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Augmented Personalized Health: Using Semantically Integrated Multimodal Data for Patient Empowered Health Management Strategies

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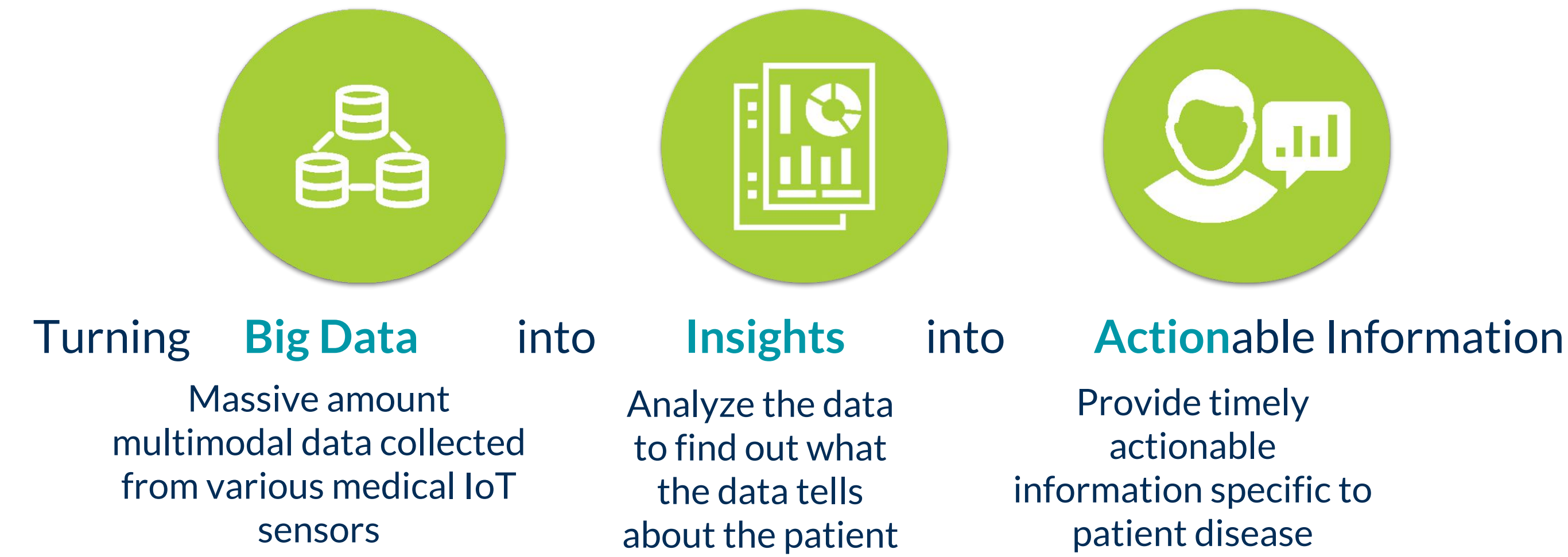
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RATIONALE

Healthcare as we know it is in the process of going through a massive change from:

★ **Episodic** to **continuous**
★ **Disease-focused** to **wellness** and **quality of life focused**
★ **Clinic-centric** to **anywhere a patient is**
★ **Clinician controlled** to **patient empowered**
★ Being driven by **limited data** to **360-degree, multimodal personal-public-population physical-cyber-social big data-driven**
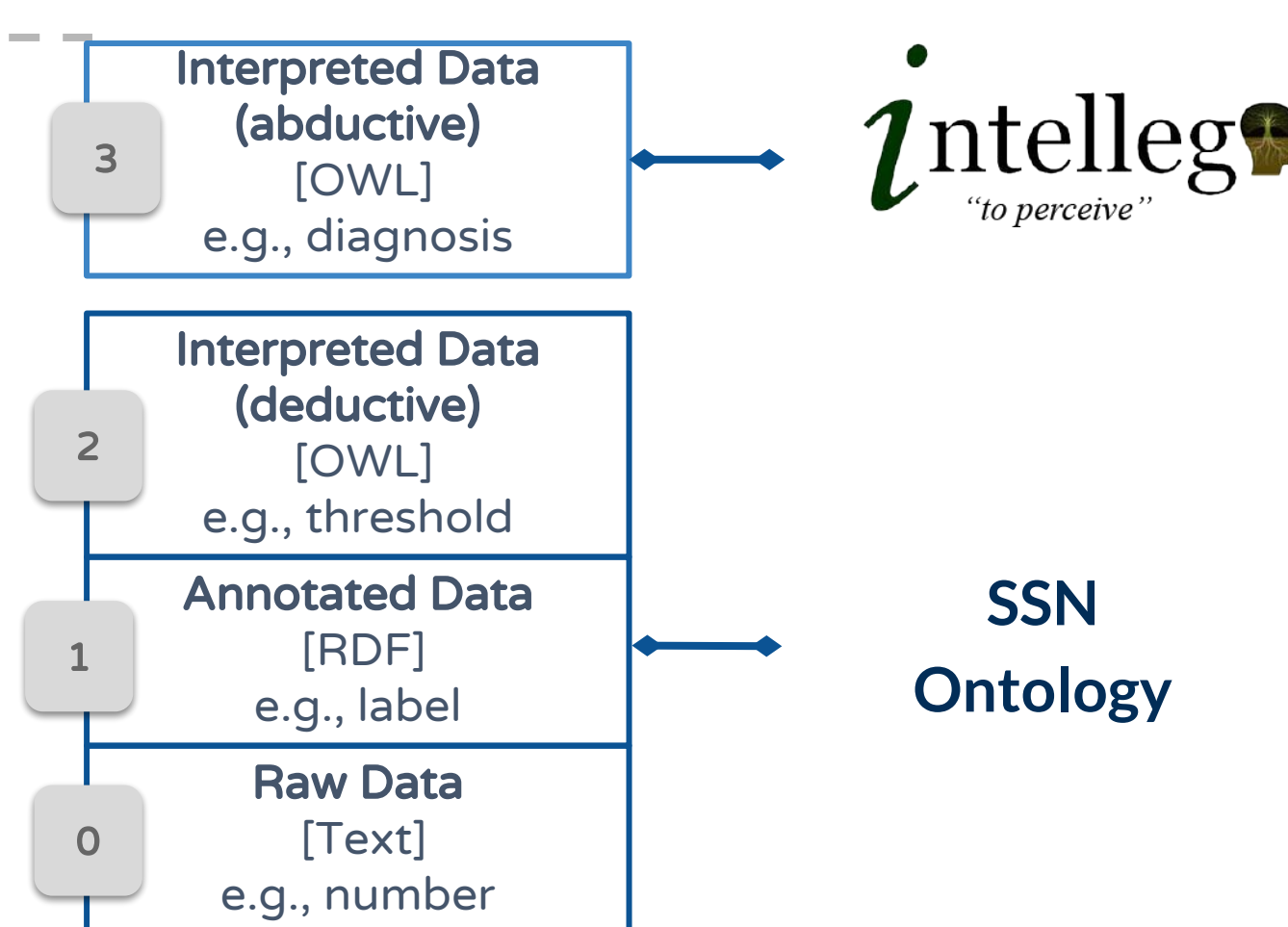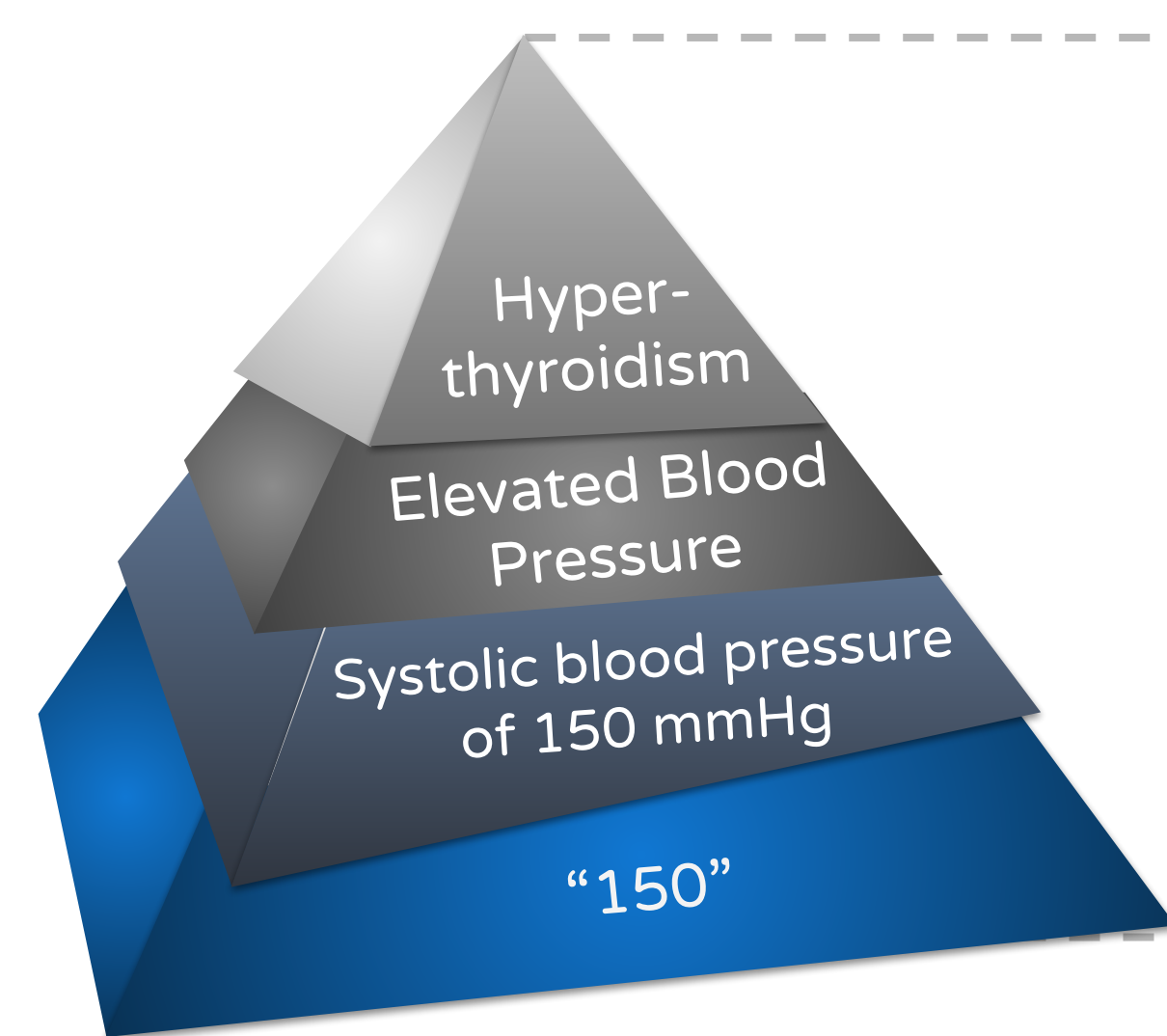
While the ability to create and capture data is already here, the upcoming innovations will be in converting this **BIG data** into **SMART data** through **contextual** and **personalized** processing such that patients and clinicians can make better decisions and take timely actions for **Augmented Personalized Health.**

Turning **Big Data** into **Insights** into **Actionable Information**

Massive amount multimodal data collected from various medical IoT sensors

Analyze the data to find out what the data tells about the patient

Provide timely actionable information specific to patient disease

Data Components
PGHD, Clinical Data, Environmental Data and Social Data

Smart Data
Meaningful data obtained after contextualised processing

- Hyper-thyroidism
- Elevated Blood Pressure
- Systolic blood pressure of 150 mmHg
- "150"

3	Interpreted Data (abductive) [OWL] e.g., diagnosis
2	Interpreted Data (deductive) [OWL] e.g., threshold
1	Annotated Data [RDF] e.g., label
0	Raw Data [Text] e.g., number

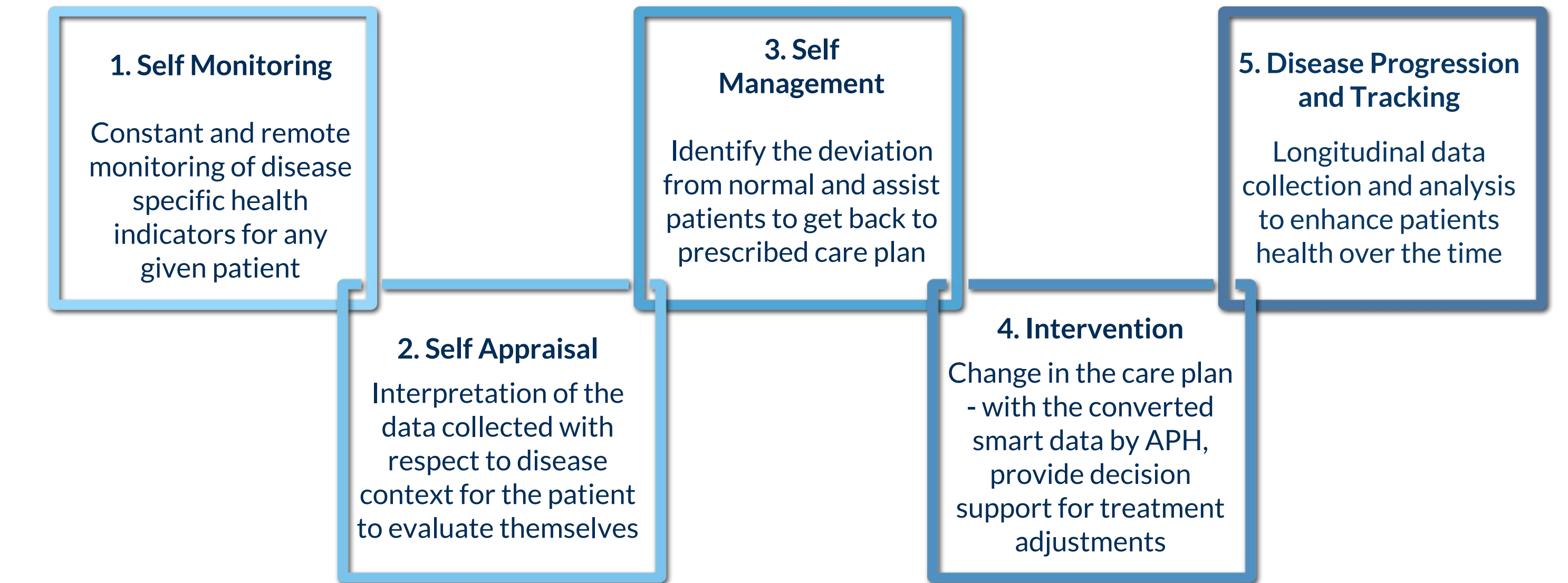*intellego* "to perceive"

SSN Ontology

AUGMENTED PERSONALIZED HEALTH

Augmented Personalised Health (APH) is a vision to enhance the healthcare by using Artificial Intelligence (AI) techniques on semantically integrated **Patient Generated Health Data** (PGHD), **environmental data**, **clinical data**, **public health data** & **social data**.

Asthma

- Show me the data that is relevant to asthma (Eg:AQI, Pollen)
- What is my asthma control level?
- Given all my asthma related data, do I need to take SABA(Short Acting Beta Agonists)?
- How was my asthma control since last year?
- Based on poor asthma control, the system encourages clinical consultation(before routine examination).

Self monitoring / Self appraisal / Self management / Disease Progression and tracking / Intervention

Bariatrics

- Show me the data related to my weight (Eg: Diet, Physical Activity)
- What is my weight trend?
- Given all my data, do I need to follow stricter diet?
- How was my weight trend since the surgery?
- Based on weight regain, the system encourages clinical consultation (before routine examination).

5 Strategies of Augmented Personalized Health for Better Disease Management and Patient's Well-Being

1. Self Monitoring — Constant and remote monitoring of disease specific health indicators for any given patient

2. Self Appraisal — Interpretation of the data collected with respect to disease context for the patient to evaluate themselves

3. Self Management — Identify the deviation from normal and assist patients to get back to prescribed care plan

4. Intervention — Change in the care plan - with the converted smart data by APH, provide decision support for treatment adjustments

5. Disease Progression and Tracking — Longitudinal data collection and analysis to enhance patients health over the time
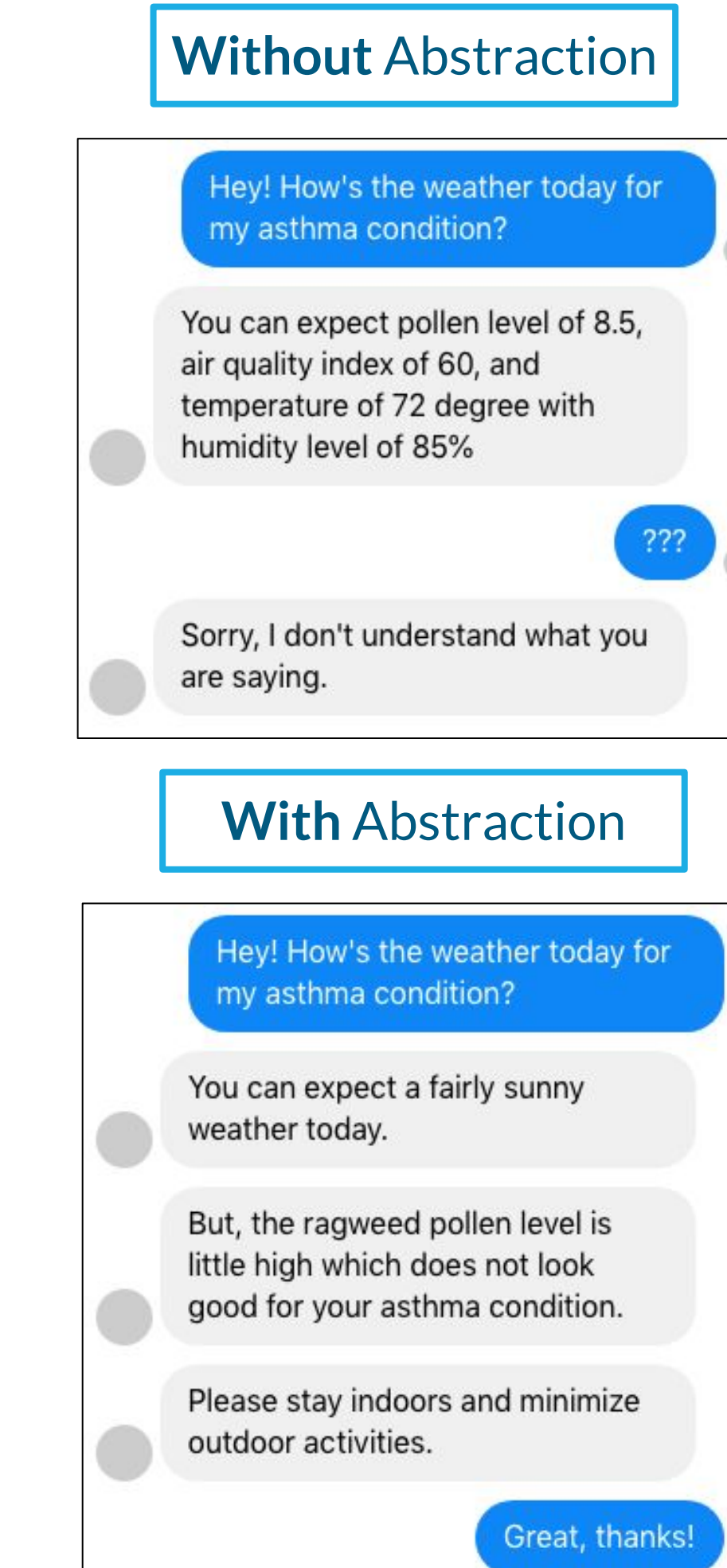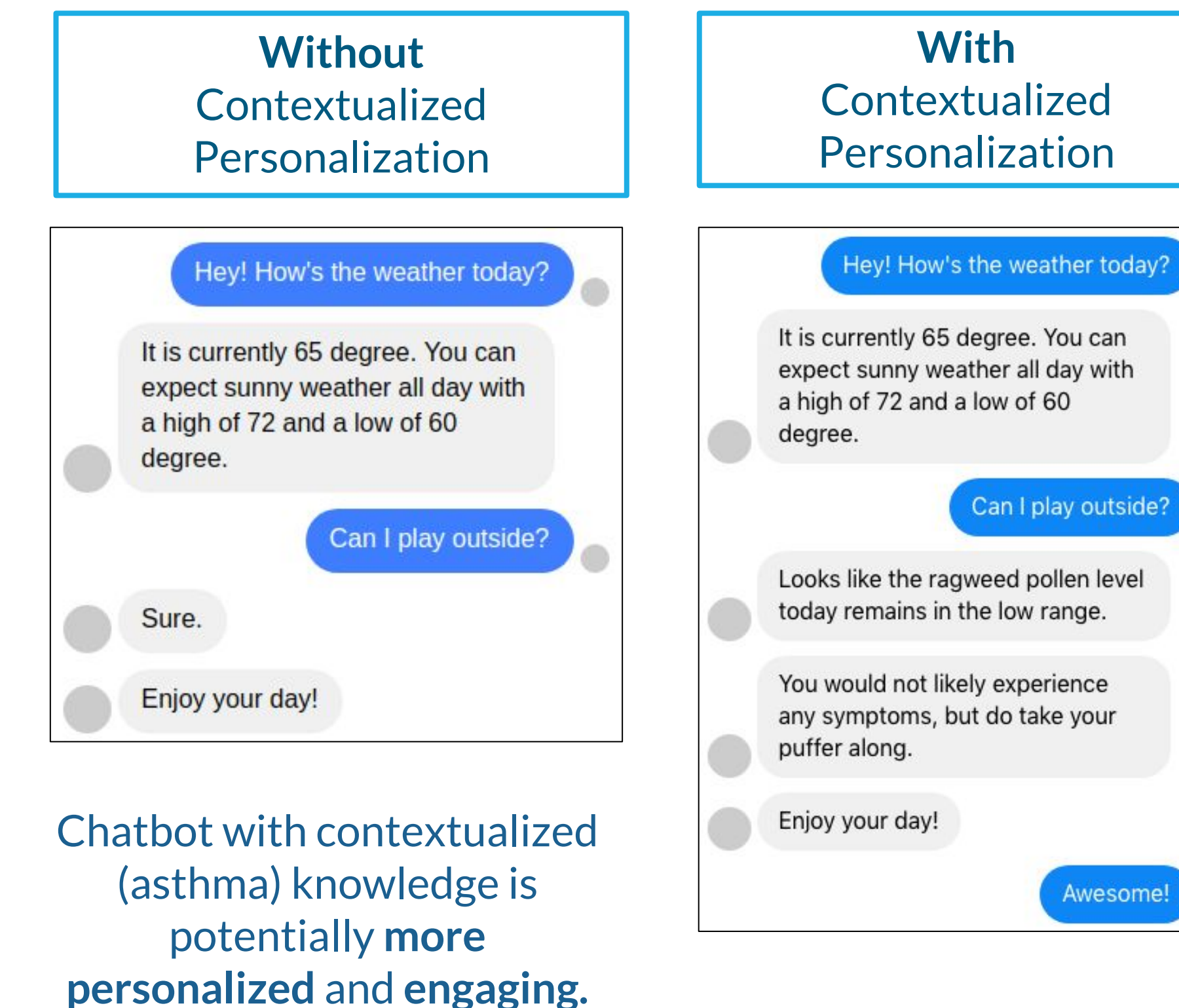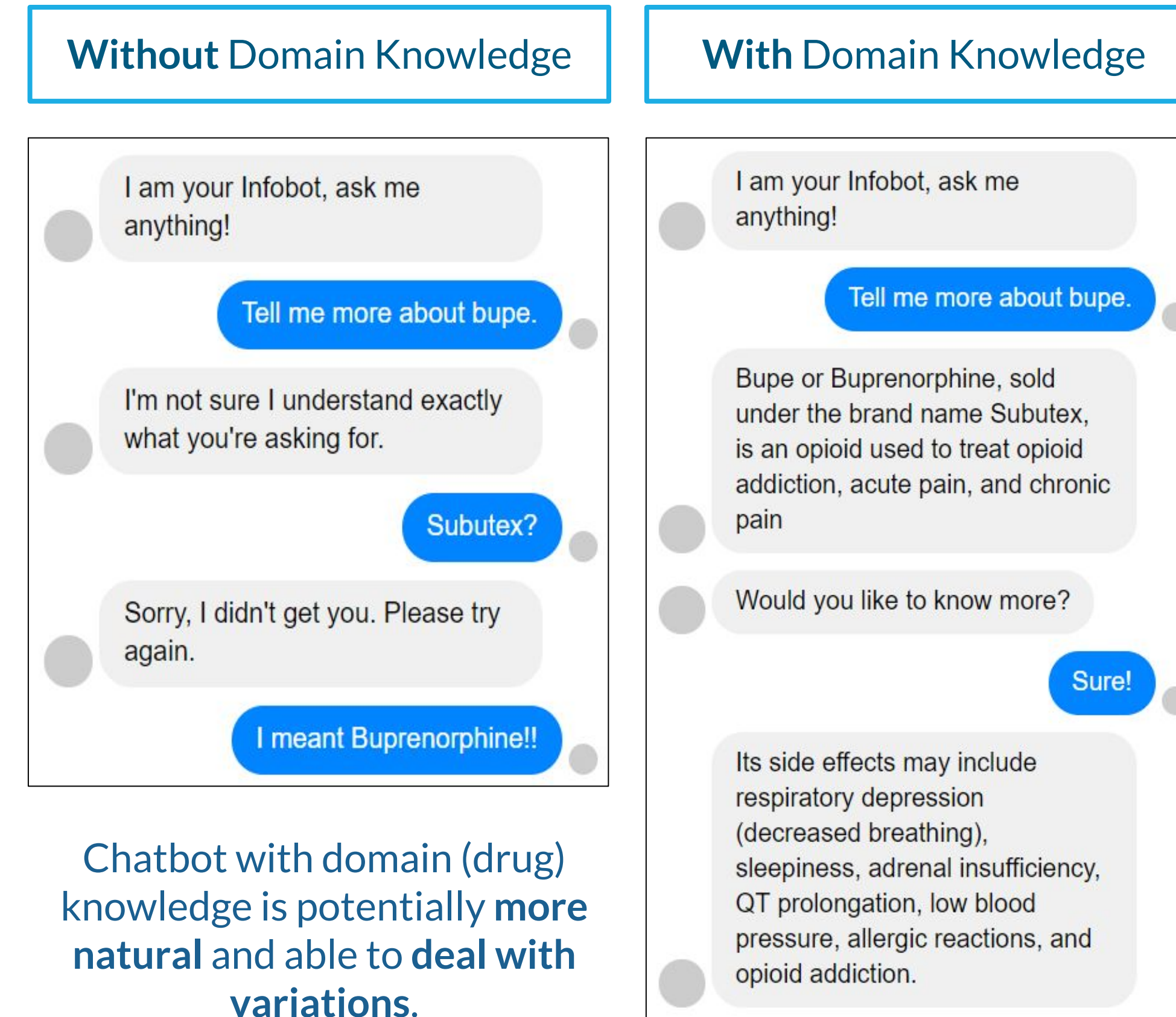
Current APH Applications : (a) Patient Evaluations Ongoing: Pediatric Asthma, Bariatric Surgery, [Dementia - Caregivers] (b) Preliminary: ADHF, Liver Cirrhosis

CHATBOTS FOR HEALTHCARE

★ **Contextualization** refers to data interpretation in terms of knowledge (context).

Without Domain Knowledge
- I am your Infobot, ask me anything!
- Tell me more about bupe.
- I'm not sure I understand exactly what you're asking for.
- Subutex?
- Sorry, I didn't get you. Please try again.
- I meant Buprenorphine!!

With Domain Knowledge
- I am your Infobot, ask me anything!
- Tell me more about bupe.
- Bupe or Buprenorphine, sold under the brand name Subutex, is an opioid used to treat opioid addiction, acute pain, and chronic pain
- Would you like to know more?
- Sure!
- Its side effects may include respiratory depression (decreased breathing), sleepiness, adrenal insufficiency, QT prolongation, low blood pressure, allergic reactions, and opioid addiction.

Chatbot with domain (drug) knowledge is potentially **more natural** and able to **deal with variations**.

★ **Personalization** refers to future course of action by taking into account the contextual factors such as user's health history, physical characteristics, environmental factors, activity, and lifestyle.

Without Contextualized Personalization
- Hey! How's the weather today?
- It is currently 65 degree. You can expect sunny weather all day with a high of 72 and a low of 60 degree.
- Can I play outside?
- Sure.
- Enjoy your day!

With Contextualized Personalization
- Hey! How's the weather today?
- It is currently 65 degree. You can expect sunny weather all day with a high of 72 and a low of 60 degree.
- Can I play outside?
- Looks like the ragweed pollen level today remains in the low range.
- You would not likely experience any symptoms, but do take your puffer along.
- Enjoy your day!

Chatbot with contextualized (asthma) knowledge is potentially **more personalized** and **engaging.**

★ **Abstraction:** Computational technique that maps and associates raw data to action-related information.

Without Abstraction
- Hey! How's the weather today for my asthma condition?
- You can expect pollen level of 8.5, air quality index of 60, and temperature of 72 degree with humidity level of 85%
- ???
- Sorry, I don't understand what you are saying.

With Abstraction
- Hey! How's the weather today for my asthma condition?
- You can expect a fairly sunny weather today.
- But, the ragweed pollen level is little high which does not look good for your asthma condition.
- Please stay indoors and minimize outdoor activities.
- Great, thanks!

★ **Putting it all together:** Example chatbot conversation which utilizes background health knowledge graph and patient's knowledge graph to infer and generate recommendation to patients.

- Knock knock, just checking in! How are you doing today?
- Hey kBOT! I am feeling great!
- How's the weather today?
- Glad to hear!
- You can expect a fairly sunny weather today.
- But, the ragweed pollen level is little high which does not look good for your asthma condition.
- Are you planning to go out?
- Yes, I am thinking of going for a walk.
- I am afraid you may experience stuffy or runny nose, sneezing, and itchy eyes.
- Do take your nasal steroid before heading out!
- Great, thanks!

Chatbot initiates greeting conversation.

Contextualization and Personalization

Understands the patient's health condition (allergic reaction to high ragweed pollen level) via the **personalized patient's knowledge graph** generated from EMR, PGHD, and prior interactions with the kBOT.

Inference based on patient's historical records and **background health knowledge graph** containing contextualized (domain-specific) knowledge.

Generates predictions or recommended course of actions.