Using IoT, AI and cloud technologies to advance home-based integrated care

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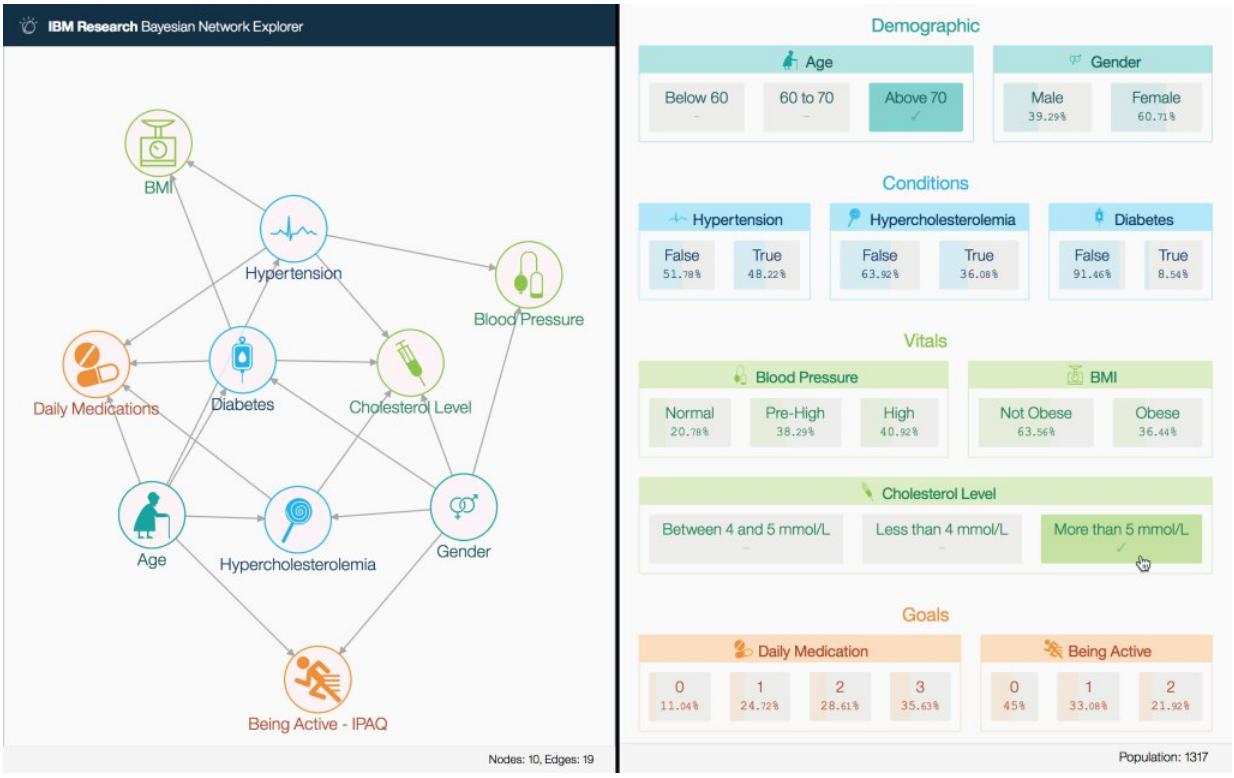

Figure 1: HW Profile User Interface

One of the largest growing demographics in the EU is individuals aged 65 and over, and two thirds of this group are in situation of multimorbidity, i.e., perons who suffer from two or more chronic diseases. The ineffective treatment of multimorbidity has been pointed

out as an urgent problem to address by the Academy of Medical Sciences in a recently released report. As part of an EU H2020 funded project called ProACT, our team at IBM Research – Ireland is working with partners in academia and industry to find new ways to use IoT, AI and cloud technologies to advance self-management capabilities and home-based integrated care for Persons with Multimorbidity (PwM).

The ProACT project is investigating ways wearable, home sensors and tablet applications can be used to help persons with multimorbidity, as well as their support actors, which include informal caregivers (e.g. family and friends), formal caregivers and health professionals (including doctors and nurses), manage a combination of conditions including chronic heart failure (CHF), diabetes and chronic obstructive pulmonary disease (COPD).

The project includes proof-of-concept trials in Ireland and Belgium, involving national health services, with a number of patients equipped with wearable and home sensors, and their support actors. The trials are beginning now. Patients are learning to use the ProACT CareApp, which aggregates the sensors readings and allows the PwMs and their support actors to monitor their status, and also suggests education videos and tutorials tailored to the self-management needs. The UI of the ProACT CareApp was co-designed with the involvement of PwMs to ensure ease of use. The main goal of our research is to use the data collected to develop a holistic model of PwM that can be used to monitor and predict the health and well-being of PwMs.

Within the framework of ProACT our Health & Person-Centred Knowledge Systems team in Dublin is building a holistic model for persons with multimorbidity, using data on conditions, vitals, self-reports and behavioural assessments. The model relies on a Bayesian network, a probabilistic graphical tool which has been widely applied in healthcare decision support. It represents the probabilistic dependence between

several variables, which allows one to predict the most probable state of a variable knowing the state of other variables. It makes it a promising technique to help with the challenges of multimorbidity.

In our MIE 2018 (Medical Informatics Europe) conference paper "An analytical method for multimorbidity management using Bayesian networks," we present our analytics called Health and Wellness Profile Builder (HWProfile), that is being tested during the ProACT trials. HWProfile is an AI model aimed at representing a PwM through several interconnected dimensions: demographics, medical factors, self-reports and behavioural factors. The state of the PwM is assessed through the sensors and self-report questionnaires taken through the ProACT CareApp. Daily questions are a valuable method to collect a wide variety of self-report information such as breathlessness scores for COPD and CHF, mood and anxiety levels or information on medication adherence.

To develop the HWProfile model we selected variables covering diverse dimensions: health/medical, lifestyle, psychological, well-being, social and behaviour, along with identifying the range of values that these variables can reach. Then the model had to machine learn the conditional probability relationships that exist between the variables, from a structural point of view, as well as from a numerical point of view. How do gender, age and suffering arthritis impact on the risk of falling? What is the expected benefit of increasing physical activity on pain level for females with COPD? These are the kind of questions that HWProfile can help resolve.

We trained the model using data extracted from TILDA, an open dataset collected from a longitudinal health study of the older Irish population, led by Trinity College. In the TILDA study, 8504 individuals over the age 50 took part in a self-filled questionnaire, a computer-assisted interview and a health assessment. To test the methodology on a small model, our team selected 12 variables from this dataset, considering the

target population and conditions covered in the ProACT trials and the data collection methods used: blood pressure watch, scale, activity questionnaire. This trained model was used as the base to develop HWProfile (see Figure 1).

To explore the Bayesian network model, we built an intuitive and interactive user interface. Variables and their associated levels are grouped by color-coded categories (see Figure 1). The Bayesian network shows how variables influence each other. The discrete probability distributions corresponding to each variable are grouped by boxes on the interactive risk panel (right of Figure 1). For a given variable, the marginal probabilities of each possible level are indicated both as a percentage and through a horizontal bar chart in the background.

The user can assign an "observed" level to any variable, by clicking on the level. The whole set of marginal probabilities is then updated to reflect these observations. Clicking again on an observed variable returns it to the unobserved state, with marginal probabilities displayed. Figure 1, right, shows the interface after Age has been set to 'above 70' and Cholesterol level to 'More than 5 mmol/L'. The resulting change in probabilities for all connected variables, like hypertension, can be seen immediately.

The HWProfile model provides a variety of outputs including probabilistic estimates for all unobserved variables whenever a new observation is made. These outputs can be fed to other analytics of the ProACT system, which include a goal and education recommender, an alert system and a condition exacerbation monitor. Our AI model is aimed at leveraging all of the information available on the PwM in the scope of ProACT in order to give insights on their status and recommendations for self-management and/or support and care.

Our IBM Research team also developed InterACT, a Cloud-based

platform within the framework of ProACT. InterACT, built on top of IBM Cloud, is exposed as a set of authenticated services to manage de-identified health data and coordinate collaboration among data providers, data analytics (like before mentioned HWProfile) and data consumer.

Future work lies in investigating the clinical validity of the model. We have observed effects between variables in our preliminary model that concur with the medical literature. Further developments also include performance analysis of the method for a larger network, inclusion of the temporal dimension and different sampling rates per variable. The HW Profile model will be evaluated in conjunction with the additional work around recommender systems developed within the ProACT project.

Provided by IBM

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