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Extended Abstract

Asthma is a multi-factorial chronic disease affecting 235 million people worldwide [WHO]. According to the Center for Disease Control and Prevention, 6.1 million children are affected by Asthma in the United States [CDC]. Asthma hampers a child's long-term physical and mental growth by reduced physical activity, feeling isolated from peers, missed school days, difficulty in concentration and in severe cases emergency room visits [van den Bemt et al.2010]. The factors affecting a child's asthma are divided into two major categories of outdoor and indoor environmental triggers. The outdoor environmental triggers consists of air quality index, pollen, ozone, particulate matter 2.5, temperature, humidity, etc and the indoor environmental triggers comprise of cigarette smoke, cooking, molds, pet, carbon monoxide, volatile organic compounds, indoor humidity, indoor temperature, etc. Each asthma patient differs in their susceptibility towards different asthma trigger(s) hence elevating the need for personalized healthcare framework. For example, Child A and B are both allergic to fall pollen, but Child A exhibits the symptom(s) for ragweed pollen level above 1.2 whereas Child B exhibits the symptom(s) for sagebrush pollen level above 3.4. With the onset of outdoor environmental trigger(s), pediatric asthma patients and their parents need to take personalized precautionary/preventive measures for alleviating asthma symptom(s), or for mitigating them [Cabana et al.2004].

The following information is vital to a parent for their child's personalized asthma management such as a parent is interested in knowing What is the Asthma Control Level of my child?, What is the Medication compliance of my child?,What are possible trigger(s) affecting my child's asthma symptom(s)?, Is it safe for my child to play outside today based on the past asthma symptom(s)/attack during similar outdoor environment?, How likely my child will get an asthma symptom(s)/attack if past outdoor environmental conditions arise in the future?, How does the onset of the asthma trigger(s) affects my child's health state?, What precautionary measures can be taken to mitigate the effect of the trigger(s) (such as restrict outdoor activity during the allergy seasons, take allergy medications), etc. The traditional healthcare practices fail to capture the above granularity which can be addressed with the use of our Personalized

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Digital Healthcare framework. In traditional healthcare practices, there is a huge gap between the patient experiencing the symptom(s) and their clinic visit. The usual clinical visits are scheduled once in three months or six months depending on the patient disease severity which leads to missing health information about the patient which might be relevant for the disease diagnosis.

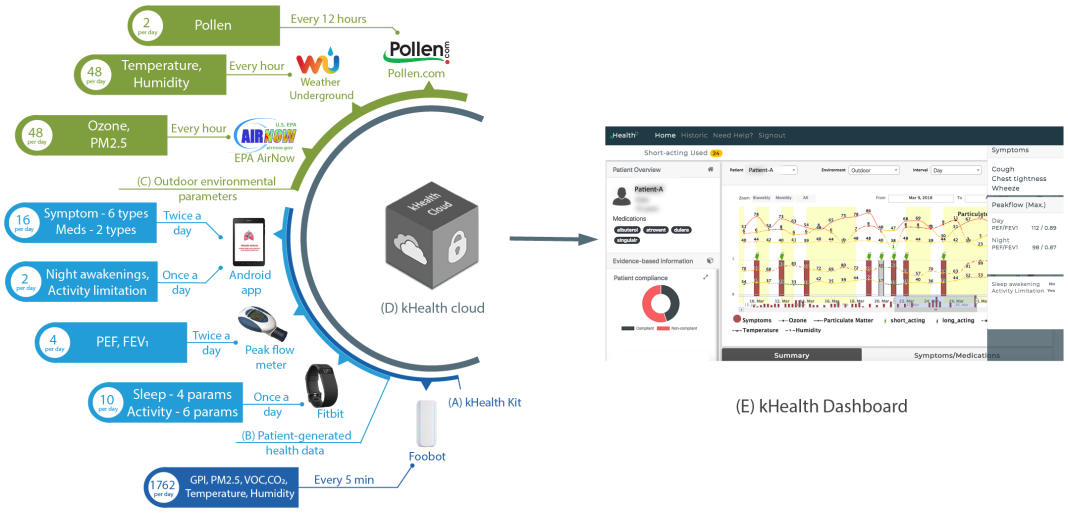

Figure 1: The kHealth-Asthma consists of kHealth kit, kHealth cloud, and kHealth Dashboard. kHealth Dashboard shows the frequency of data collection, the number of parameters collected, and the total number of data points collected per day per patient. (A) Dark blue; the kHealth kit components that are given to the patient. (B) Light blue; the kHealth kit components that collect patient-generated health data. (C) Green; the outdoor environmental factors and their sources. (D) The kHealth cloud(gray). (E) The kHealth Dashboard. All kHealth data are anonymized by assigning patient IDs to each patient. FEV1: forced expiratory volume in 1 second; PEF: peak expiratory flow; PM2.5: particulate matter.

kHealth-Asthma, a personalized digital healthcare framework (described in Figure 1) is developed to address the above shortcomings by continuous monitoring of the child's digital phenotype, indoor, and outdoor environmental data. The kHealth-Asthma study has recruited 140 children (ongoing) with an aim to complete recruitment of 150 children. The study period is either 1 month or 3 month depending on the choice of the study participant. kHealth-Asthma collects 29 multi-modal parameters leading to 1852 data points per patient per day (i.e. deployment: 1 month:1852*30=55,560 data points per patient and 3 month:1852*90=166,680 data points per patient). The digital phenotype collected using the kHealth-Asthma generates a Digital Phenotype Score (DPS) which is a cumulative measure of a child's health and well-being [Jain et al.2015, Jaimini et al.2018]. The generated DPS is clinically equivalent to the Asthma Control Test Score calculated during the clinical visits. The DPS can generate personalized actionable insights into a child's health condition which can be used by the clinician for possible future interventions.

Furthermore, the data collected from the kHealth-Asthma is being used to a) Develop a Personalized Bayesian Prediction framework to predict the future occurrences of a child's asthma symptom(s) with the onset of asthma trigger(s), b) Using a Personalized Causal Model understand the cause and effect relationship between a child's asthma symptom(s) and multiple co-occurring asthma trigger(s), c) Generate a Child's Health coefficient as a measure of an overall health condition of the child with the onset of asthma trigger(s).

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