Visualizations to Support Patient-Clinician Communication of Care Plans

Adam Perer
IBM T.J. Watson Research Center
Yorktown Heights, NY 10598
United States
adam.perer@us.ibm.com

David Gotz
IBM T.J. Watson Research Center
Yorktown Heights, NY 10598
United States
dgotz@us.ibm.com

CHI PCC Workshop'13, April 28, 2013, Paris, France.
ACM 978-1-XXXX-XXXX-X/XX/XX.

Abstract
CareFlow is a novel system designed to help doctors and patients communicate about possible care plans and their outcomes. Using observed outcomes from clinically similar patients, CareFlow allows doctors and patients to understand which treatments have historically been most effective.

Introduction
When a patient is diagnosed with a disease, their doctor will often devise a *care plan*, a sequence of medical treatments to help manage their disease or condition. A successful outcome often relies on patients understanding and adhering to the care plan, and our work aims to help doctors communicate with patients about the impact of a care plan on their health.

Our work leverages the rich longitudinal data found in Electronic Medical Records (EMRs) to empower clinicians with a new data-driven resource. This paper describes CareFlow, a system designed to visualize the effectiveness of different treatment sequences among similar patients. Using the relevant clinical data of a specific target patient, CareFlow mines EMR data to find clinically similar patients using our patient similarity analytics. CareFlow then visualizes all of the different care plans that these similar patients have undergone, while providing context on which care plans were

successful and which were not. The resulting visualization supports the identification of the most desirable and most problematic care plans, which can serve as evidence for patients to understand and adhere to their prescribed course of treatment.

Mining and Visualizing Care Plans from Data

CareFlow is designed to show doctors and patients a personalized view of the various care plans and associated outcomes that are most relevant to the patient and their medical condition. As the interface is personalized, CareFlow begins by analyzing the medical history of the patient. Using historical medications, symptoms, diagnoses and lab results of the patient, CareFlow applies our patient similarity analytics [1] to find a population of clinically similar patients. The care plans and outcomes of this similar patient population will be made visible by CareFlow.

While patients may be able to make sense out of their own care plan, doing so for all care plans observed within a population of similar patients is much more challenging. Alternative care plans may include a large variety of different types of treatments, and the sequence of these treatments often varies as well. CareFlow was designed to summarize the temporal sequence of treatments in a comprehensive visual interface using an enhancement of the Outflow visualization technique [2]. As described in Figure 1, treatments are represented as nodes and positioned along the horizontal axis, which represents the sequence of treatments over time. The diagnosis of a disease occurs on the far left of the visualization, and treatments in the care plan extend to the right. For instance, in this illustrative example, patients diagnosed with a specific disease were then given either *Diuretics* or *Cardiotonics*. The height of each node is proportional to the number of patients that took a given treatment. So, in this example, twice as many patients

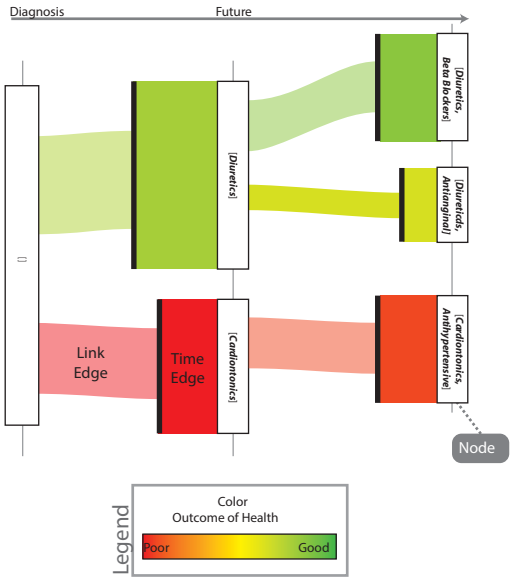

Figure 1: The visual encoding of care plans in CareFlow. The height of nodes represents the number of patients. The width of time edges represents the average duration of treatments. Color represents the average patient outcome.

were prescribed *Diuretics* than treatment *Cardiotonics*.

Each treatment node is also augmented with a time edge, whose width encodes the duration of a how long it took patients to transition to this treatment. In this example, patients were typically prescribed *Cardiotonics* more quickly than *Diuretics* after diagnosis. Link edges are also present to connect nodes from their previous and future nodes in the care plan.

The visual elements are colored according to the average outcome of all patients represented by the node or edge.

Elements that are colored green represent parts of the care plan where patients remained healthy, whereas elements that are colored red indicate that the corresponding patients ended up in poor health. For example, for patients who initially took *Diuretics*, the next treatment that leads to the best outcome for patients is *Beta Blockers*, whereas the patients treated with *Antianginal Agents* ended up with worse outcomes.

Patient-Clinician Communication of Care Plans for Congestive Heart Failure

This scenario involves a doctor who has recently diagnosed a patient with congestive heart failure and wishes to use CareFlow to communicate the effectiveness of possible treatments with their patient. CareFlow connects to a longitudinal EMR database of over 50,000 patients with heart conditions spanning over 8 years.

On the left-hand side of Figure 2, a summary of the patient's relevant medical history is shown, including recent medications, symptoms, and diagnoses. In the center panel of Figure 2, a visualization of the care plans of the 300 most similar patients is shown. The left-most node represents these similar patients at their point of diagnosis with heart failure. As the visualization extends to the right, the various treatment sequences of similar patients are shown. The care plans are colored according to a continuous color scale, as indicated by the legend in the upper-right. By default, plans that are colored red implies most patients within that node ended up being hospitalized, whereas green plans means most patients managed to stay out the hospital. However, CareFlow empowers doctors to interactively customize the outcome measure. For example, it is possible for the doctor to use CareFlow to focus on care plans that lead to patient deaths, to better understand treatments associated with mortality.

Patients may be curious how the similar patients were chosen, and they can find details in the Similarity panel (not pictured). Here, the dominant features are presented that were used to derive this patient population, including medications, diagnoses, lab tests, and symptoms. This information may be useful in convincing the patient that the care plan outcomes presented in CareFlow are relevant to them.

CareFlow provides doctors and patients with the ability to get more information about the patients who undertook a particular care plan. By selecting a Treatment node, doctors an view a precise count of the number of patients the node represents, as well as the average outcome for these patients. In addition, the right panel of the interface displays summary information about a set of patients by displaying factors common to this cohort, as well as factors rare in this group. For instance, the selected patients in Figure 2 typically exhibit symptoms of Rales and have more diagnoses of Chronic Kidney disease. On the other hand, these patients exhibit *Acute Pulmonary Edema* and *Pleural Effusion* less frequently than the rest of the similar patients. By presenting this information, patients can understand what they have in common with the similar patient population.

Conclusion

To conclude, CareFlow is a novel system designed to help doctors and patients understand the outcomes associated with possible treatment plans. CareFlow provides an overview of the care plans used to treat a cohort of similar patients which may help promote understanding and adherence among patients.

About the Authors

Adam Perer and David Gotz are research scientists in the Healthcare Analytics Research Group at IBM T.J. Wat-

son Research Center. Our research group is composed of physicians, medical informatics researchers, and computer scientists to design, develop, and deploy novel healthcare analytics and visualization technologies. Adam Perer plans to attend the workshop.

Acknowledgments

We thank Jianying Hu, Robert Sorrentino, Harry Stravopolous, and Jimeng Sun for their assistance and feedback in designing the CareFlow system.

References

[1] Wang, F., Sun, J., and Ebadollahi, S. Integrating distance metrics learned from multiple experts and its application in inter-patient similarity assessment. In *SDM*, SIAM / Omnipress (2011), 59–70.

[2] Wongsuphasawat, K., and Gotz, D. Exploring flow, factors, and outcomes of temporal event sequences with the outflow visualization. *IEEE Transactions on Visualization and Computer Graphics 18*, 12 (Dec. 2012), 2659 –2668.

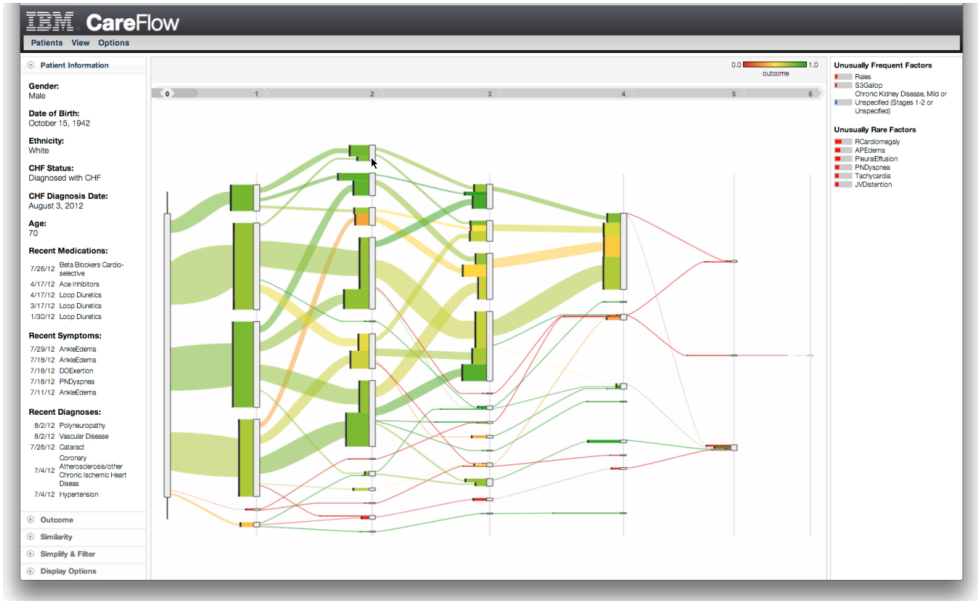

Figure 2: CareFlow's visual interface. The left panel displays a summary of the patient's relevant medical history. The center panel displays a visualization of the care plans of the 300 most similar patients. The right panel displays the factors associated with a selected subset of patients.