Chapter 27
An Artificial Neural Network Classification of Prescription Nonadherence

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ABSTRACT

This study investigates the use of artificial neural networks (ANNs) to classify reasons for medication nonadherence. A survey method is used to collect individual reasons for nonadherence to treatment plans. Seven reasons for nonadherence are identified from the survey. ANNs using backpropagation learning are trained and validated to produce a nonadherence classification model. Most patients identified multiple reasons for nonadherence. The ANN models were able to accurately predict almost 63 percent of the reasons identified for each patient. After removal of two highly common nonadherence reasons, new ANN models are able to identify 73 percent of the remaining nonadherence reasons. ANN models of nonadherence are validated as a reliable medical informatics tool for assisting healthcare providers in identifying the most likely reasons for treatment nonadherence. Physicians may use the identified nonadherence reasons to help overcome the causes of nonadherence for each patient.

INTRODUCTION

Prescription (pharmaceutical) treatment plans require a specific pharmaceutical drug to be taken in specific amounts at specific intervals for a specific period of time. Nonadherence is the violation of any of these specified treatment requirements: not taking the correct dosage (too little or too much), missing or delaying scheduled administrations of the pharmaceutical, or not completing the treatment (Hugtenburg et al., 2013). Nonadherence to pharmaceutical treatment plans is a worldwide dilemma and prior research results examining the rate of nonadherence in 20 countries are shown in Table 1. As

DOI: 10.4018/978-1-7998-1204-3.ch027

may be seen, documented nonadherence rates vary in different cultures, but range from 10% to 88%. Prescription nonadherence is a persistent problem in healthcare today (Lehane & McCarthy, 2007) and nonadherence through underuse of a medication is rising significantly in prevalence (Kirking et al., 2006).

Nonadherence, especially to antibiotics and antimalarials, causes increased risks to the population by enabling evolution of resistant strains of malaria and other diseases (Andrajati et al., 2016; Awad & Eltayeb, 2007; Okuboyejo, 2014; Pechère, 2001) and harms population health by promoting further spread of diseases due to resulting ineffective treatment (Andrajati et al., 2016; Awad & Eltayeb, 2007; Center for Disease Control, 2013; Gibson et al., 2011; Okuboyejo & Eyesan, 2014). The Center for Disease Control states that pharmaceutical treatment nonadherence leads to significant economic and well-being impacts with direct costs estimated at $289 billion annually and 125,000 deaths annually (Center for Disease Control, 2013).

Reasons for patient nonadherence with the pharmaceutical portion of their treatment plans vary. Self-medication is a rising worldwide problem (Agarwal, Yewale, & Dharmapalan, 2015) especially in regions of the world where antibiotics and other medications are available without prescription, and has been identified as a contributing factor to improper treatment including nonadherence to recommended treatment plans (Awad & Eltayeb, 2007; Grigoryan et al., 2006; Zhu et al., 2016). Other reasons for pharmaceutical nonadherence are: cost of medication (Center for Disease Control, 2013; Gibson et al., 2011; Hirth et al., 2012; Kirking et al., 2006), negative attitude toward drug or don't like taking drugs (Kirking et al., 2006; Okuboyejo, 2014; Urquhart, 2005), lack of time/employment/travel (Au et L., 2014; Okuboyejo, 2014), don't trust or other issues with physician (Okuboyejo, 2014, Zhu et al., 2016), lack of (Kirking et al., 2006; Urquhart, 2005), forgetfulness (Au et al., 2014), religious or cultural reasons (Urquhart, 2005), fear of side effects (Gottlieb, 2000; Kirking et al., 2006), and other personal reasons (Urquhart, 2005). It is important to note that each patient may have multiple reasons for being nonadherent (Okuboyejo, 2014; Urquhart, 2005).

Various methods have been proposed to lessen nonadherence, including: better physician-patient communication (Agarwal, Yewale, & Dharmapalan, 2015; Buckalew & Sallis, 1986; Okuboyejo, 2014), other patient education (Oyelami, Okuboyejo, & Ebiye, 2013), and sending automatic reminders (Eyesan & Okuboyejo, 2013; Okuboyejo, Omoregbe, & Mbarika, 2012). Each of these proposed solutions is generic for a whole population of patients and typically addresses only a single reason for nonadherence. Identifying an individual patient's specific reasons for nonadherence would enable tailored individualized responses to address the reasons for nonadherence relevant to each patient. An artificial neural network (ANN) informatics tool to predict the nonadherence reasons for individual patients is developed based on Social Learning Theory. The ANN is tested for predicting individual nonadherence reasons on a population of patients in Nigeria.

BACKGROUND

Brief Background on Artificial Neural Networks

ANNs are nonparametric machine learning systems inspired by the human brain and composed of processing elements arranged in layers and highly interconnected (see Figure 1) (Caudill, 1987). Each connection is initially assigned a randomized value or weight. Input layer nodes receive raw numeric values representing the independent variables. Additional processing nodes are arranged into some number of