needs. It then goes on to analyse whether the individual has already attended or booked relevant EDEN training to decide whether training or mentoring is more appropriate.

Box Out : Examples of Artificial Intelligence and Machine Learning in Diabetes

Neural networks and machine learning tools are already being used in a number of contexts within diabetes. Royal Free NHS Hospital Trust (London) have shared 1.6 million patient records with Google, whose A.I. application DeepMind will send alerts to healthcare professionals (HCPs)⁶ and Google are partnering with NHS Moorfields Eye Hospital to use DeepMind to analyse one million eye scans, with a view to diagnosing diabetic retinopathy and age-related macular degeneration.⁷ Feedforward neural networks have been used for the diagnosis of diabetes in conjunction with the Pima Indians Diabetic Dataset⁸ and for the detection of pre-diabetes and type 2 diabetes in India.⁹ Elsewhere, A.I. is being used to help diabetes patients better navigate health and lifestyle decisions,¹⁰ identify the risk of readmission for patients with diabetes,¹¹ or to connect HCPs and patients with smart insulin pens.¹² Multilayer neural networks trained to predict patient well-being in diabetes¹³ and to detect neuropathy in type 2 diabetes mellitus are already in use.¹⁴

Prioritising Training Needs amid Scarce Resources

Of course, decision-making is rarely that simple. A CCG may not always have the resources to train everyone that needs training, and this means making a much more complex decision as to which training need is the most *urgent*? For example if there are three practices, each of which have a GP identified by the TOD as needing training in Clinical Presentation and Management of Micro/Macro Vascular Complications, limited funding availability will mean that there is a need to prioritise who needs training most urgently. The TOD could simply compare each of the three HCPs knowledge and confidence levels, and identify the one with the lowest score but there may be other factors that will need evaluation.

In this scenario, it could be that the first GP works in an inner city practice where diabetes prevalence is at 10%, whereas the second works in a more rural practice where prevalence is just 4%, and the third GP's practice also has a high prevalence of 8%, but he or she differs from the first practice in having yet to complete any specific diabetes education. These are all factors in the decision-making process, and for this reason, we are now using multilayer neural networks to be able to take these kinds of factors into account.

Figure 2 – Determining Healthcare Professional Diabetes Training Needs Using Practice Demographics



Hidden layers or functions like the one above can choose an appropriate set of weightings taking account of a practice's demographic profile when assessing training needs. They enable us to consider factors like the number of people on the diabetes register, the proportion of patients with diabetes, deprivation levels, population growth and so on. Above, the weightings can potentially change for a practice working extensively with patients with diabetes from various ethnic backgrounds, in assessing training needs. There are several advantages to this flexible approach in that (1) a CCG has the possibility of identifying and prioritising those HCPs with the most urgent training requirements; and (2) individual HCPs benefit from a decision making process that takes account of both (i) their individual need and (ii) the particular characteristics of the practice in which they are based.

How could Artificial Neural Networks Benefit the Healthcare Professional?

EDEN provides opportunities both for healthcare professionals who are new to diabetes and unsure of where to begin meeting their up-skilling needs through to analysing the training needs of more seasoned diabetes professionals looking to grow and develop their skills and knowledge further. It also provides an opportunity to get a useful baseline of where they are now, and to chart their skills development confidence over time which is useful for training and education portfolios including appraisals, training plans and revalidation needs or requirements. For a CCG, the numbers of HCPs identified by the neural networks who need training, along with the mean average of knowledge and confidence scores provide an invaluable snapshot of knowledge and confidence level across practices, and identifies possible EDEN courses to cover them.

In conclusion, neural networks have great potential in modelling healthcare professionals' training needs and adding more detail than decision tree algorithms. Their flexibility enables them to take account of many variables that go into a decision on who might benefit from attending training and determining the level of urgency of their training need. Practice demographics from deprivation levels, prevalence, and age range to ethnicity can influence that decision-making process. Neural networks may have a potential wider application in healthcare professional education beyond diabetes including areas such as cardiology or dermatology which are also based around certain core competences and key performance indicators.

The Future

The future of diabetes healthcare professional education is likely to be much more focused around the individual and their learning rather than one-size fits all. Neural networks can be used not just to make decisions about their training recommendations, but to predict what training content would be most appropriate and engaging to a particular learner. The key is in making use of analytic data to refine the user experience. Not only should the HCP learn from the e-learning, but the e-learning should learn from the healthcare professionals. It should analyse the time spent on each section, the efficacy of learning in each competency area covered by the course (revealed through each exercise and assessment) and directly through user ratings on the usefulness of video clips, case studies, journal resources and the like. In short, the future e-learning we envisage is tailored both to the type of learner and their working environment, with the neural network using each analytic input and its corresponding weighting to determine what content it should display. As computing power continues to grow,¹⁵ neural networks and machine learning more generally are set to play an increasingly important role in diabetes education, so there are interesting times ahead.

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