

Improving medication compliance with ingestible sensors

BHI 505: Digital Health

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Reference

Moorhead, P., Zavala, A., Kim, Y., & Viridi, N. S. (2017). Science and Practice: Efficacy and safety of a medication dose reminder feature in a digital health offering with the use of sensor-enabled medicines. *Journal Of The American Pharmacists Association*. 57155-161.e1. doi:10.1016/j.japh.2016.12.067



Why Medication Compliance?

- Noncompliance has been reported in 50% of patients taking chronic medications.
- Noncompliance is associated with up to \$300 billion in avoidable healthcare costs annually in the US alone.
- Previous methods of increasing compliance have been ineffective
 - Or require frequent (daily) interventions from Healthcare staff



Prescription Non-Adherence Rates



Prescription Non-Adherence Results



Prescription Non-Adherence Reasons



Novel Method For Increasing Compliance

▪ Sensors!!!

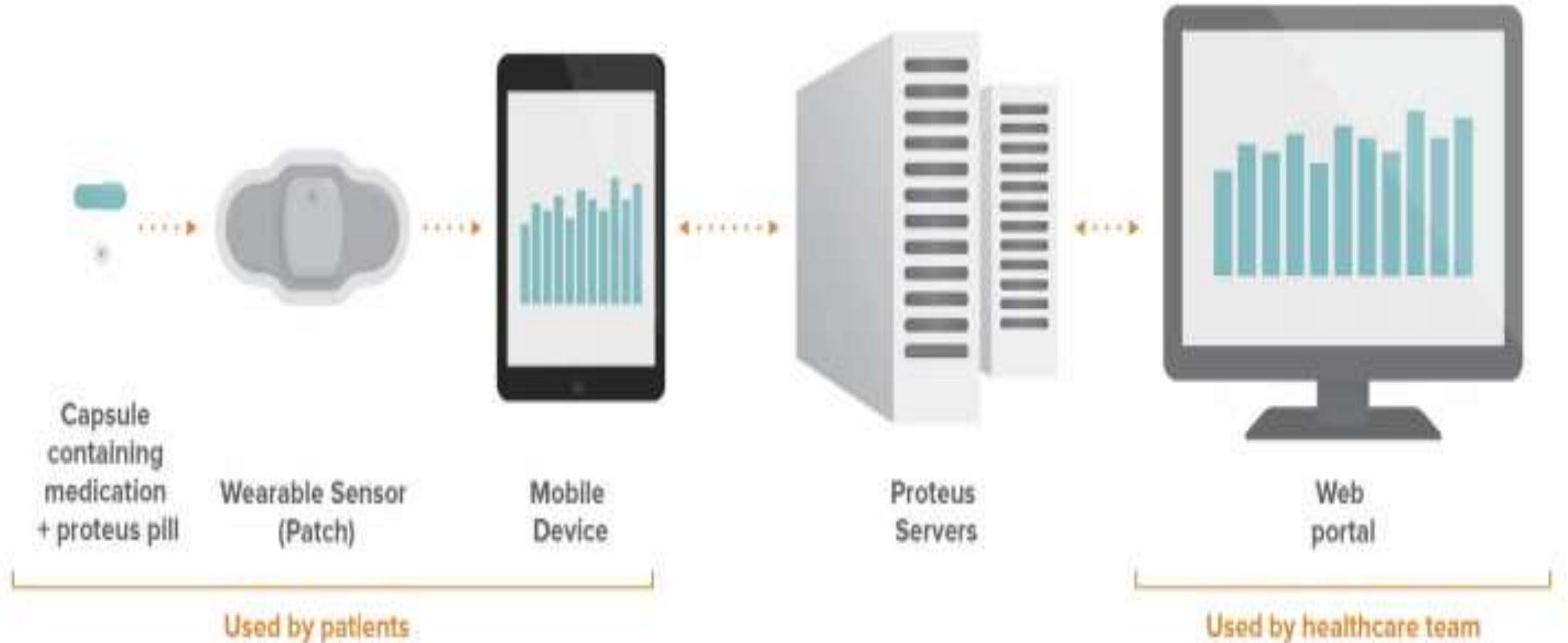
Simple 3 part system:

- Edible sensor
 - FDA Approved
- Wearable patch sensor
 - Detects ingested sensor
 - Also tracks user activity level, etc
- Interface with mobile device via Bluetooth



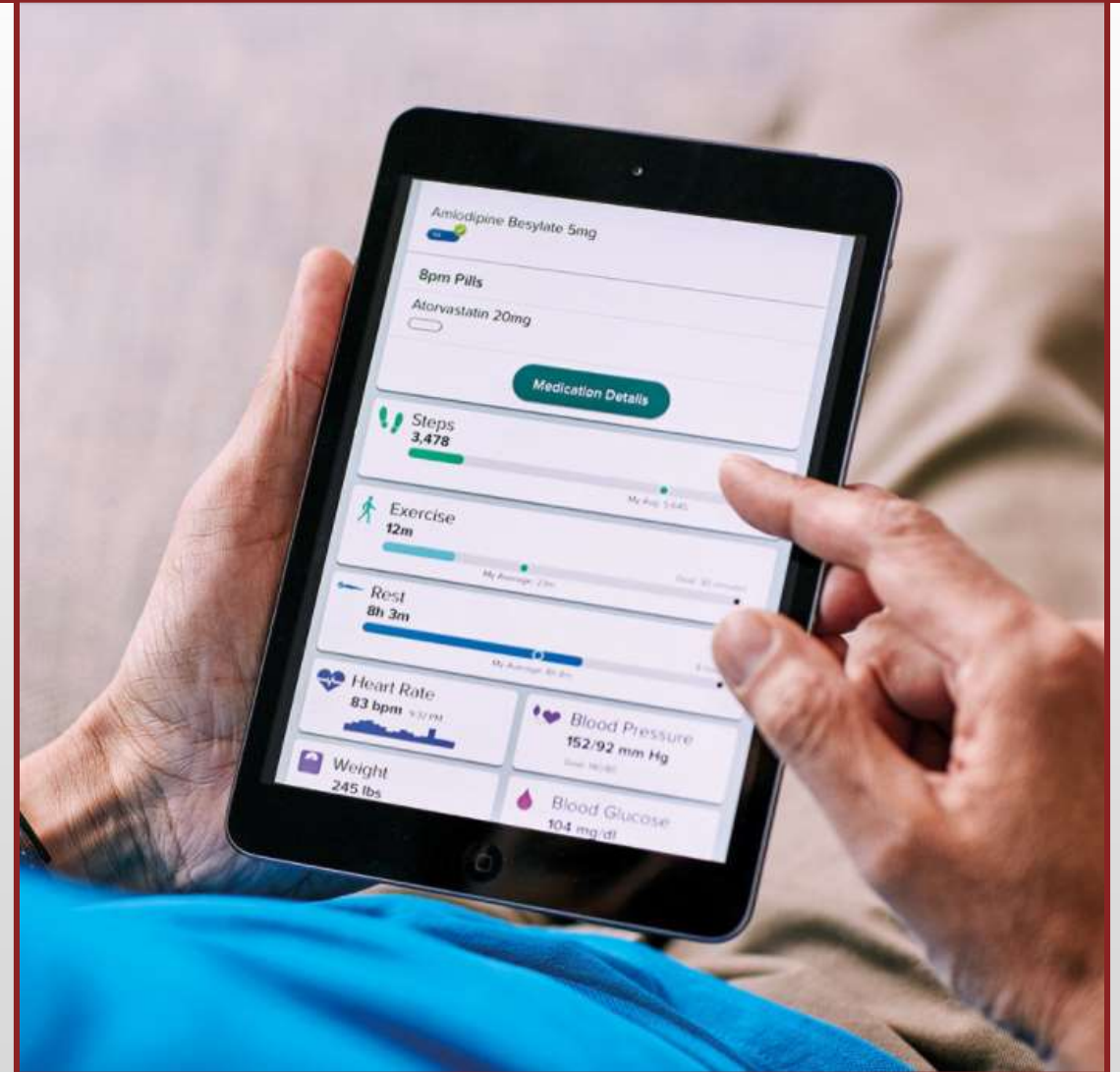
edible[®]
arrangements

The Proteus System (<http://www.proteus.com>)



Sensor Network for Increasing Compliance

- Mobile device reminds the user when medications are due to be taken.
- Device also tracks when and what has been taken (from patch sensor).
- What happens when someone takes their medication and then sees the dose reminder on the mobile device?

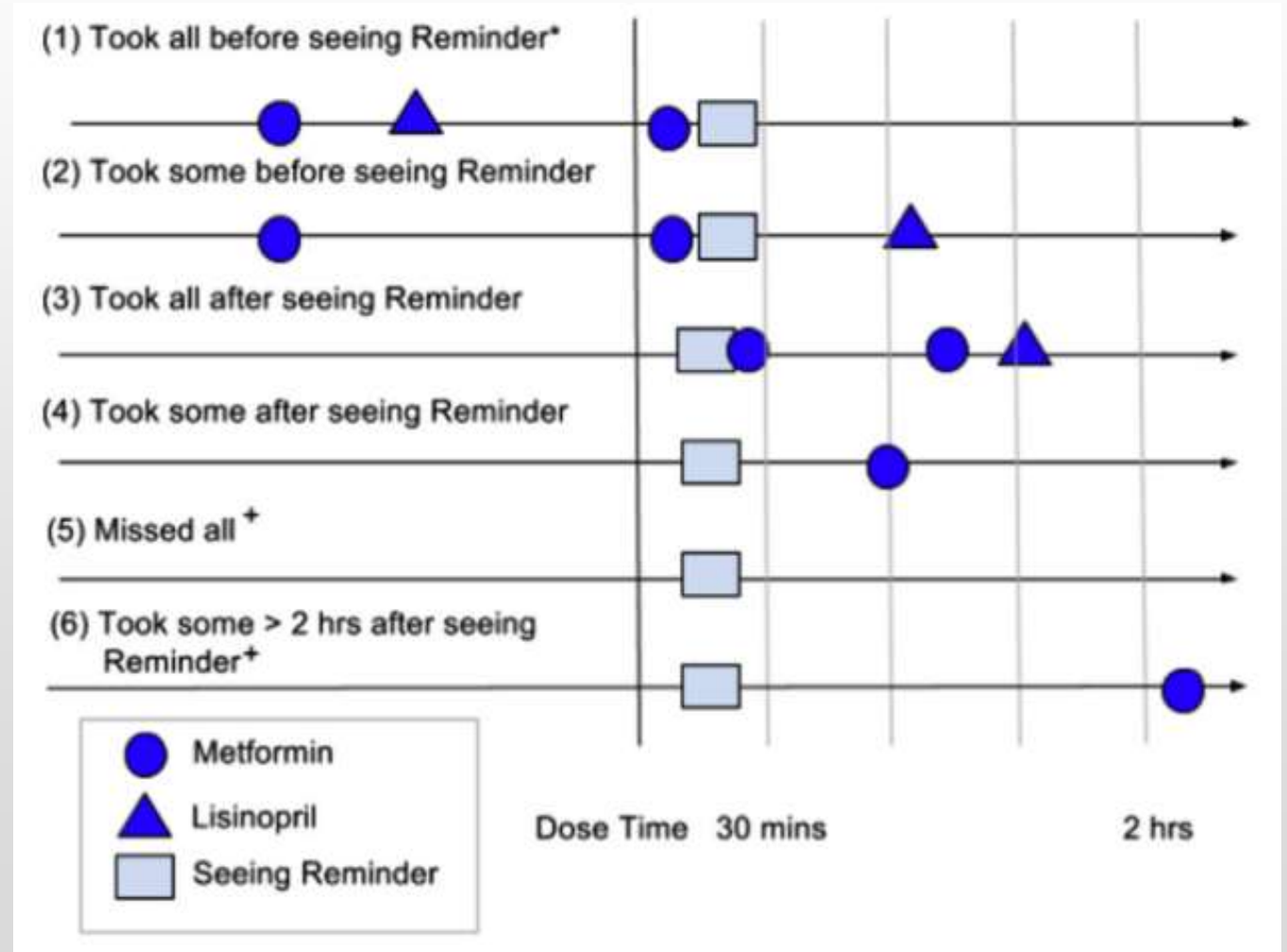


Study Evaluation

Study Design

- Hypothesis 1:
 - System improves compliance
- Hypothesis 2:
 - System does not cause people to take too much medicine
- Post hoc analysis
- No control group reported

Categories of observed events



Adherence Improved?

Difference in proportions of medication taken after “seeing” (P_{seeing}) and “not seeing” ($P_{\text{notseeing}}$) the medication dose reminders at different levels of overall adherence

Overall adherence	n	Number of dose windows	P_{seeing}	$P_{\text{notseeing}}$	$P_{\text{seeing}} - P_{\text{notseeing}}^a$
≤60%	2	286	65.8 ± 9.3	24.8 ± 19.8	41.0 ± 10.5
>60% to 70%	2	304	56.3 ± 5.2	35.7 ± 4.9	20.6 ± 0.4
>70% to 80%	8	815	57.8 ± 18.1	38.5 ± 19.0	19.3 ± 14.8
>80% to 100%	45	4641	79.2 ± 16.9	65.6 ± 21.6	13.6 ± 15.3
All	57	6046	74.9 ± 18.4	59.3 ± 24.0	15.6 ± 15.6

^a Note that this is the mean of the $P_{\text{seeing}} - P_{\text{notseeing}}$ differences of each subject.

Note about “seeing” and “notseeing”:

It would be more accurately titled as “within Bluetooth range of mobile device” and “not within Bluetooth range of mobile device”

Less adherent subjects increased adherence the most

Adherent versus Adherence

What is in a name?

- Is someone taking a medicine 3 out of 5 days 60% adherent or nonadherent?
- What is the long-term effect on adherence?
- Is the expectation that people would use this sensor system indefinitely?
 - Cost?
 - Compliance with the system?

What's in a name? That which we call a rose by any other name would smell as sweet.

William Shakespeare

www.thequotes.in



Control group data???

Safety of the dose reminders

- 8236 data points recorded assessing overdosage
 - 6 events were actual overdosage.
 - The 6 events happened when the user was “not within Bluetooth range.”
 - Mobile device reminder was determined to be not the cause.
- Upper limit of CI for overdose events was reported as 0.143%

- First, do no harm.



Note:

- FDA approved
- Not only study of the system

Usability

- Over 50% of research subjects made less than \$20,000 a year income.
 - Over 25% had not graduated high school.
- Noteworthy because usability of the system was rated highly by the research subjects confirming that the system interface is relatively user-friendly.



Study Conclusion

- The authors report on a novel sensor system for increasing compliance in a safe and effective manner.
- The study effectively increases awareness of using ingestible sensors.
- Safe and apparently user-friendly.
- The authors successfully set the stage for prospective studies to further analyze the clinical usefulness of the studied sensor system



How else can this system be used?

- Compliance with as needed medication!

Prescription Painkillers

Prescription painkiller abuse
is one of the most difficult
addictions to treat.

-doctors and rehabilitation therapists.

40 U.S. DEATHS
per day due to
prescription painkiller abuse
according to the CDC.

1 in 20

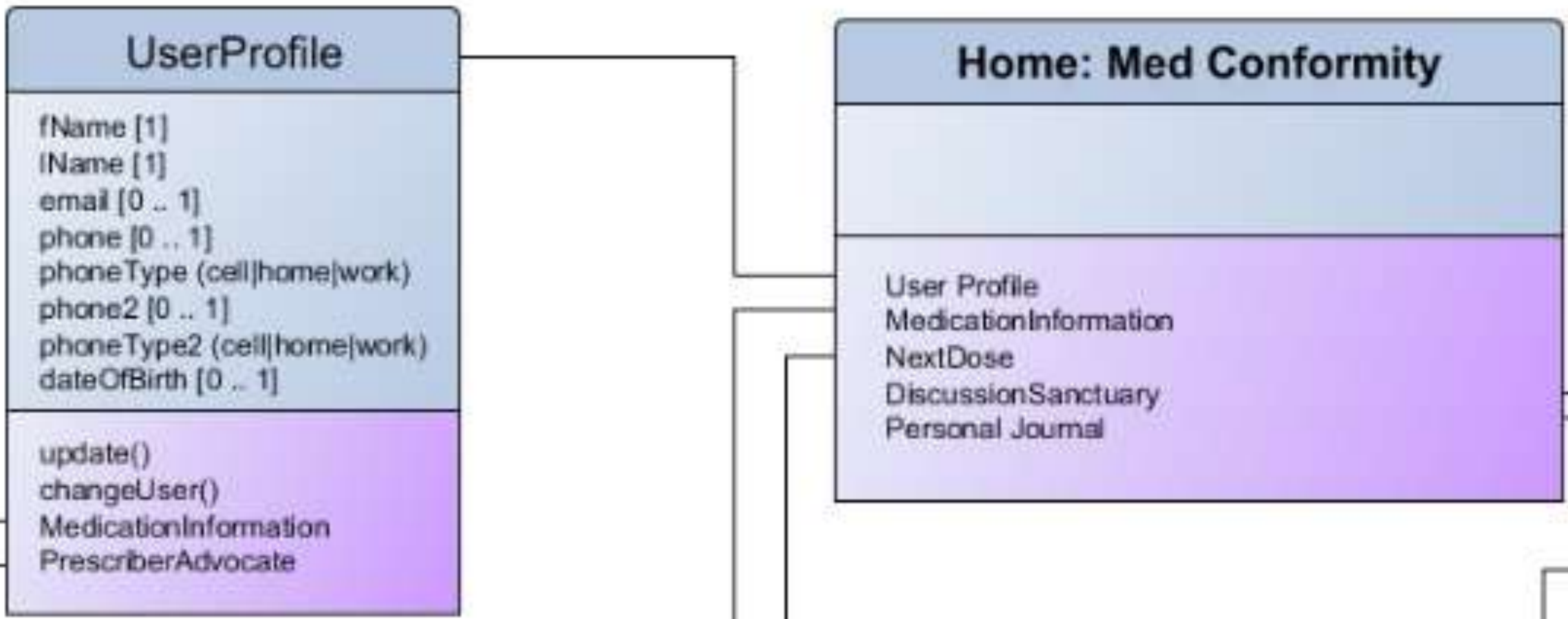


people in U.S.

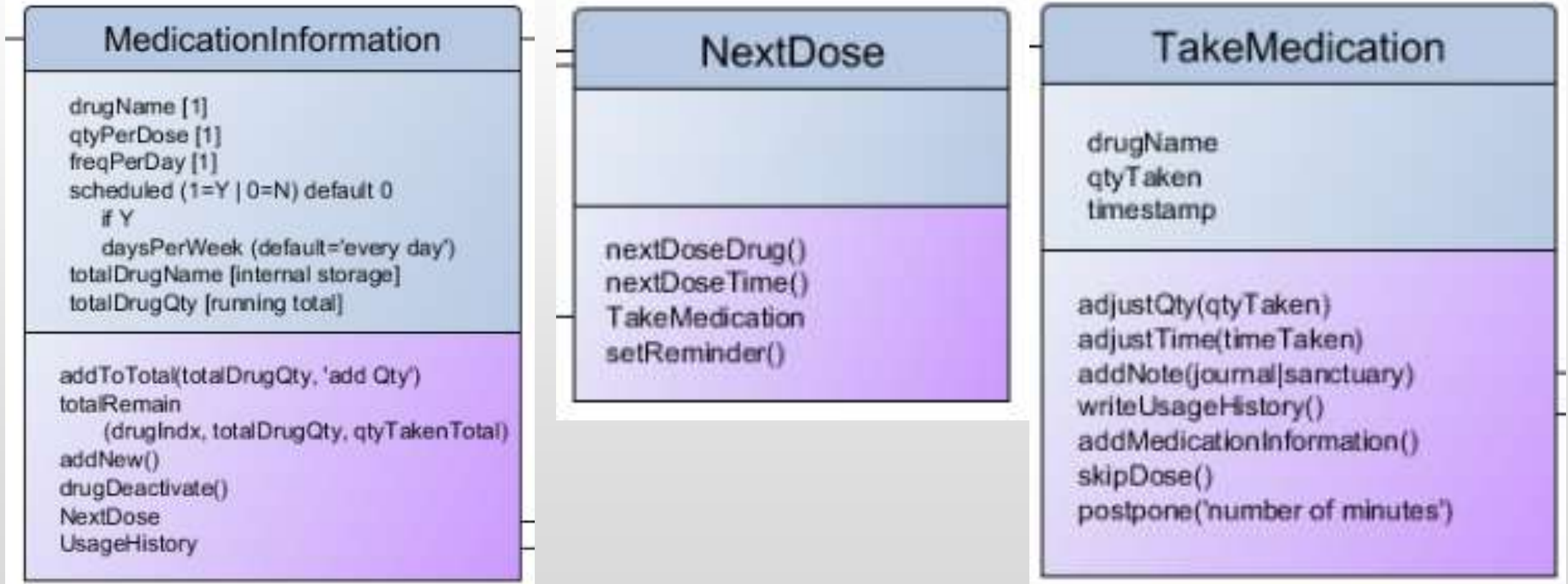
(12 and over)

admit to non-medical use
of prescription painkillers
in the past year.

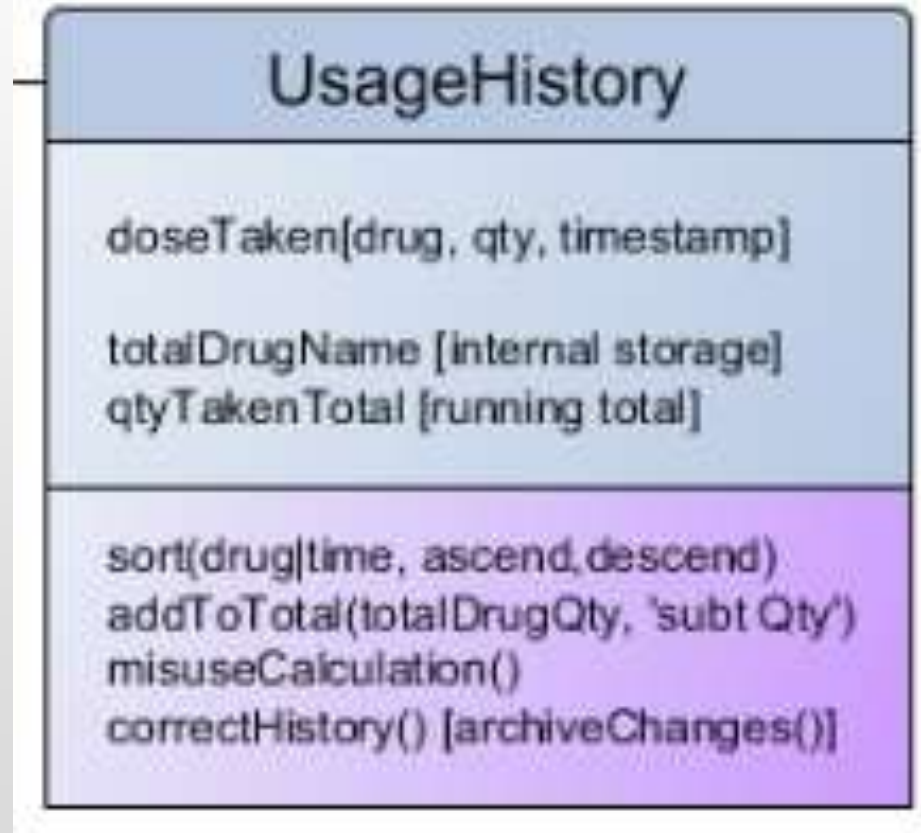
“Med Conformity” Project



Class Diagram Continued



Data Storage



Full Prod vs. Prototype:

- For example:
 - Full Prod would have capability to add prescriber and patient advocate data, personal journal entries and messages to prescriber and/or advocate
 - Full Prod would use sensors to confirm when doses of medication were taken
- Class segments reflect Full Prod

User Stories

- I am not a huge fan of User Stories, but the process of creating the stories has helped in designing elements of the app.
- All Users:
 - Scenario 0: Taking Medication
 - Given that I am prescribed medication
 - And the quantity of medication I possess has been updated.
 - When I notify Med Conformity that I have taken my medication,
 - Then I am notified of the remaining quantity of medication
 - And new 'Next Dose' information is calculated.

Persona: Medication User



As a user of medications,

- I want a tool like Med Conformity
- So that I can keep track of the medications I have taken and when my next dose is due.

Scenario 1: Medication Reminder

- Given that I am prescribed medication
 - And I have loaded the prescribed directions for usage into Med Conformity
 - And the quantity of medication I possess has been updated.
- When I receive a reminder from Med Conformity for my next dose,
- Then I take my prescribed medication
 - And I am updated with my new remaining quantity of medication
 - And then I am notified about my 'Next Dose' information.

Persona: Medication Misuser



As a misuser of medications

- I want a tool like Med Conformity to track my medication usage
- So that my prescriber can be assured that I am using my medication appropriately.

Scenario 3: Taking a Dose Too Soon

- Given that I am prescribed medication
 - And I have loaded the prescribed directions for usage into Med Conformity
 - And the quantity of medication I possess has been updated at the insistence of my prescriber.
- When I take a dose before the dose was due,
- Then I am warned that the dose was too early
 - And I am updated with my new remaining quantity of medication
 - And I am reminded that the amount of medication received will need to last until the date of my next refill.