Gamification of Clinical Practice Guidelines

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Introduction

Clinical Practice Guidelines are documents that contain recommendations to assist clinicians providing optimized health care, based on latest evidence.
Some advantages:

- Clinicians don't have to search through and review an overwhelming amount of research articles to keep up to date with the latest best evidence.
- Improved quality of health care (benefits and harm).
- Reduce practice variability.
- Reduce cost of health care.

Introduction

Despite the advantages, Clinical Practice Guidelines have had an limited effect on changing clinicians practice methods.

- Lack of awareness.
- Lack of familiarity.
- Lack of self-efficacy.
- Inertia of previous practice.
- Not easy to use, inconvenient, cumbersome.

Example: Guidelines for the Diagnosis and Management of Asthma consists of 440 pages.

Possible asthma in paediatrics - Norway

Symptomer og funn

Hoste. Varierende grader av åndenød og tetthetsfølelse. Piping fra brystet. Forlenget ekspirium og ekspiratoriske pipelyder. Eventuelt andre atopiske symptomer.

Astmaanfall klassifiseres i to alvorlighetsgrader hos barn 5 år eller yngre:

	Mildt/moderat astmaanfall	Alvorlig eller livstruende astmaanfall ved ett av følgende funn:
Tale	Setninger	Kan ikke prate (ev. enkeltord) eller drikke
Cyanose	Ingen	Sentral cyanose
Inndragninger	Ingen	Markert subkostale og/eller subglottale inndragninger
Respirasjon	Åndenød	Stille bryst ved auskultasjon
Agitasjon	Agitert	Forvirring eller døsighet
Puls	≤200/min (0–3 år) ≤180/min (4–5 år)	>200/min (0–3 år) >180/min (4–5 år)
SaO_2 (romluft)	92 %	<92 %

Differensialdiagnoser

Akutt bronkiolitt. Hyppigste årsak til luftveisobstruksjon og hoste hos barn under 2 år. Som regel er det kliniske bildet uatskillelig fra astma, siden bronkialt slimhinneødem dominerer ved begge tilstander. Residiverende bronkiolitt er sjelden, og tilbakevendende symptomer gir grunn til å mistenke og utrede astmatisk genese.

Falsk krupp. Inspiratorisk stridor, gjøende hoste og heshet.

Pneumoni

Bronkialt fremmedlegeme. Må særlig mistenkes ved ensidige funn og opplysninger om hyperakutt debut.

Tiltak

Tiltak avhenger av alvorlighetsgrad av anfallet:

Akutt livstruende astmaanfall

Akutt sykehusinnleggelse er påkrevd. Sikre beredskap for hjerte-lunge-redning. Behandlingen gjennomføres under transport.

Behandling:
1) Oksygen. SaO_2-mål er 94–98 %.
2) Inhalasjon av β2-agonist 6 puff salbutamol (Ventoline 0,1 mg/dose) på maske eller 2,5 mg på forstøver (2,5 ml Ventoline 1 mg/ml). Gjentas hvert 20. minutt ved behov.
3) Inhalasjon av ipratropium 8 puff (Atrovent 20 ug/dose) på maske eller 0,25 mg på forstøverapparat (1 ml Atrovent 0,25 mg/ml), kan gjentas hvert 20. minutt i en time. Kan gis samtidig og i samme kammer som β2-agonist.
4) Systemisk glukokortikoid (Betapred) 2 mg/kg (maks 20 mg for barn <2 år, maks 40 mg for barn 2–5 år).

Mildt/moderat astmaanfall

Behandling på legevakten:
1) Oksygen. SaO_2-mål er 94–98 %.
2) Inhalasjon av β2-agonist 2–6 puff salbutamol (Ventoline 0,1 mg/dose) på maske, eller 2,5 mg på forstøver (2,5 ml Ventoline 1 mg/ml). Gjentas hvert 20. minutt ved behov.
3) Vurder tilstanden kontinuerlig neste 1–2 timer. Overvåk respirasjonsfrekvens og SaO_2.

Innleggelse? Ved akutt, livstruende astmaanfall innlegges barnet alltid. I tillegg skal barnet legges inn ved manglende effekt av salbutamol (Ventoline) etter 1–2 timer, økende eller uendret respirasjonsfrekvens og fallende SaO_2. Vurder også innleggelse dersom sosiale faktorer reduserer evnen til akuttbehandling eller foresatt ikke er i stand til å behandle akutt astma i hjemmet.

Initial bedring, men residiv innen 3–4 timer? Gi følgende behandling:

Gi salbutamol (Ventoline) 3–4 puff hver time.

Gi inhalasjon av ipratropium 20 ug to ganger (4 puff Atrovent 20 ug/dose) på maske, eller 0,25 mg på forstøverapparat (1 ml Atrovent 0,25 mg/ml). Kan gjentas hvert 20. minutt i en time. Kan gis samtidig og i samme kammer som β2-agonist.

Gi systemisk glukokortikoid (Betapred) 2 mg/kg oralt (maks 20 mg for barn <2 år, maks 40 mg for barn 2–5 år).

Praktiske tiltak. Unngå utløsende faktorer (for eksempel dyrehår, midd), passiv røyking og luft- og støvforurensing. Ha lav terskel for rekontakt med lege.

Oppfølging ved fastlege. Barnet bør ha kontroll hos fastlege i løpet av 1–7 dager. Dersom astmadiagnosen ikke er kjent, bes foreldre ta kontakt med fastlegen for utredning, blant annet med tanke på allergi (anamnese, IgE og eventuelt kutantester). Videre henvisning til barnelege med astma- og allergikompetanse kan være aktuelt.

Research questions

- **RQ1:** Based on clinical guidelines, how can we define and represent a generic data structure that can be used to implement applications such as online guidelines or training games for such guidelines, and where applications can adapt to the level of their users?
- **RQ2:** Can the generic data structure in RQ1 be used to generate a specific data model for another domain such as paediatric asthma?
- **RQ3:** How can we use the data model in RQ2 to implement a game for guideline training that can adapt to the level and progression of users?
- **RQ4:** Is the guideline metamodel at an abstraction level such that it can be used for other guidelines?

Approach

Design science

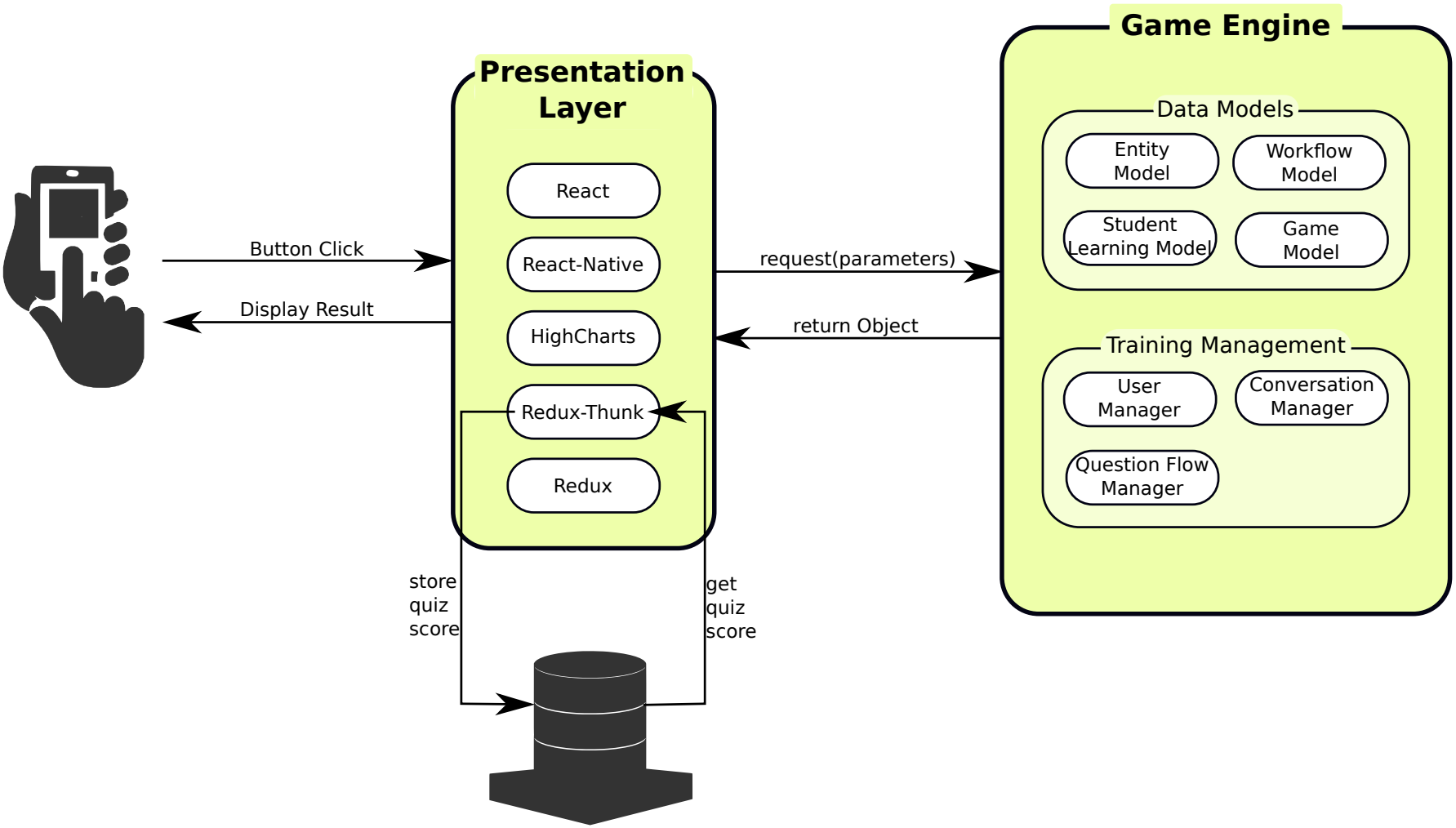
- **Problem:** CPGs have proven to have a great potential, but are not used enough.
- **Design an artefact** that will contribute to more use of clinical guidelines.
- **Iterations:** Evaluation of the artefact will give us more knowledge around the domain and challenges. Improve and adjust the artefact accordingly. The research will appear from the design.
- **Contribution:** Scientific contribution to health informatics. The artefact will provide value to the medical community.

Gamification of Clinical Practice Guidelines

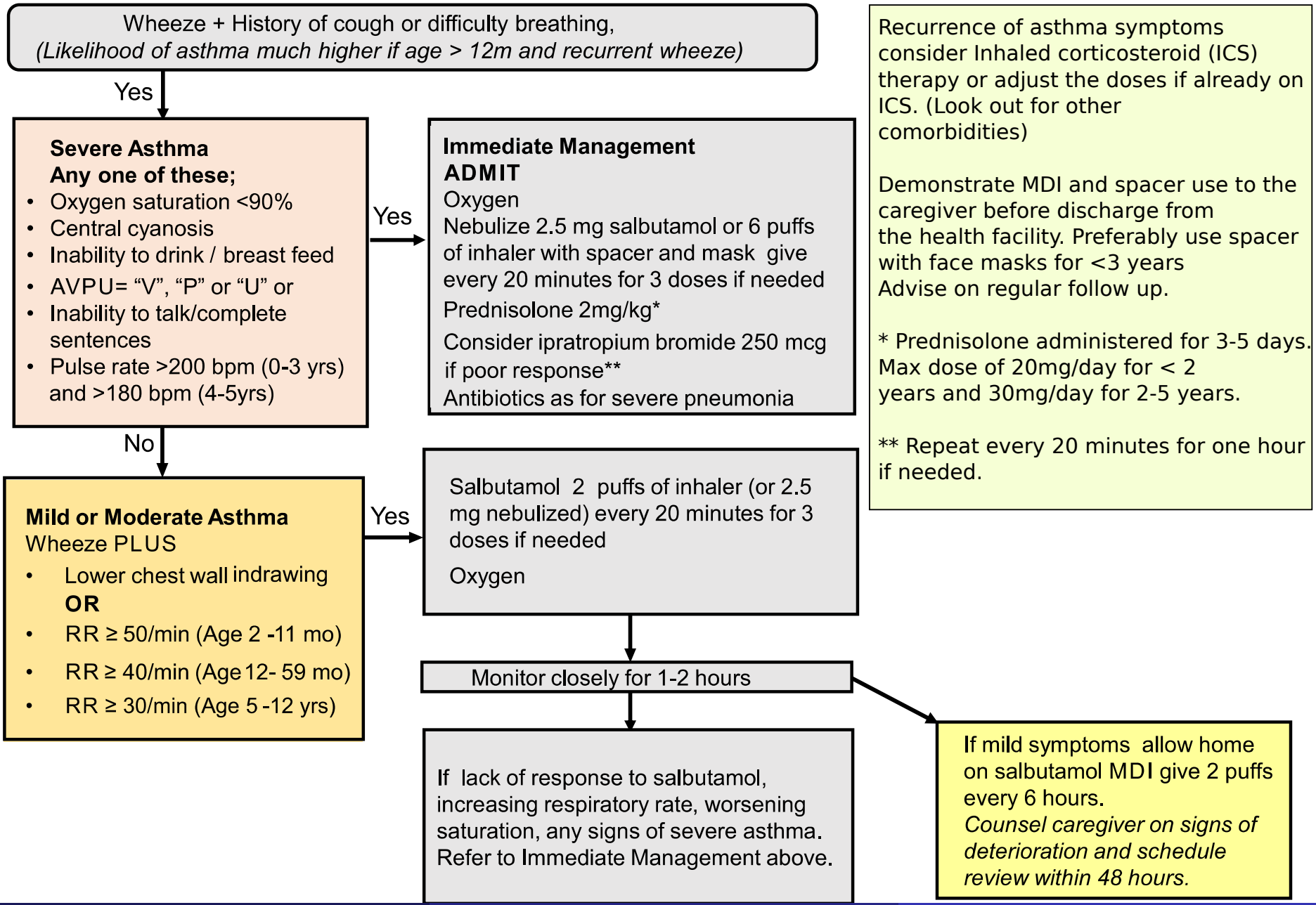
The contributed artefact

- A mobile game in a quiz format for learning the content of CPGs.
- Multiple-choice and multiple-try with feedback.
- Adaptive to the individual learner.
- Intended for medical students and clinicians.

Architecture

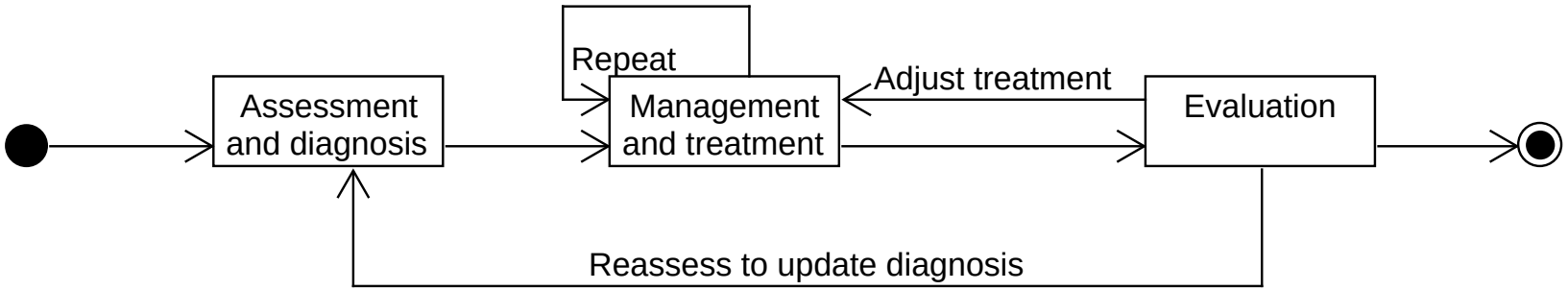


Possible asthma in paediatrics - Kenya



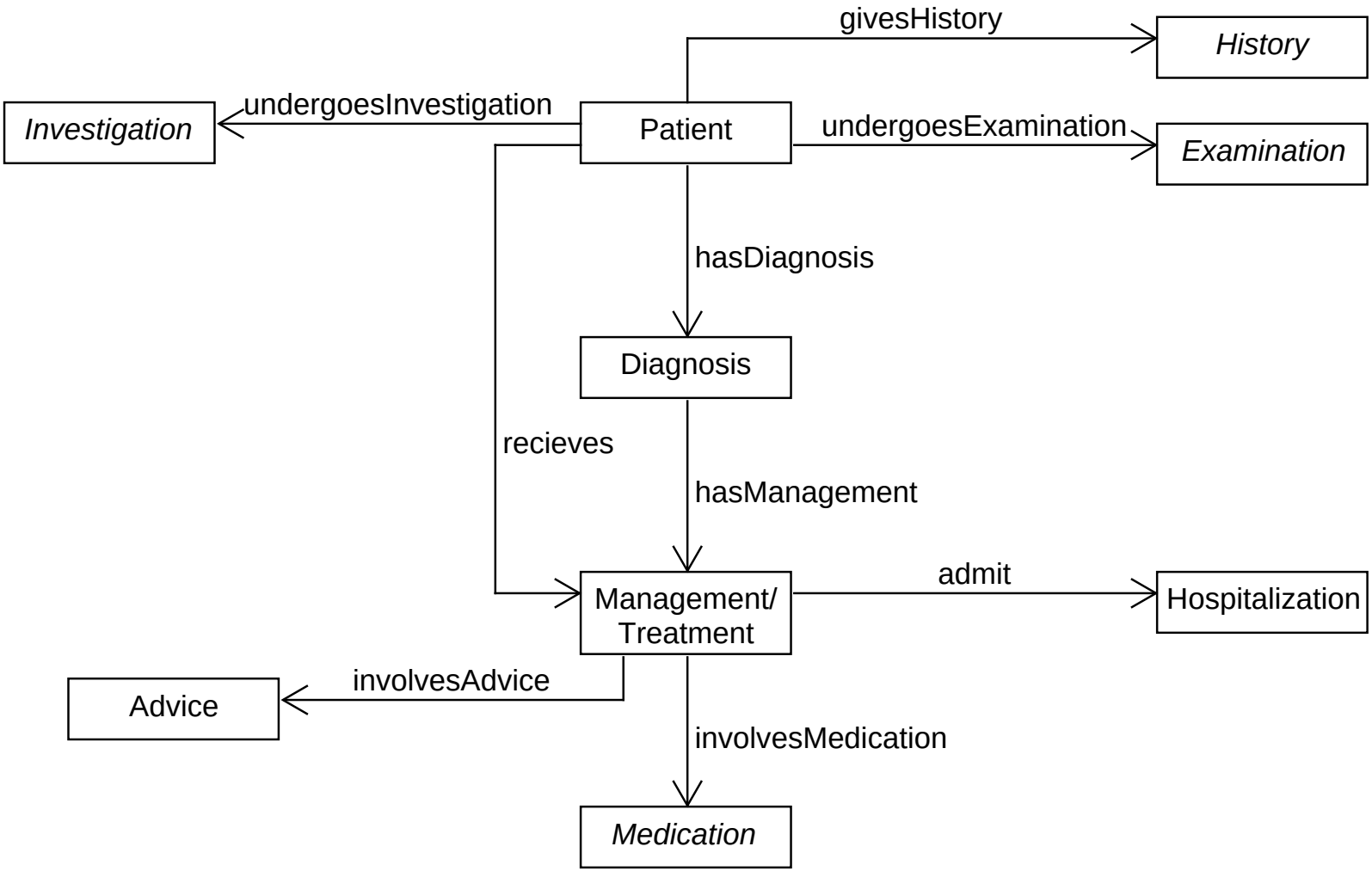
Workflow graph

The workflow graph is a model of the different steps through a clinical encounter.



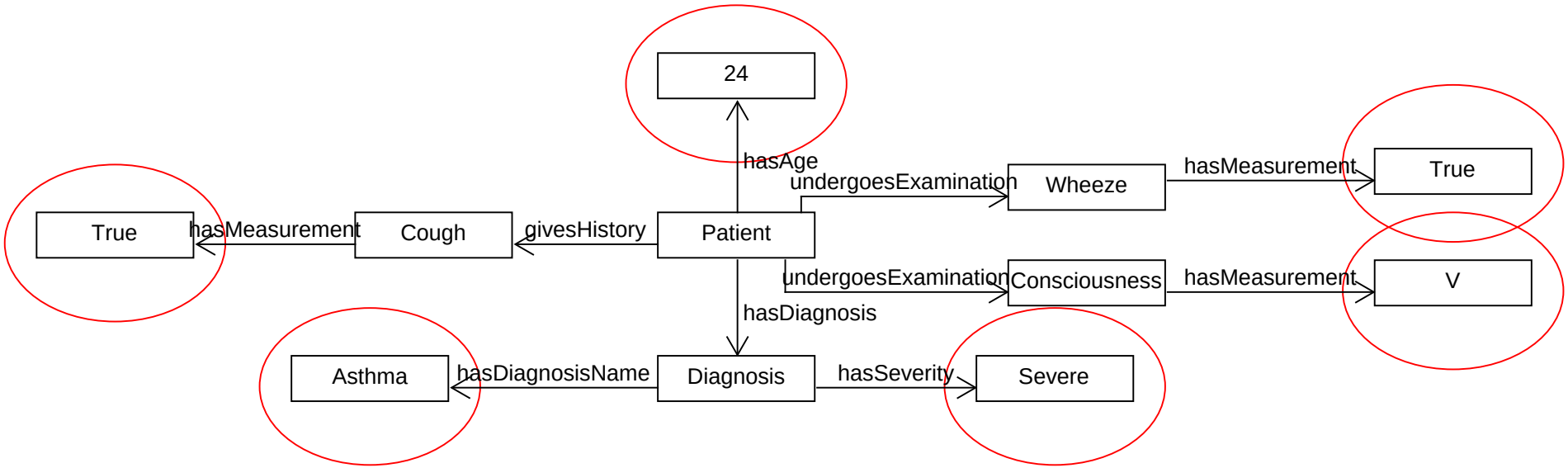
Excerpt of the entity graph

The entity graph is a model of the patient profile at a specific point in the clinical encounter.



Making scenarios, answer keys, distractions

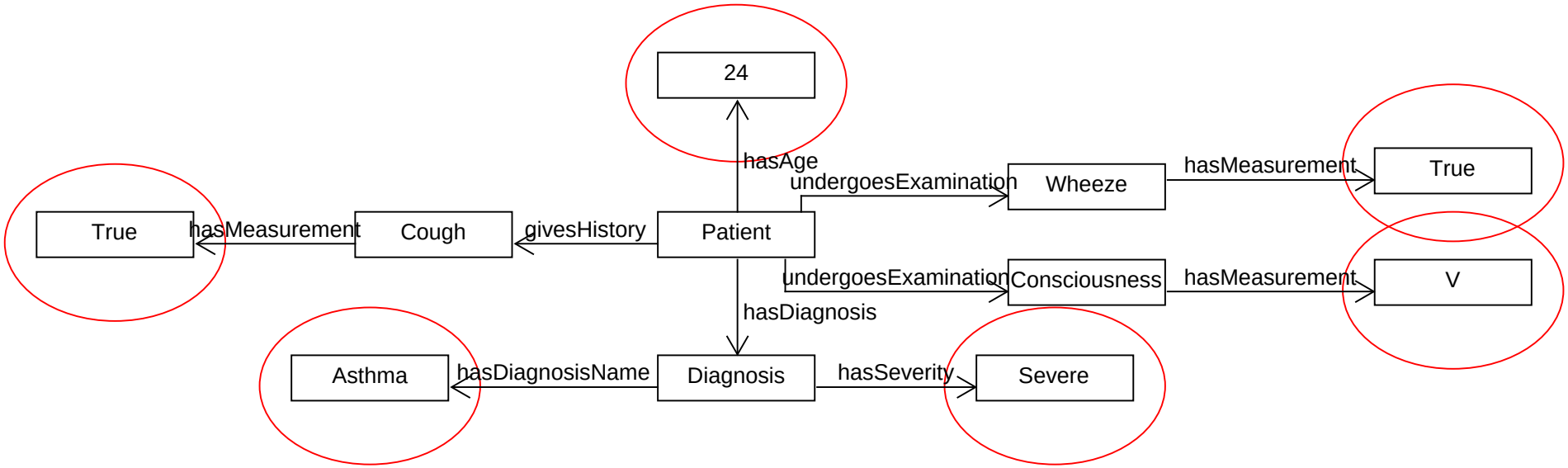
An instance of the entity model.




```
A <%Patient.hasAge.Age%> old has arrived at the
emergency clinic.
She <%Patient.givesHistory.Cough%>
<%Patient.undergoesExamination.Wheeze%>
<%Patient.undergoesExamination.Consciousness%>
```

Making scenarios, answer keys, distractions

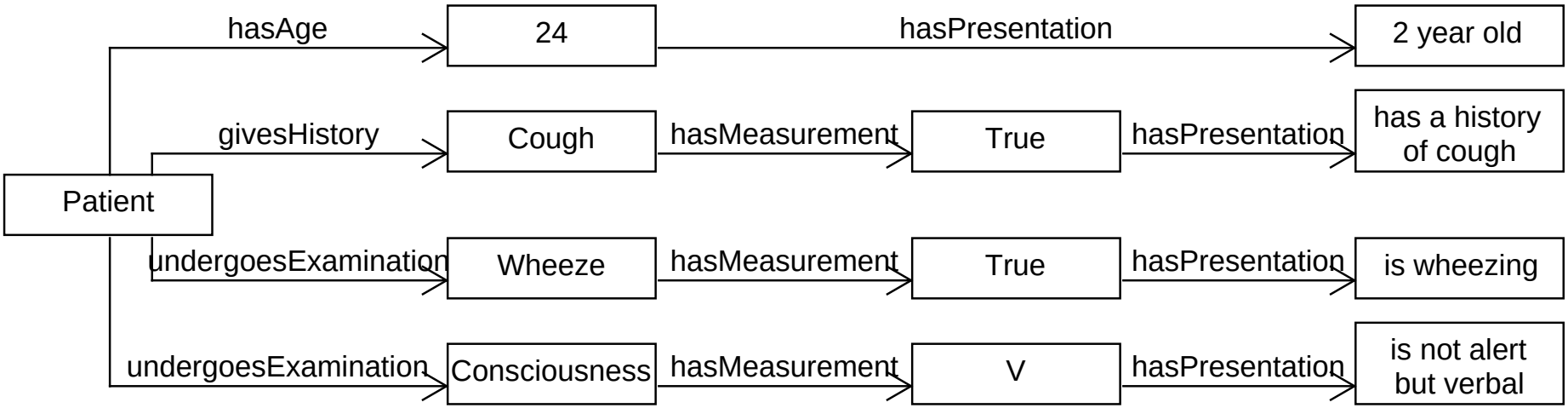
An instance of the entity model.




```
A 24 old has arrived at the
emergency clinic.
She True
True
V
```

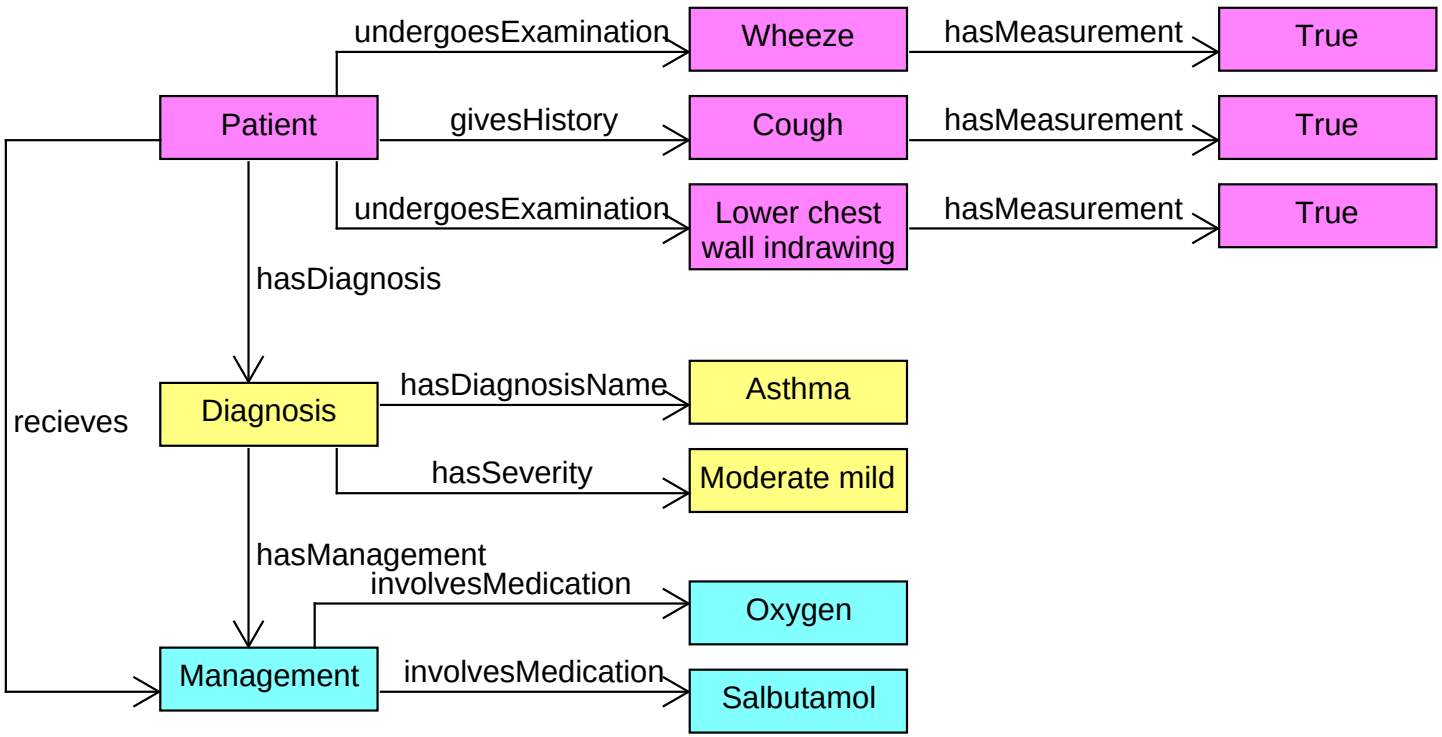
Making scenarios

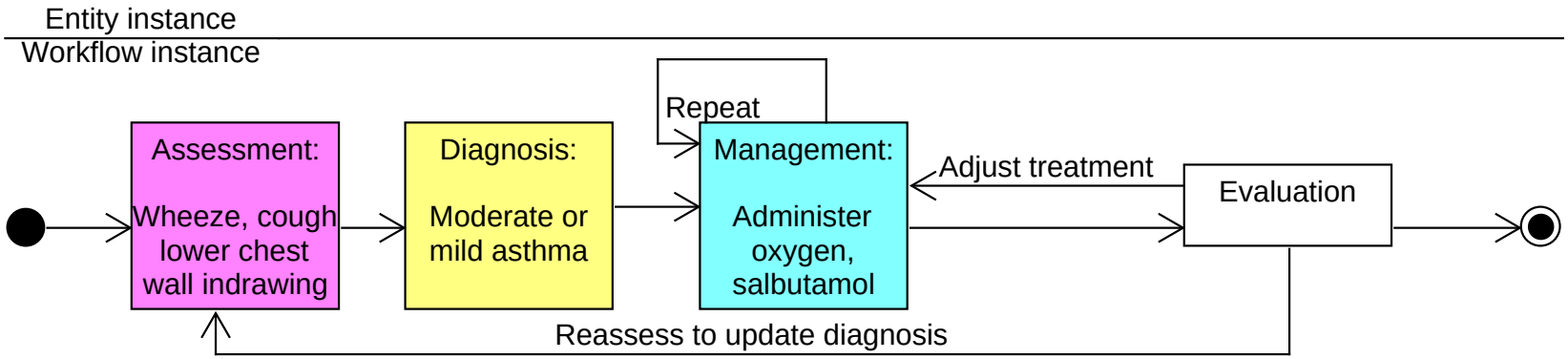
Adding presentation vertices to the instance.



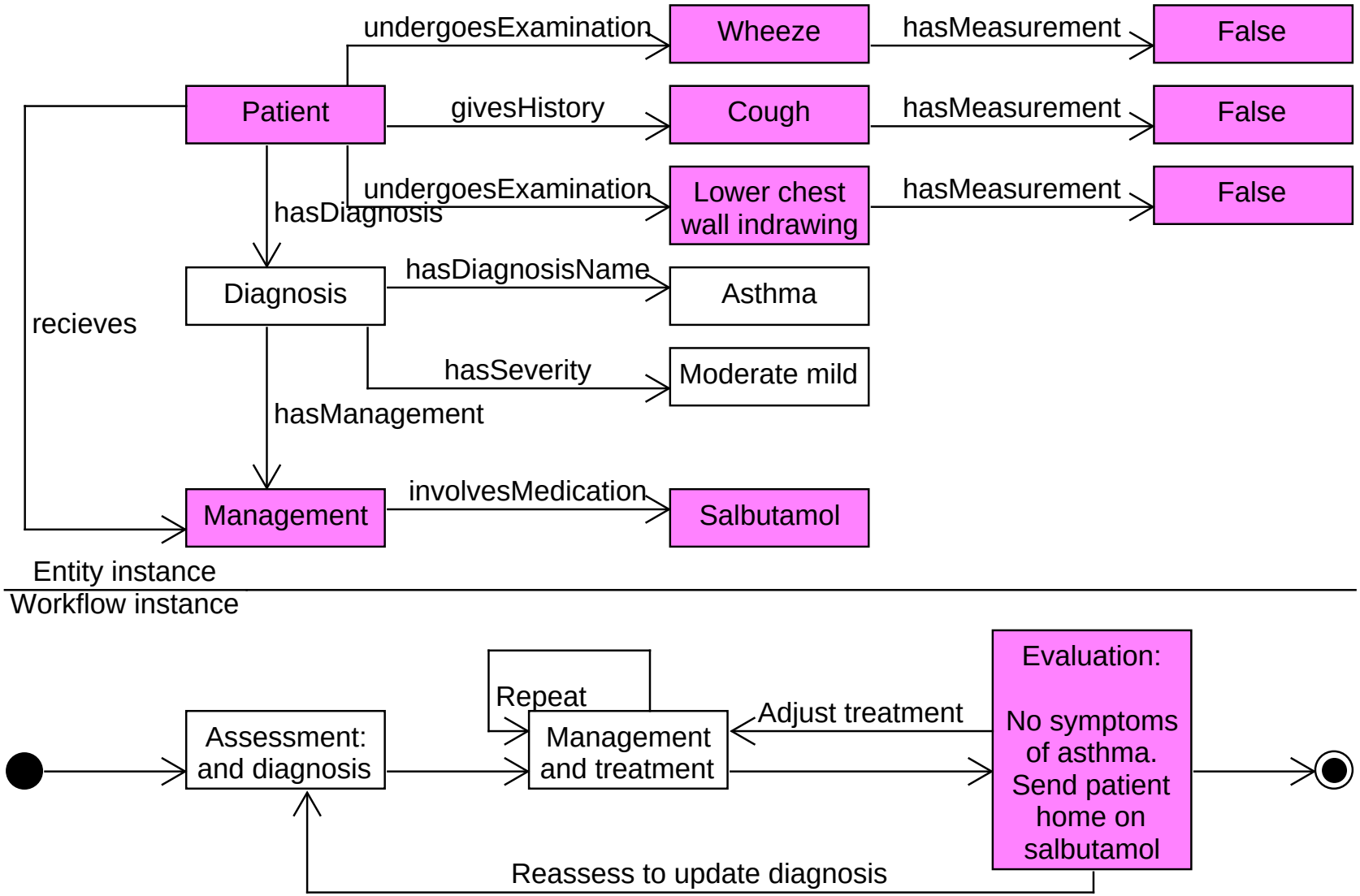

```
A 2 year old has arrived at the
emergency clinic.
She has a history of cough,
is wheezing
and is not alert but verbal.
```

Entity- and workflow model working together





Entity- and workflow model working together

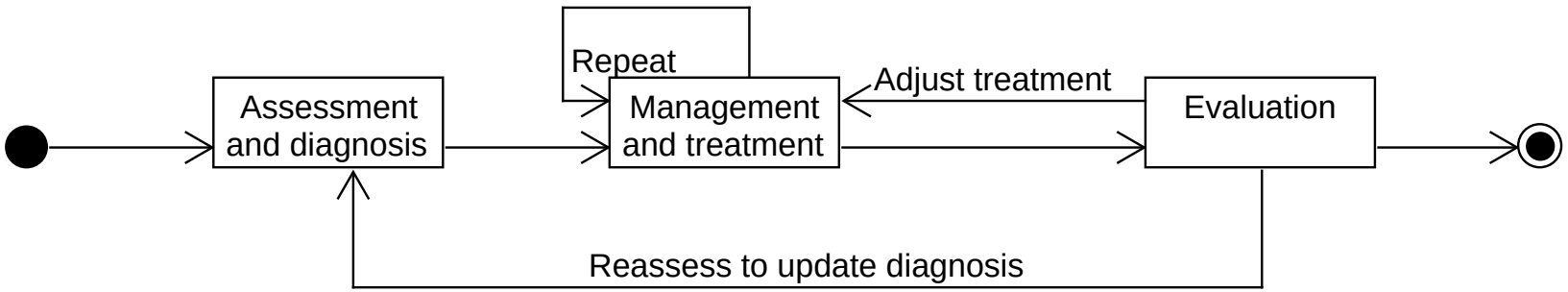


Dynamic Content Management

- Adaptive learning. Students will solve problems which are suited to their level of knowledge.
- Flexibility in the learning process. As long as the students follow the knowledge dependencies, they can go through the learning material in many different ways.

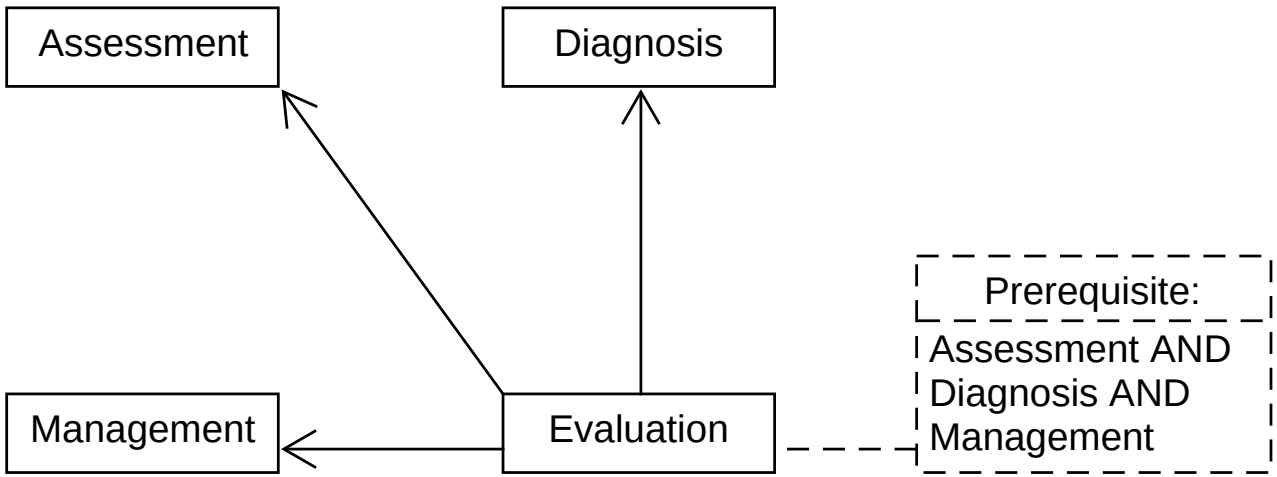
Dynamic Content Management

- Split the learning content into atomic units of knowledge.
- Build up courses (quizzes) by selecting and organizing the knowledge units.
- Identify dependencies between the knowledge units.



Dynamic Content Management

Knowledge Map shows the dependencies in the learning process.

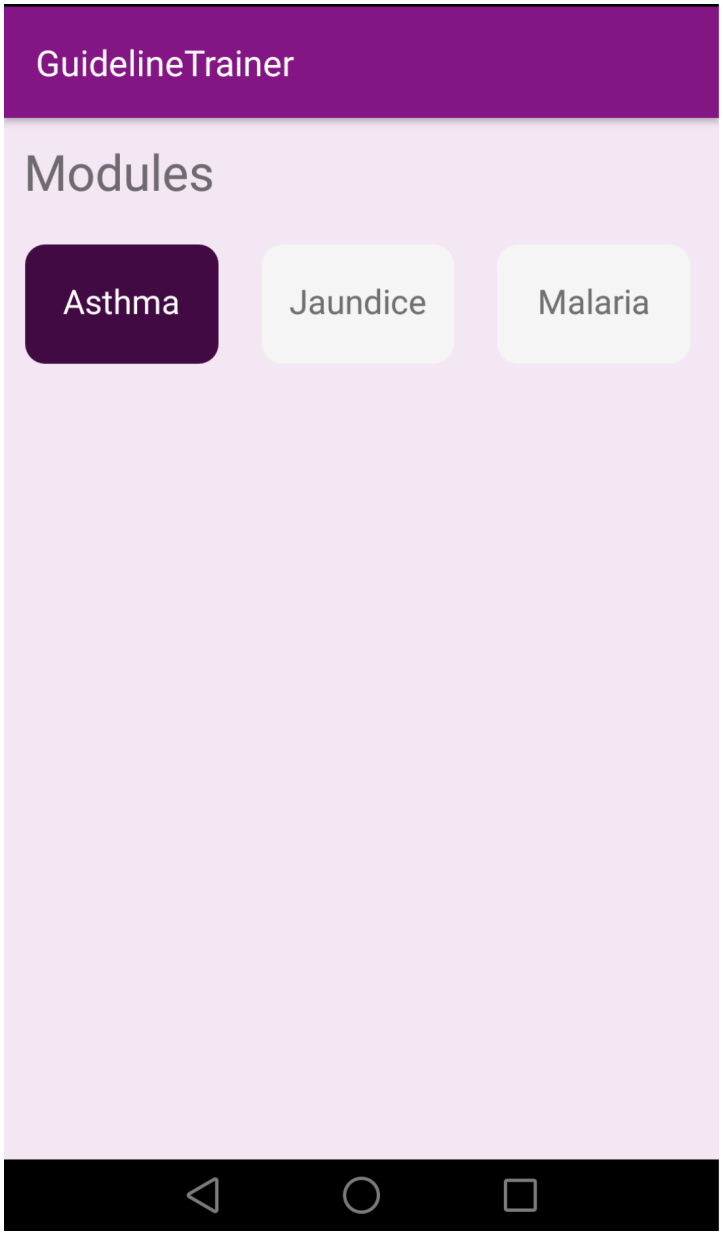


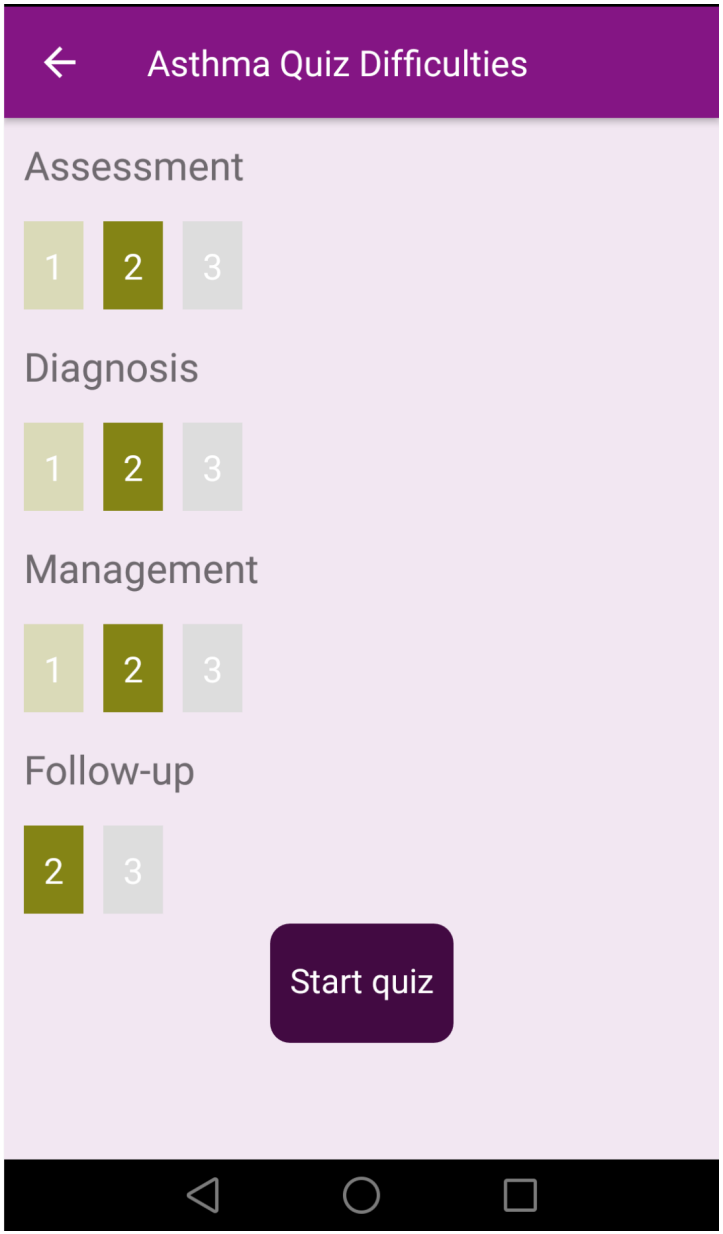
Dynamic Content Management

Level	Assessment	Diagnosis	Management	Evaluation
1	Factual	Factual	Factual	-
2	Scenario	Scenario	Scenario	Scenario
3	Detailed scenario	Detailed scenario	Detailed scenario	Detailed scenario

- Learning map shows all paths through the learning material.
- Student map shows one student's path in the learning map.

Demonstration





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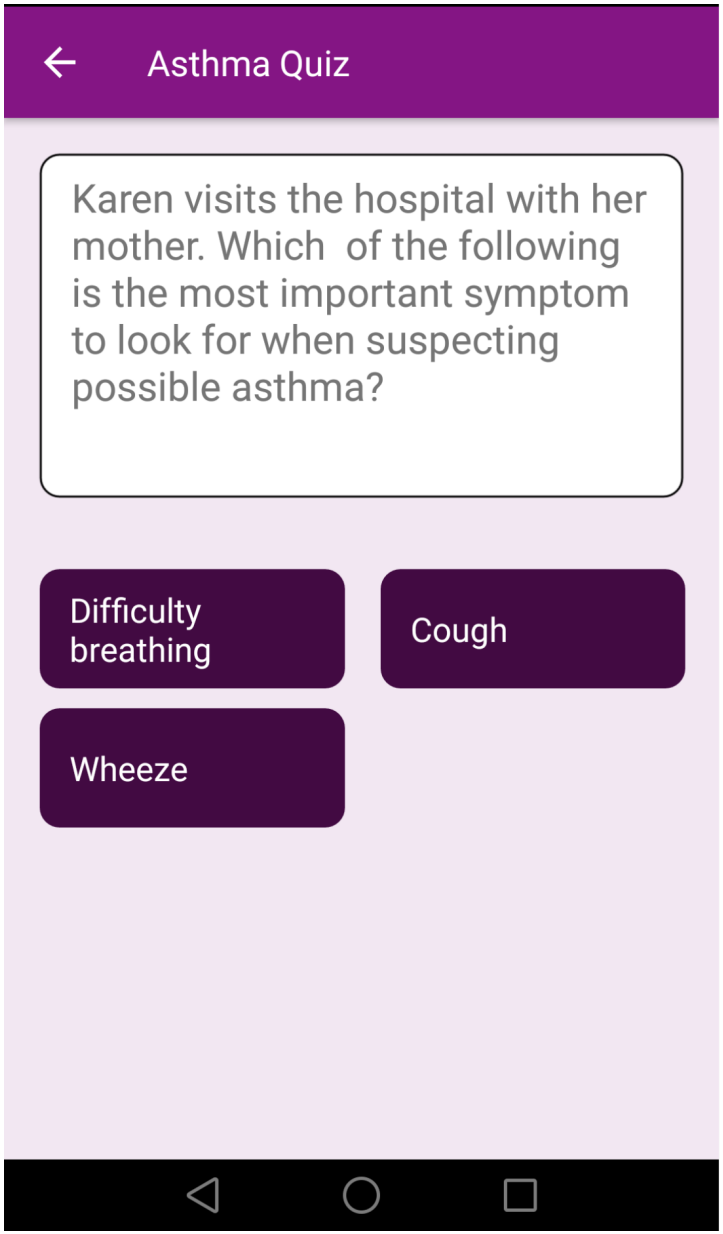

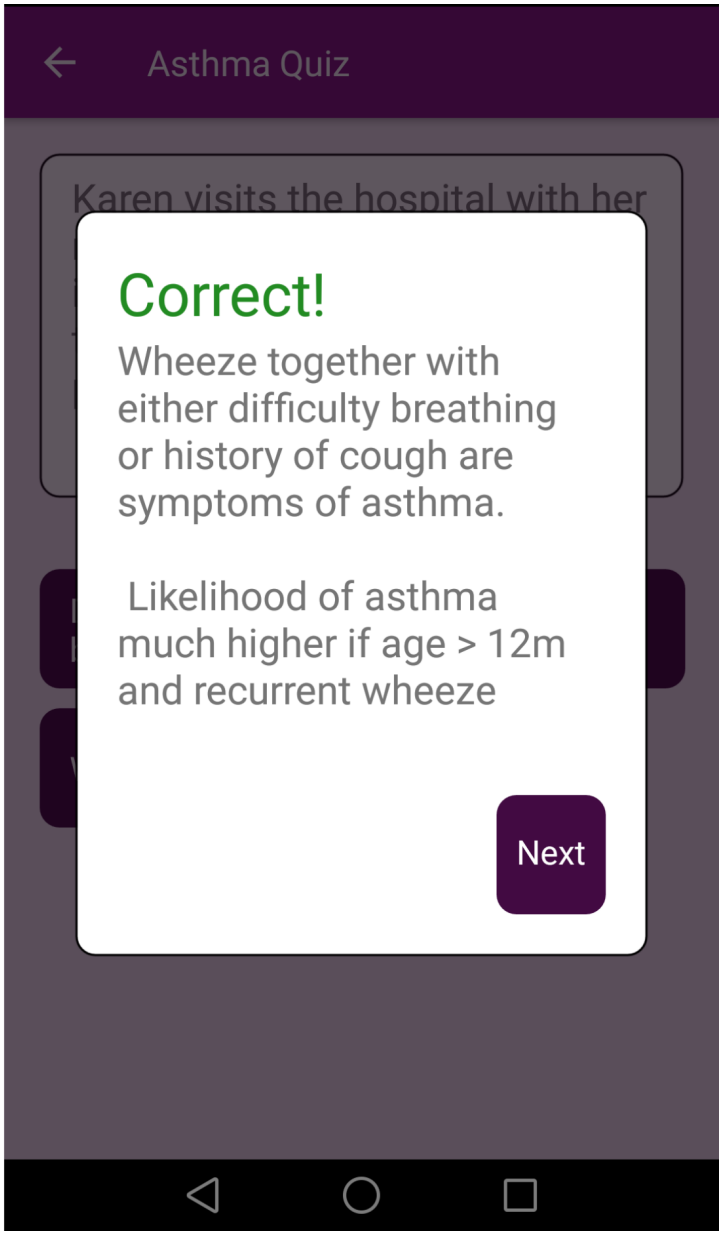

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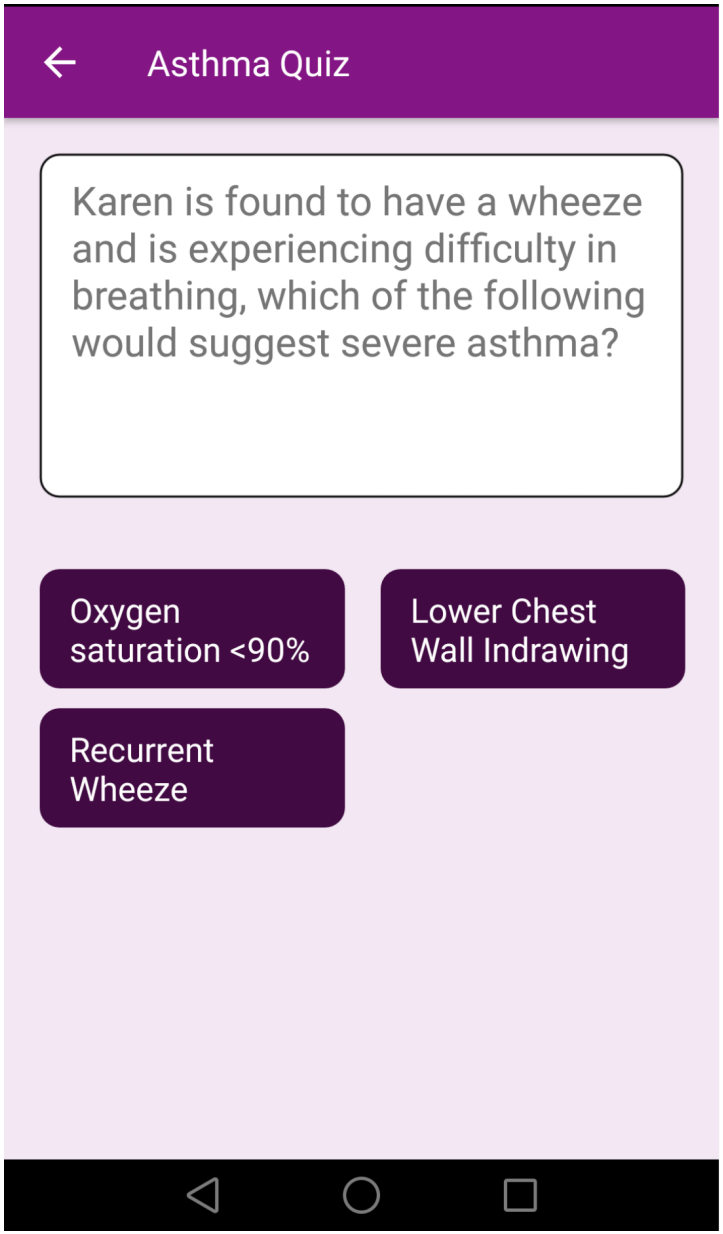

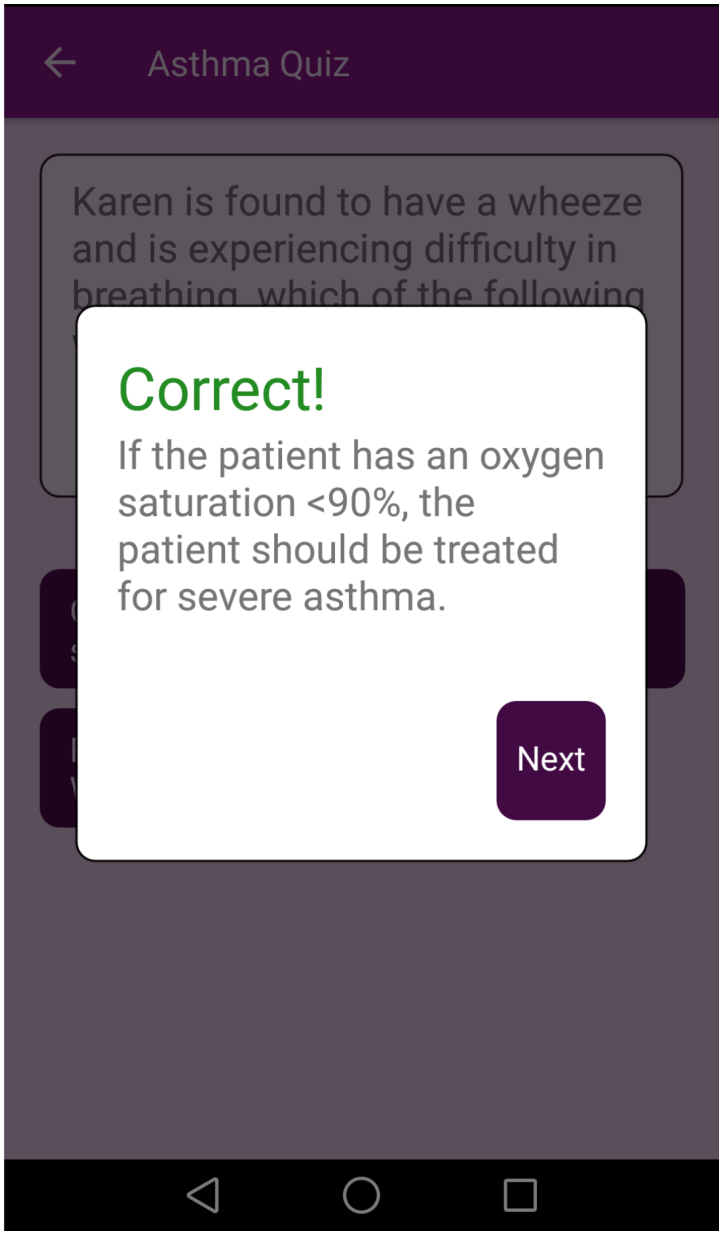

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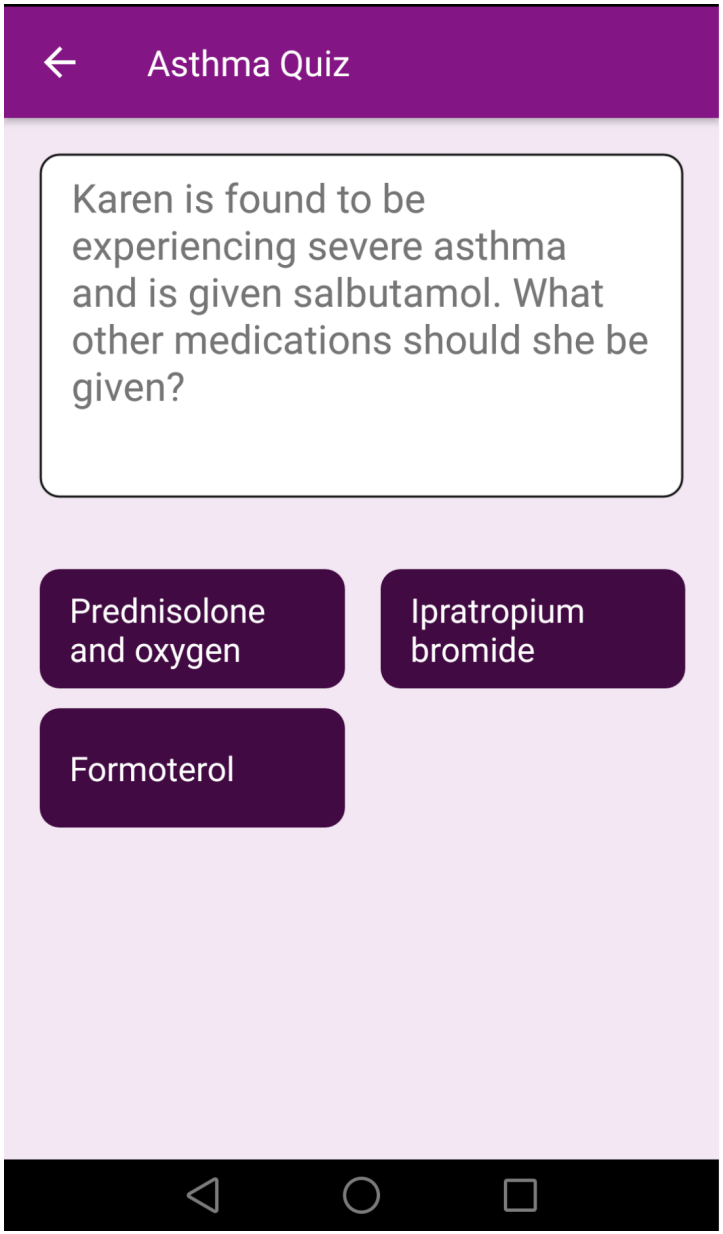

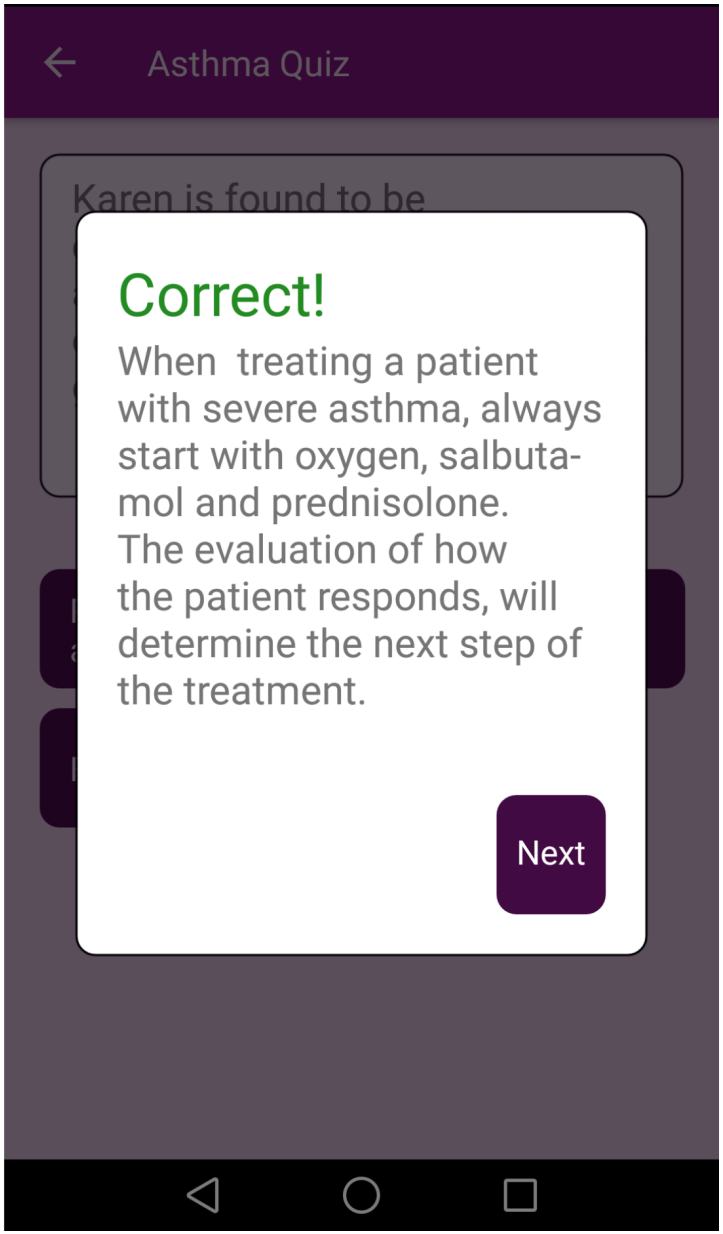

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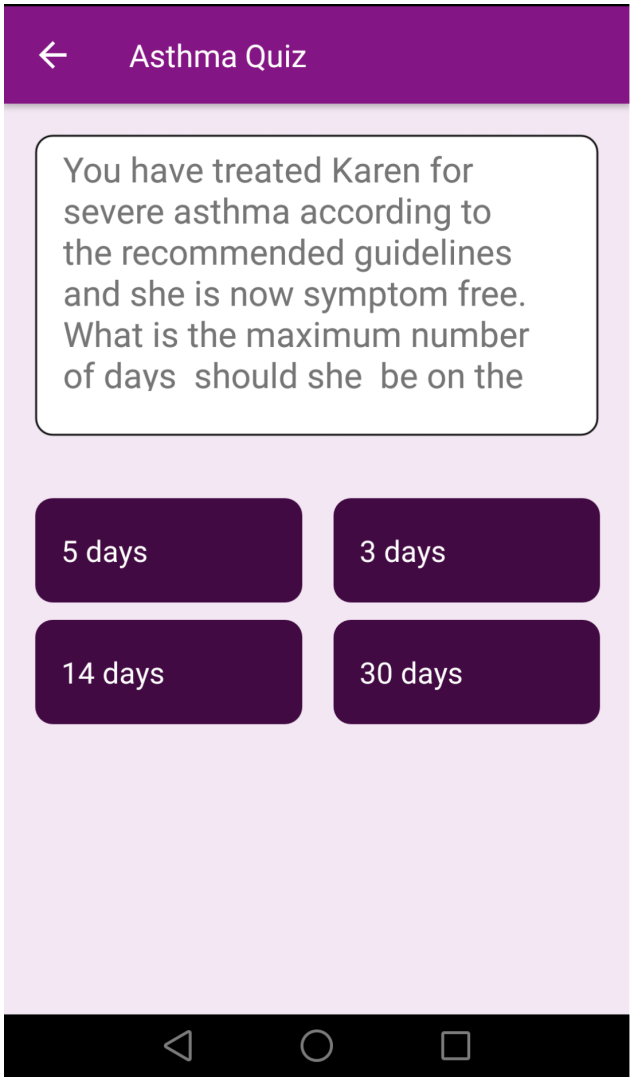

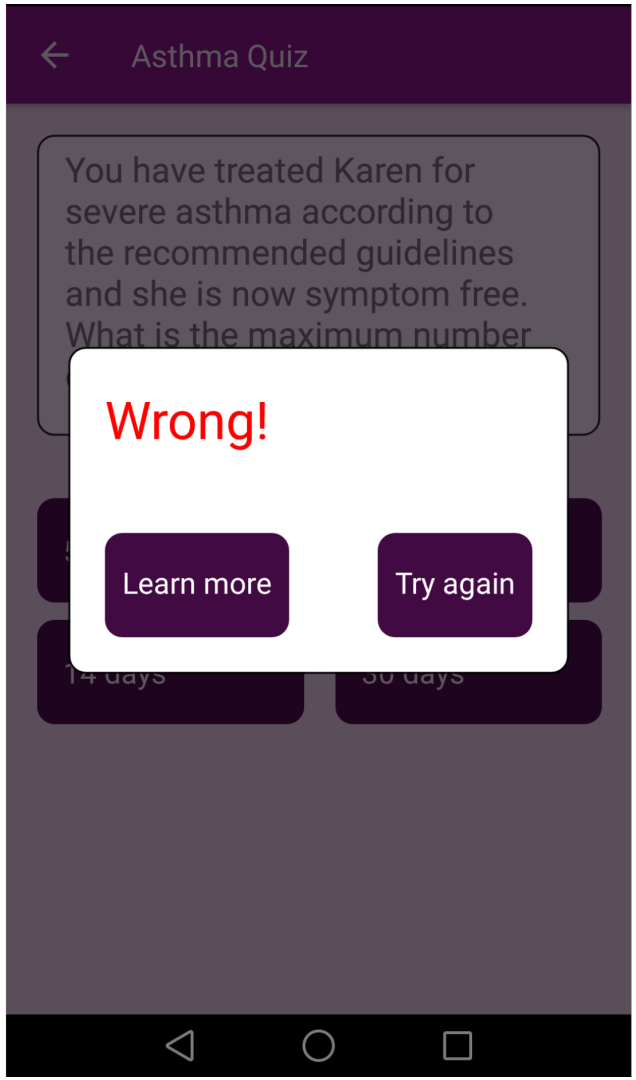

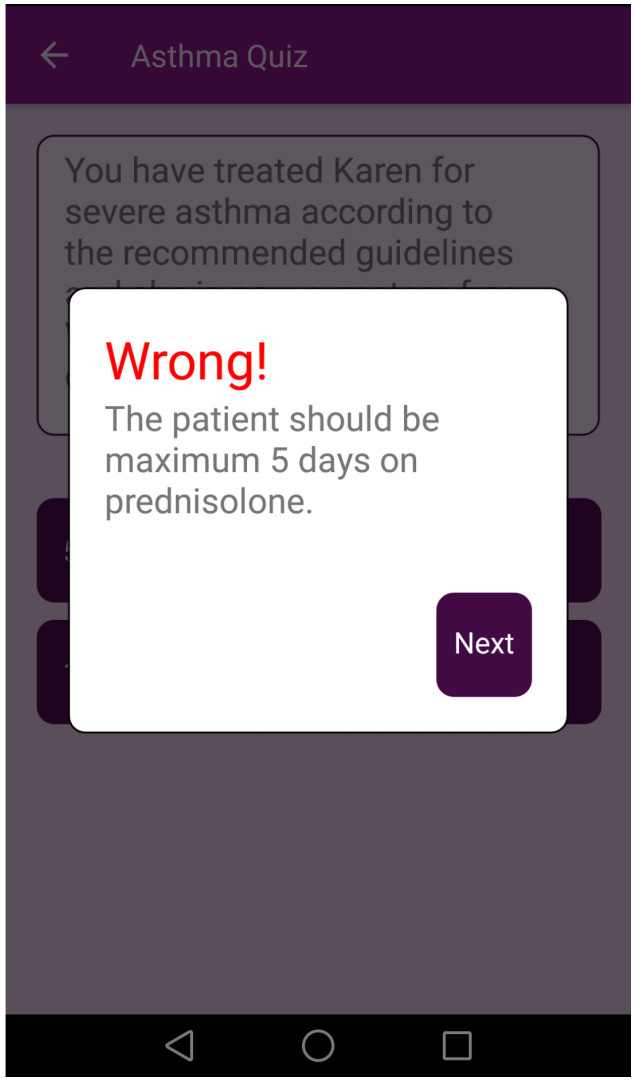

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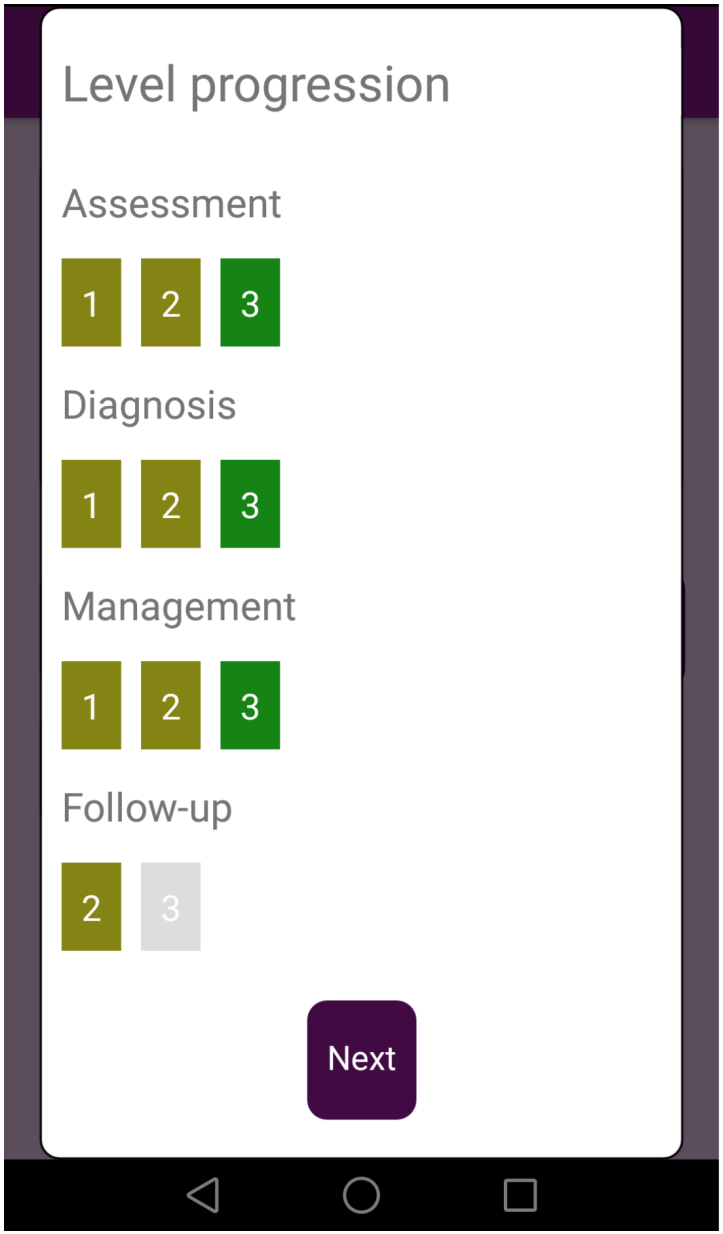

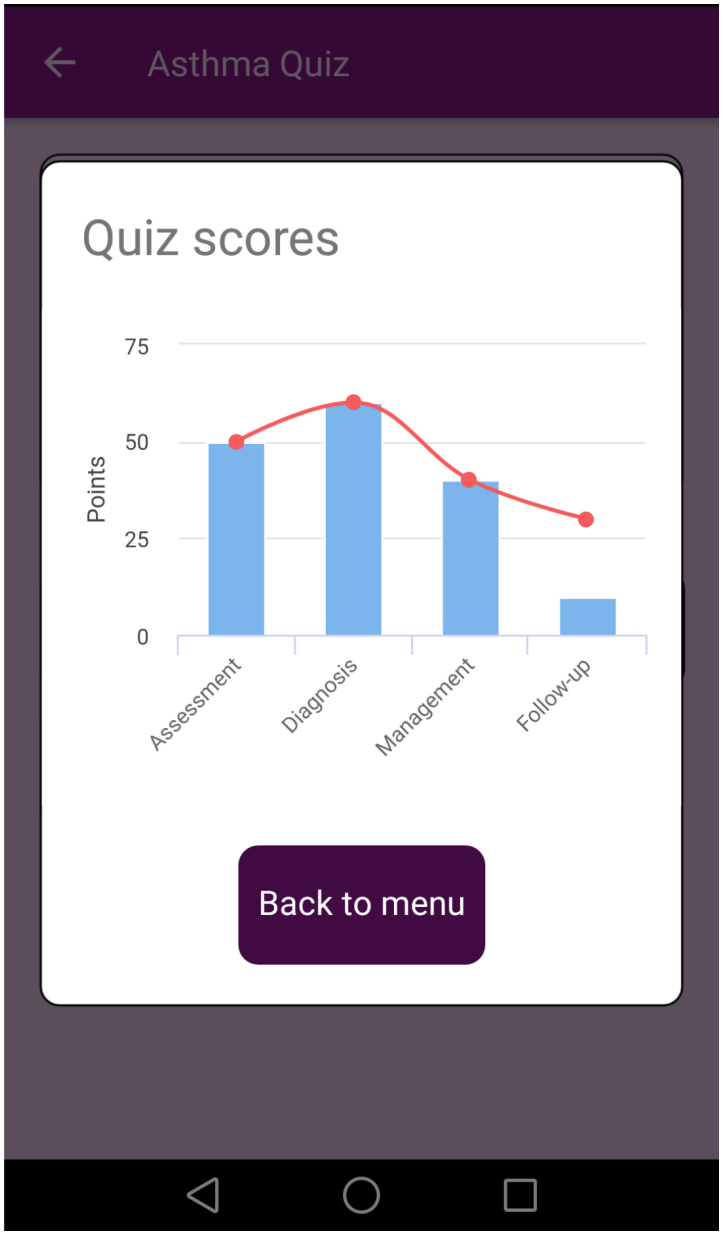

Evaluation - Contribution to medical domain

User tests:

- Specialist nurses in respiratory medicine were playing one level of the game.
- Medical doctors were playing the whole game and could evaluate the learning model.

Findings:

- Great value for medical students and nurses. Need much more detailed questions for medical doctors.
- Adjusting the detail level to make harder questions is the right approach.
- Multiple-try with hints was very much appreciated by the clinicians.
- Scenario-based questions was positive, but some details were missed and the categories could be clearer.

Evaluation - Research questions

- Through the application and the implementation we showed that:
  - We can define a generic data structure that can be used to implement applications. such as guideline training games **(RQ1)**.
  - The generic data structure can be used to generate a specific CPG **(RQ2)**.
  - The data model can adapt to the knowledge and knowledge progression of users **(RQ3)**.
- We have demonstrated that the model can be used to represent other respiratory diseases by modelling paediatric pneumonia **(RQ4)**.

Research paper

- This thesis is part of a larger project.
- More about the project can be read in an article we published for ENASE 2019:

A Model Driven Approach to the Development of Gamified Interactive Clinical Practice Guidelines
Nyameino, Rabbi, Ebbesvik, Were, Lamo (2019)

State of the art

- Ontology-Based Generation of Medical, Multi-term MCQs (Leo, Kurdi, Matentzoglu et al 2019).
- A Model-Driven Approach to Clinical Practice Guidelines Representation and Evaluation Using Standards (Farkash, Timm, Waks 2013)
- Models and mechanisms for implementing playful scenarios (Aouadi, Pernelle, Amar, Carro, Talbot 2016)

Related work

- Dynamic content manager - A new conceptual model for e-learning (Kristensen, Lamo, Hinna, Hole 2009).
- A diagrammatic formalisation of mof-based modelling languages (Rutle, Rossini, Lamo, Wolter, 2009).
- Coordination of multiple metamodels, with application to healthcare systems (Rabbi, Lamo, MacCaull).
- The effects of different forms of feedback on fuzzy and verbatim memory of science principles (Clariana, Koul 2006).