



## **PRAKTIKUM MEDIZINISCHE INFORMATIONSSYSTEME**

Titel

Literature Research - Medication Management App with  
FHIR

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# 1 Abstract

In this article a concept for an iOS-App which helps users manage their medications using FHIR[2] is presented. To create this concept similar existing apps and existing standards where examined.

## 2 Literature Research

When researching existing solutions three in particular were chosen which are presented in further detail below. These were selected due to several reasons.

AMTS[1] (Arzneimitteltherapiesicherheit) for example is not an app but was still analysed in detail as it is a functioning solution and shows what scope an app has to cover in order to be practical. It is a paper-based system which is "easy to use" as 80 percent of the patients who saw the MedicationPlan for the first time intuitively knew how to read and comprehend it correctly.

"MyTherapy" and "MediSafe" were chosen as they are both iOS Applications currently being used. They were selected in order to have a good comparison of what existing iOS Applications are capable of currently. They are very similar in functionality and also cover the functionality of the AMTS system.

These three existing medication-management solutions where individually examined with focus on following aspects.

- Which data is required?
- Which additional information can be used?
- Advantages and disadvantages of the particular solution?

### 2.1 AMTS

The AMTS medication-plan is a basis for helping patients manage their medications. Patients receive paper printed plans which contains the medications for a single day. It has a Bar-Code allowing the medication-plan to be opened on a device to modify the plan.

The form is titled "AMTS-System MEDIKATIONSPLAN®". It contains several sections:

- Patient Data:** Fields for Name, Vorname, Geb.-Datum, Wohnort, Telefon, Krankenkasse, Versicherung-Nr., Befragung bis, and Stamme-Patienten-Nr.
- Medication List:** A table with columns for Wirkstoff, Medikament, Wirkstoff-stärke, Dosis, and Anweisung. Below this is a grid for recording intake with columns for Morgens, Mittags, and Abends, and rows for each medication.
- Barcode:** A barcode area with the text "Hinweise für den Patienten" and "Medikationsplan".
- Footer:** A small note at the bottom: "Copyright © 2010 AMTS-System. Alle Rechte vorbehalten. AMTS-System ist ein eingetragenes Warenzeichen.".

Figure 1: Empty AMTS Medicationplan

As one can see in Figure 1 the printed Medication-Plan by AMTS lists all active pharmaceutical ingredients and the corresponding medication name. The practitioner can indicate the time of day the medication is to be taken (morning, midday, evening) and whether it is to be taken before, with or after a meal. There is also space for notes and which doctor prescribed it.

### **2.1.1 Used data**

- medication-name
- active pharmaceutical ingredient
- time(s) of day when medication should be administered
- additional information if medication should be taken before, after or during a meal
- notes for the patient for instance: instructions for medication administration

### **2.1.2 Advantages**

The system doesn't rely on a database or anything similar and therefore is very flexible and changes can be made very quickly. It gives an overview of all medications to be taken by a patient allowing a professional to determine possible medication interactions as he has the full list given. Only the practitioner can enter information into the system which ensures a certain data-quality.

### **2.1.3 Disadvantages**

The AMTS medication-plan only provides the medication overview for a single day so when evaluating the plan for possible medical interactions the practitioner only has a small subset of the entire medication-plan at his disposal. When a medication is not scheduled to be taken on a daily basis such interactions could potentially go unnoticed. It does document if a patient takes the medication or not but no reason why a patient has not taken it. The practitioner has to manually input the information provided by the patient into the system.

## **2.2 My Therapy**

MyTherapy[3] is an iOS-app with the same goal as the AMTS medication-plan of helping users manage their medication by building a schedule. It has reminders of when medication or measures have to be taken. If one is tracking his blood pressure for example the app will also be able to show an overview of the past week, month, year in form of a graphic of the actual values. The diary function shows the percentage of actions taken - so if one has to take 4 tablets a day and indicates that he has taken one so far the patient has completed 25 percent of the actions of the day.

MyTherapy has four types of information which can be scheduled.

- Medication
- Measure (e.g. blood pressure)
- Activity
- General Well-Being

All information in this app has to be input manually. After entering this information the app displays a schedule for the current day and generates notifications reminding the user to perform a task (e.g. take medication, measure blood pressure) at the appropriate time. Upon performing/not performing such a task the user can mark these tasks as done/not done. The app also provides a "Journal" where the user is shown a history of what tasks were performed/not performed.

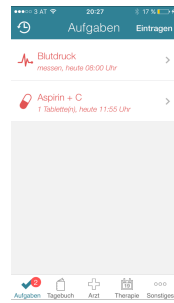


Figure 2: Screenshot of the Daily Schedule View

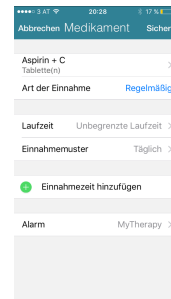


Figure 3: Creating and scheduling a medication

### 2.2.1 Used Data

#### Required Information

- medication-name
- active pharmaceutical ingredient
- time(s) of day when medication should be administered

#### Optional Information

- additional information if medication should be taken before, after or during a meal
- notes for the patient for instance: instructions for medication administration

### 2.2.2 Advantages

The Journal function can provide the practitioner with more accurate and reliable information than the users recollection. The reminders are reliable and give the patient an overview of what medication has to be taken.

### 2.2.3 Disadvantages

Since the data in this app is structured implementing changes to this structure can be very complicated for example - editing the frequency a medication has to be taken is complicated.

## 2.3 MediSafe

MediSafe[4] is also an iOS-app helping users manage their medications. In this app the user also has to manually enter which medications he/she would like to manage. In addition the app also supports managing other tasks than medications. (e.g. measuring blood pressure)

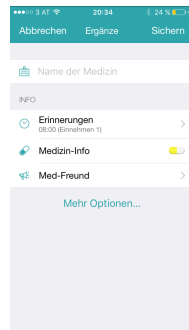


Figure 4: Creating medication



Figure 5: Scheduling a medication

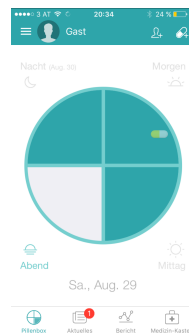


Figure 6: Daily Overview

### 2.3.1 Used Data

#### Required Information

- medication-name
- active pharmaceutical ingredient

- time(s) of day when medication should be administered

#### Optional Information

- additional information if medication should be taken before, after or during a meal
- notes for the patient for instance: instructions for medication administration

#### 2.3.2 Advantages

The same advantages as for "MyTherapy" apply to this app. The Journal function can provide the practitioner with more accurate and reliable information than the users recollection.

#### 2.3.3 Disadvantages

Structured data limits the flexibility of the app.

## 3 FHIR

FHIR (Fast Healthcare Interoperability Resources) defines Resources that represent clinical concepts. Those resources can be managed in isolation or aggregated into complex documents. The resources are based on XML or JSON structures with an HTTP-based RESTful protocol.

Before building a concept for a app it is important to know the capabilities and limitations of FHIR.

### 3.1 Resources

FHIR has a set of resources which allow managing medications.

#### 3.1.1 Patient

Is the central resource and represents the user of the app. MedicationOrder, MedicationDispense, MedicationAdministration reference this resource.

#### 3.1.2 Practitioner

Describes a person engaged in the health-care process i.e. physician, dentist, ... The practitioner is usually the person who initiates the *prescribe* → *dispense* → *administer* sequence.



### **3.1.3 Medication**

The prescribed Medication. Contains information about the active pharmaceutical ingredient, name, brand but no additional information about recommended dosage or instructions.

### **3.1.4 MedicationOrder**

A MedicationOrder is an order for supply of a medication. and also contains administration-instructions for the patient.

### **3.1.5 MedicationDispense**

Represents the dispense of a medication to a patient.

### **3.1.6 MedicationAdministration**

Represents the consumption or lack thereof of a medication. Can contain information why a prescribed medication was not taken.

## **3.2 Capabilities**

These resources (if fully defined) make it possible to:

### **3.2.1 generate a list of a patients prescribed medications**

The display of this information follows a typical "master-detail" flow. The "Medication-Master-View" displays a potentially long list of all prescribed medications. The information displayed for each individual item is very limited (i.e. the name of the medication). Each item can be selected which shows the "Medication-Detail-View" for the selected item. The Detail-View shows one single item in greater detail than in the Master-View.

Information shown in this view is (if available):

- medication-name
- active pharmaceutical ingredient
- dosage instructions
- administration instructions
- additional notes

### **3.2.2 generate a schedule for administering medications**

Similar to the "Medication-Master-View" it displays a list of medications. The list is sorted in chronological order and is limited to only the medications which should be consumed within that day. Additionally the time for which the consumption of the medication is scheduled is displayed. In this view the user can also mark medications as consumed/not consumed and additionally provide a reason why the medication was not taken.

### **3.2.3 generate a list of prescribed medications which where not dispensed yet**

Displays a list of all medications which were prescribed to the patient but no record of the medications dispense is present. The information is displayed similarly to the "Medication-Master-View". The user cannot actively edit this list (i.e. add or delete items). Once the medication has been picked up and the medications dispense is recorded in the FHIR-Database these changes will be reflected in this view.

### **3.2.4 generate a list of medications which have been administered or a reason why they weren't administered**

A list is displayed of all recorded events concerning the consumption of Medication. In FHIR the corresponding resource is MedicationAdministration Note that a MedicationAdministration resource can also be created even when the medication was not actually consumed. This is indicated by setting the "was-NotGiven" flag to true. Each list item should display when the medication was consumed or when it was recorded that the medication was not taken.

## **3.3 Limitations**

FHIR resources have almost no required properties. The app has to define which properties are required to work. If insufficiently defined data is ignored the user is shown potentially incomplete data which could lead to complications in his/her therapy.

## 4 Overview

	<i>daily overview</i>	<i>medications overview</i>	<i>enter medication-consumption</i>	<i>journal</i>
<b>AMTS</b>	✓	✓	✓	
<b>MyTherapy</b>	✓	✓	✓	✓
<b>MediSafe</b>	✓	✓	✓	✓
<b>Fhir</b>	✓	✓	✓	✓
<b>myMedApp</b>	✓	✓	✓	✓

Figure 7: Overview showing capabilities of different solutions

Because the information about medication prescriptions is entered into FHIR by the practitioner the patient does not need to manually enter these. Therefore the focus of the app lies on retrieving the data via a RESTful FHIR-API and displaying it.

The user should be able to see a schedule for the current day which shows which medications he/she should take.

The app should provide an overview of all currently prescribed medications.

The app should allow the user to record the consumption of medication or provide a reason why the medication was not consumed.

## 5 Proposed Concept

The proposed app should have following capabilities:

- User Sign-In
- Medication Overview
- Schedule
- Journal

## 5.1 User Sign-In

In order to use the app in a meaningful way the user is required to log-in. The proposed app communicates with a FHIR-API intended for testing-purposes. This API has no user-profiles which can be used for a conventional log-in via username and password. The only requirement after a successful Sign-In is authorized access to the users Patient resource. Since the FHIR-API does not require authorization the Sign-In can be mocked by letting the user provide the id of a existing Patient-Resource.

## 5.2 Medication Overview

This view shows all medications which were prescribed to the patient. This view represents the "Medication-Master-View" described in section 3.2.1.

## 5.3 Schedule

The schedule shows all medications which have to be consumed within the current day. The user can additionally mark items as consumed or not consumed as described in section 3.2.2.

## 5.4 Journal

The journal screen shows the user a chronologically sorted list of past prescriptions. Instead of the ability to mark items as consumed or not consumed this view shows how the item was marked in the past. More information can be found in 3.2.4.

# 6 Example FHIR-Resources

Resources can be created or updated in FHIR via a HTTP-POST-Request to the FHIR-REST-API. The Request should contain either a XML or JSON representation of the resource in its body. The FHIR-API assumes a data-format of XML by default. To override this default The "ContentType" header must be set. The following examples following examples use JSON.

When creating a resource no id should be specified. These ids are assigned by the FHIR-API. When a resource is successfully created or updated the response contains a representation of it in the format specified in the "ContentType" header. This representation also contains the id which was assigned to it.

To update an existing resource the procedure is the same as when creating one but additionally the id must be provided in the POST-Request.

## 6.1 Example Patient

This JSON represents how a Patient with the following values is represented in FHIR.

Name	Peter Meier
Nickname	Pedro
Social Securitynumber	12345
Birthday	1990-12-25
Adress	Jägerstrasse 21, 1200 Wien (since 1990-12-25)
Phone	(Home) +43 660 1234567
Gender	male
Emergency Contact	Martina Meier (Phone number : +43 660 7654321)

Listing 1: Example of a JSON-representation of a Patient in FHIR

```
{
  "resourceType": "Patient",
  "id": "PLACEHOLDER_ID",
  "identifier": [
    {
      "use": "usual",
      "type": {
        "coding": [
          {
            "system": "http://hl7.org/fhir/v2/0203",
            "code": "SS"
          }
        ]
      },
      "system": "urn:oid:1.2.36.146.595.217.0.1",
      "value": "12345",
      "period": {
        "start": "1990-12-25"
      }
    }
  ],
  "active": true,
  "name": [
    {
      "use": "official",
      "family": [
        "Meier"
      ],
      "given": [
        "Peter"
      ]
    }
  ],
  {
    "use": "usual",
    "given": [
```

```

        "Pedro"
    ]
}
],
"telecom": [
{
    "system": "phone",
    "value": "+43 660 1234567",
    "use": "home"
}
],
"gender": "male",
"_gender": {
    "fhir_comments": [
        "    use FHIR code system for male / female    "
    ]
},
"birthDate": "1990-12-25",
"_birthDate": {
    "extension": [
        {
            "url": "http://hl7.org/fhir/
                StructureDefinition/patient-birthTime",
            "valueDateTime": "1990-12-25T14:35:45-05:00"
        }
    ]
},
"deceasedBoolean": false,
"address": [
{
    "use": "home",
    "type": "both",
    "line": [
        "Jaegerstrasse 21"
    ],
    "city": "Vienna",
    "district": "Brigittenau",
    "state": "Vienna",
    "postalCode": "1200",
    "period": {
        "start": "1990-12-25"
    }
}
],
"contact": [
{

```

```

    "relationship": [
      {
        "coding": [
          {
            "system": "http://hl7.org/fhir/patient-
              contact-relationship",
            "code": "emergency"
          }
        ]
      }
    ],
    "name": {
      "family": [
        "Meier"
      ],
      "given": [
        "Martina"
      ]
    },
    "telecom": [
      {
        "system": "phone",
        "value": "+43 660 7654321"
      }
    ],
    "gender": "female"
  }
]
}

```

## 6.2 Example Medication

This JSON represents how a simple Medication named "Testmedication Tablets" is represented in FHIR.

Listing 2: Example of a JSON-representation of a Medication in FHIR

```

{
  "resourceType": "Medication",
  "text": {
    "status": "generated",
    "div": "<div>Testmedication Tablets</div>"
  },
  "code": {

```

```

    "text": "Testmedication Tablets"
  }
}

```

### 6.3 Example MedicationOrder

This JSON represents how a MedicationOrder is represented in FHIR. The MedicationOrder describes the prescription of "Testmedication Tablets" in increasing dosages for the patient Peter Meier.

- Beginning with 2015-10-01 the patient should consume one tablet twice a day for 30 days
- Beginning with 2015-11-01 the patient should consume two tablets twice a day for 30 days
- Beginning with 2015-12-01 the patient should consume three tablets twice a day for 30 days

Note that the resources Patient and Medication are referenced and therefore have to exist before the MedicationOrder is created.

Listing 3: Example of a JSON-representation of a Patient in FHIR

```

{
  "resourceType": "MedicationOrder",
  "id": "MEDICATION_PLACEHOLDER_ID",
  "identifier": [
    {
      "use": "official",
      "system": "http://www.bmc.nl/portal/
prescriptions",
      "value": "12345"
    }
  ],
  "dateWritten": "2015-01-15",
  "status": "active",
  "patient": {
    "reference": "PLACEHOLDER_ID",
    "display": "Peter Meier"
  },
  "reasonCodeableConcept": {
    "coding": [
      {
        "system": "http://snomed.info/sct",

```



```

        "code": "195967001",
        "display": "Asthma"
    }
]
},
"medicationReference": {
    "reference": "Medication/MEDICATION_PLACEHOLDER_ID",
    "display": "Testmedication Tablets"
},
"dosageInstruction": [
    {
        "text": "Take 1 tablet twice daily for 30 days",
        "additionalInstructions": {
            "coding": [
                {
                    "system": "http://snomed.info/sct",
                    "code": "311504000",
                    "display": "With or after food"
                }
            ]
        },
        "timing": {
            "event": [
                "2015-10-01"
            ],
            "repeat": {
                "duration": 30,
                "durationUnits": "d",
                "frequency": 2,
                "period": 1,
                "periodUnits": "d"
            }
        },
        "siteCodeableConcept": {
            "coding": [
                {
                    "system": "http://snomed.info/sct",
                    "code": "181220002",
                    "display": "Entire oral cavity"
                }
            ]
        },
        "route": {
            "coding": [
                {

```

```

        "system": "http://snomed.info/sct",
        "code": "26643006",
        "display": "Oral Route"
    }
]
},
"doseQuantity": {
    "value": 1,
    "system": "http://hl7.org/fhir/v3/
        orderableDrugForm",
    "code": "TAB"
}
},
{
    "text": "Take 2 tablet twice daily for 30 days",
    "additionalInstructions": {
        "coding": [
            {
                "system": "http://snomed.info/sct",
                "code": "311504000",
                "display": "With or after food"
            }
        ]
    },
    "timing": {
        "event": [
            "2015-11-01"
        ],
        "repeat": {
            "duration": 30,
            "durationUnits": "d",
            "frequency": 2,
            "period": 1,
            "periodUnits": "d"
        }
    },
    "siteCodeableConcept": {
        "coding": [
            {
                "system": "http://snomed.info/sct",
                "code": "181220002",
                "display": "Entire oral cavity"
            }
        ]
    },
    "route": {

```

```

    "coding": [
      {
        "system": "http://snomed.info/sct",
        "code": "26643006",
        "display": "Oral Route"
      }
    ],
    "doseQuantity": {
      "value": 2,
      "system": "http://hl7.org/fhir/v3/orderableDrugForm",
      "code": "TAB"
    }
  },
  {
    "text": "Take 3 tablet twice daily for 30 days",
    "additionalInstructions": {
      "coding": [
        {
          "system": "http://snomed.info/sct",
          "code": "311504000",
          "display": "With or after food"
        }
      ]
    },
    "timing": {
      "event": [
        "2015-12-01"
      ],
      "repeat": {
        "duration": 30,
        "durationUnits": "d",
        "frequency": 2,
        "period": 1,
        "periodUnits": "d"
      }
    },
    "siteCodeableConcept": {
      "coding": [
        {
          "system": "http://snomed.info/sct",
          "code": "181220002",
          "display": "Entire oral cavity"
        }
      ]
    }
  }
]

```

```

    },
    "route": {
      "coding": [
        {
          "system": "http://snomed.info/sct",
          "code": "26643006",
          "display": "Oral Route"
        }
      ]
    },
    "doseQuantity": {
      "value": 3,
      "system": "http://hl7.org/fhir/v3/orderableDrugForm",
      "code": "TAB"
    }
  }
]
}

```

## 7 Conclusion

This article focuses only on managing medications but FHIR provides much more information which can be used. Some examples of how the proposed app could be extended are:

- Medication Interaction Check
- Diet Plan (CarePlan, NutritionOrder)
- Exercise Plan (CarePlan)
- Appointments with Practitioner (Appointment, AppointmentResponse)

## References

- [1] AMTS Medikationsplan. <http://www.ams-system.com/medikationsplan.html>.
- [2] FHIR. <https://www.hl7.org/fhir/2015May/index.html>.
- [3] SMARTPatient GmbH. MyTherapy - Medikamente im Griff. Vitalwerte im Blick. <https://itunes.apple.com/at/app/mytherapy-medikamente-im-griff/id662170995?mt=8>.
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