Norwegian Centre for
E-health Research

IARIA

National Clinical Decision Support Framework for Norway: Expert Assessment and Proposed Architecture

Luis Marco-Ruiz, Kristian Malm-Nicolaisen, Alexandra Makhlysheva, Rune Pedersen

[1]Norwegian Centre for Integrated Care and Telemedicine

Luis.Marco.Ruiz@ehealthresearch.no

©Luis Marco-Ruiz 2020

Luis Marco-Ruiz, PhD

- Data engineer focused on the adoption of information standards and terminologies for clinical data reuse and clinical decision support. MSc in Applied Statistics and a PhD in Health Science.
- Since 2007 I have participated as a developer, advisor, and researcher in private- and public-funded projects in Norway, Germany, the UK, and Spain.
- 2013 – Present - Norwegian Centre for E-health Research working on the development of data reuse infrastructures and advising the Norwegian health authorities on the adoption of clinical information standards and biomedical ontologies.
- 2018 - Present - Semantic interoperability specialist at the Peter L. Reichertz Institute for Medical Informatics (Hannover Medical School) developing a cross-institutional data reuse network involving major German University Hospitals.
- Member of the OpenEHR Specification Editorial Committee Expert Panel

©Luis Marco-Ruiz 2018

Agenda

- Introduction – Norwegian context
- Methods
- Results
  - Software Architecture and Information Standards
  - Biomedical Terminologies
  - Organization, governance, and shared development
  - Knowledge base
  - Proposed Architecture

- Discussion & conclusion

©Luis Marco-Ruiz 2018

Introduction - Norwegian context.

- Norway has allocated significant funds to build momentum for advancing medical informatics.
- EHRs have been adopted to enable data reuse including highly structured formats (openEHR and HL7 FHIR).
- National primary care research network (PraksisNett & LHS-toolbox),

research projects (Big Med).

©Luis Marco-Ruiz 2018

Image: This cover has been designed using resources from www.clipartmax.com

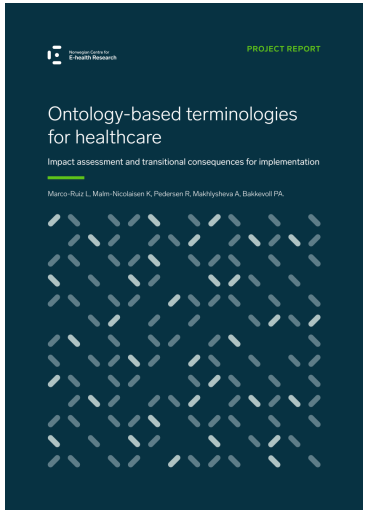
Introduction - Norwegian context.

- Several initiatives have provided knowledge on best approaches for Computerized Clinical Decision Support (CCDS) interventions.

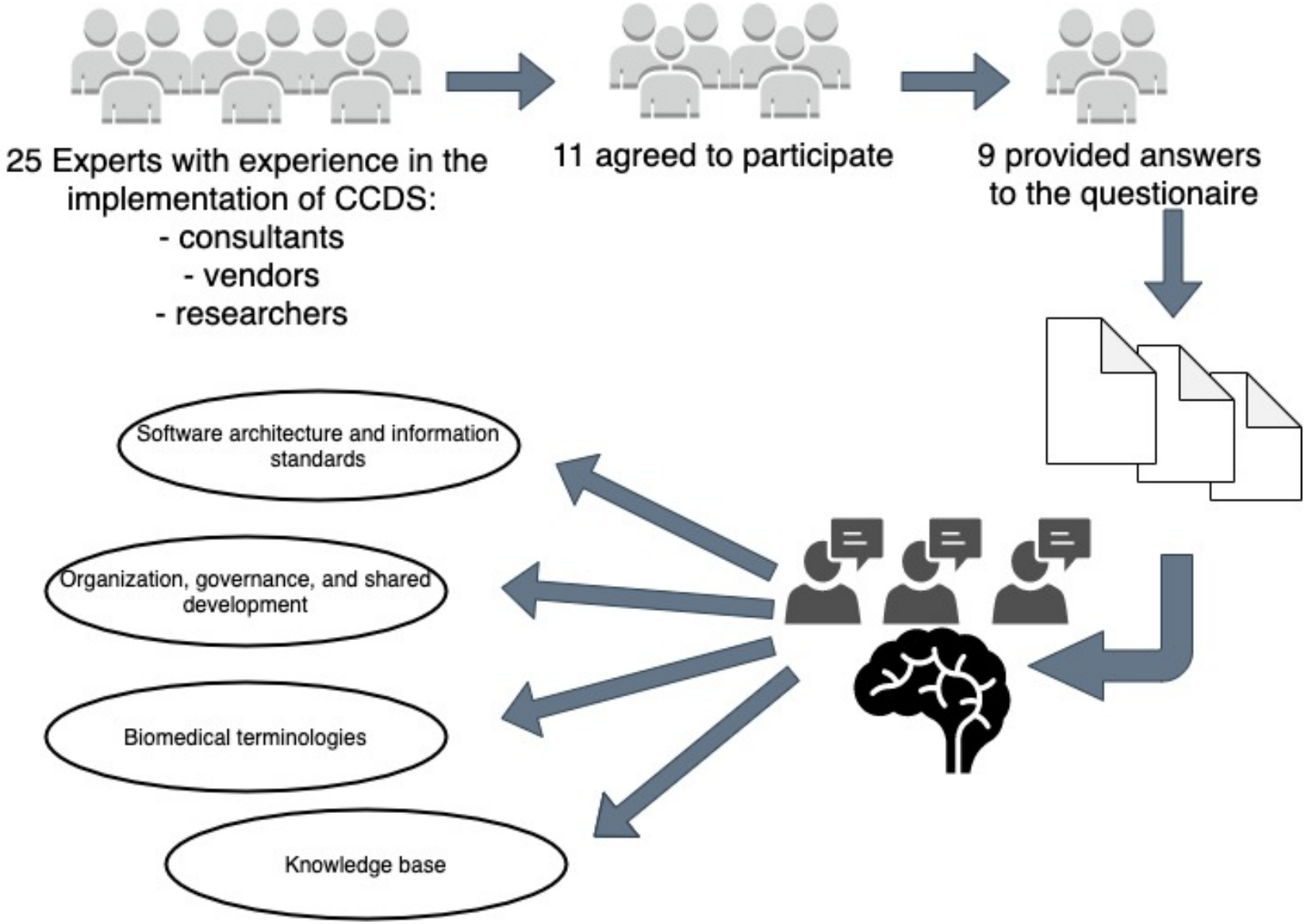
- Previous projects about CCDS have provided valuable knowledge specifying requirements and success factors during EHR adoption.

- When it comes to building a large-scale national infrastructure to govern and manage CCDS systems, knowledge about their architecture and organization is still needed.

- The Norwegian context, is complex as a result of a mixture of legacy and recently introduced Health Information Systems (HIS) that operate using different clinical information standards and terminologies.

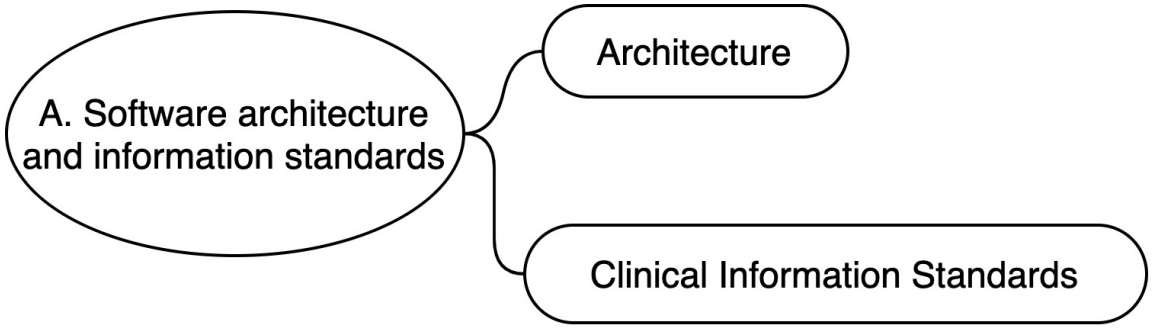


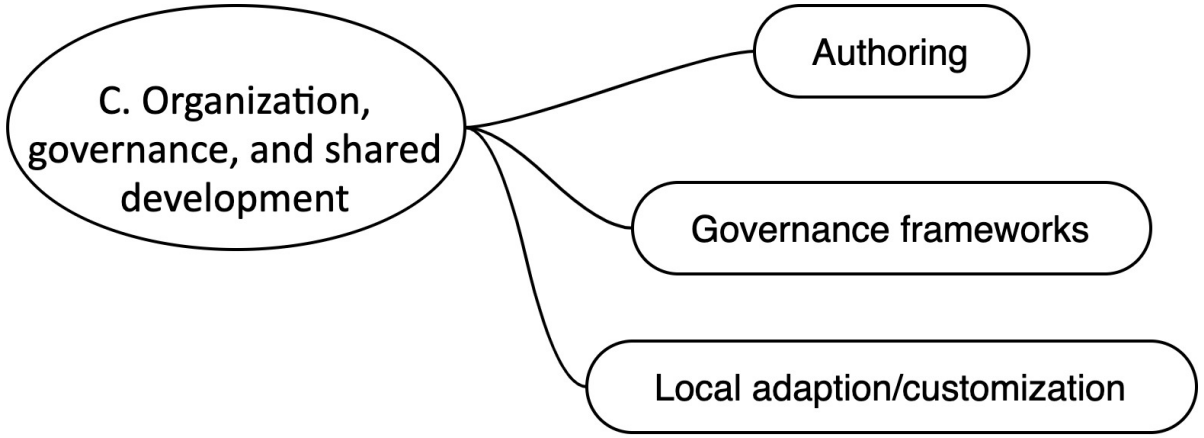
Methods

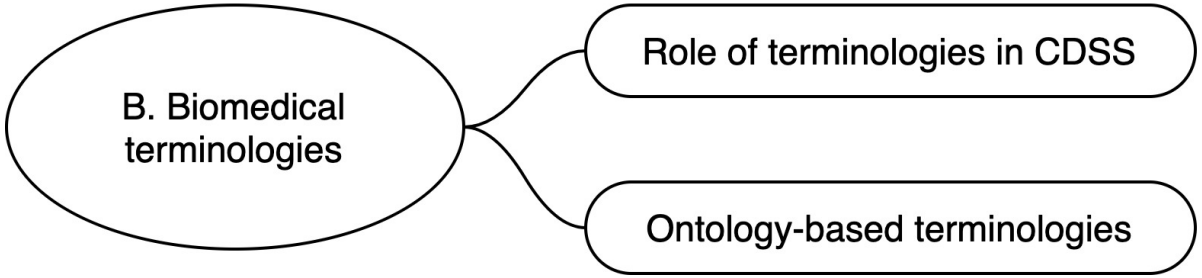

25 Experts with experience in the implementation of CCDS:
- consultants
- vendors
- researchers
11 agreed to participate
9 provided answers to the questionaire
Software architecture and information standards
Organization, governance, and shared development
Biomedical terminologies
Knowledge base

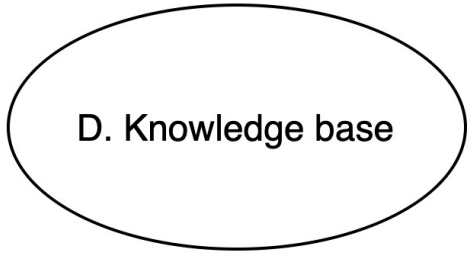
Results-Overview

We identified the following main categories and subcategories:









A. Software Architecture and Information Standards - Architecture

- SOA optimal choice for fulfilling the mentioned requirements in large and distributed CCDS environments.

- The use of RESTful stateless Web service architectures is also seen as beneficial for simplifying the architecture. Both synchronous and asynchronous ways of operating are needed.

- One respondent wrote that, in general, SOA is better but it is important to understand the requirements because the optimal architecture may be a mixture of some approaches (SOA, stand-alone, process oriented, etc.).

A. Software Architecture and Information Standards - Clinical Information Standards (i)

- Standardization of CCDS was considered essential by all respondents (for both VMR schema and SOA payload).
- Standardization was seen as a way to communicate the payload of Web service messages in and out of the CCDS Web service in a normalized way that all clients can understand.
- Another respondent leveraged both views by relying on openEHR for both the VMR and the EHR.
- For CCDS interoperability, FHIR is the preferred standard by respondents since they claimed it to be the one with the highest acceptance rate across vendors.
- National context often have iso-semantic models -> transformations are required.

A. Software Architecture and Information Standards - Clinical Information Standards (ii)

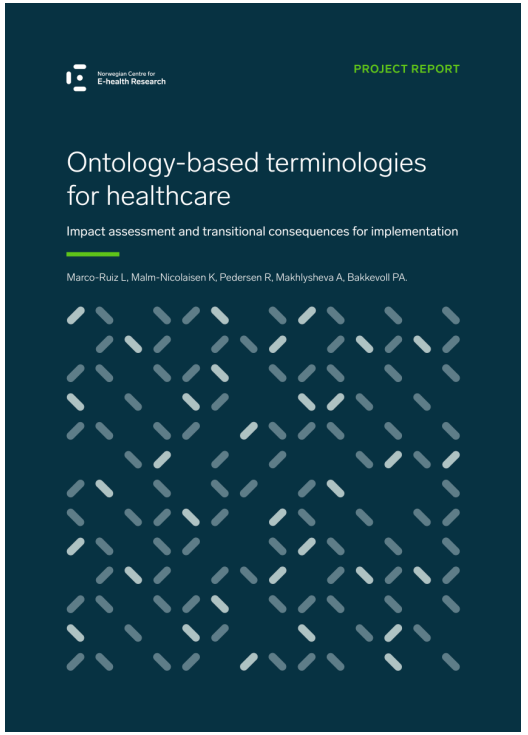
- SMART on FHIR was seen as a positive but not critical addition on top of FHIR.
- **vMR** is considered as a very comprehensible standard, but has a low adoption rate.
- OpenCDS has developed conversion mechanisms between HL7 vMR and FHIR.
- CDS Hooks is a useful and disruptive standard for embedding CCDS requests in the appropriate part of the clinical workflow -> triggering at a precise point of the clinical workflow.

B. Biomedical Terminologies and Ontologies - Role of terminologies in CCDS

- Terminologies play a critical role to avoid ambiguity and identify the same concept identified sometimes in different ways -> they facilitate data reuse for CDS and research.
- They require centralized management when possible.
- Allow for content and semantic binding in CIMs.
- Proprietary terminologies will need to be mapped to the reference value sets used by the national CCDS.

B. Biomedical Terminologies and Ontologies - Ontology-based terminologies (i)

Ontology-based terminologies such as SNOMED-CT could be useful for the maintenance of complex terminologies, the maintenance of CCDS rules, and the definition of mappings across terms from different terminologies.



B. Biomedical Terminologies and Ontologies - Ontology-based terminologies (ii)

- Curating and pre-processing of ontologies into the internal CCDS format is common. Also, implementing support for third party terminologies is needed due to the amount of proprietary code systems.
- The use of the logic underpinning of SNOMED-CT was rather sparse. It is mainly used for the maintenance of the terminology itself, e.g., when defining new concepts.
- Formal ontological models are not crucial at the moment. One respondent actually said that simpler CCDS functionality does not require complex semantic analysis.
- The only use from SNOMED-CT its underlying logic model was subsumption. Subsumption ("is-a" relationships) reasoning is considered useful for facilitating the setup and maintenance of rules in CCDS, but respondents observed that, in order to truly use this capability, a supportive infrastructure is needed.

C. Organization, Governance, and Shared Development - Authoring

- Authoring tools are needed so that different stakeholders can collaborate in a distributed manner having discussions and defining clinical decision algorithms.
- Respondents considered that a national portal with narrative and semi- structured guidelines can be helpful in the CCDS development.
- In addition, two respondents indicated that measuring and monitoring the impact of CCDS interventions would be needed to clarify their effect and decide on their long-term maintainability.
- First step in the development of CDS interventions is to define goals that the CCDS intervention pursues and then, once the goal is clear, to identify the steps towards improving that goal.
- Other vendor with CIGs implementation experience pointed out that for each clinical guideline, a medical specialist is appointed. The specialist should be a national or regional leading figure that already has active participation in guidelines development.
- That specialist is the one responsible for the acceptance and follow-up of the deployment.

C. Organization, Governance, and Shared Development – Governance Framework

- The governance framework should enable access to terminology services, access to evidence-based guidance, and access to editorial tools for the development and maintenance of CCDS content.

- Respondents pointed out that CCDSs need to be shared and contrasted among organizations. To that end, organizations should gradually incorporate more CCDS modules performing pilot interventions and running studies to evaluate them.

- A mixed model for governance was recommended -> Local and National levels.

C. Organization, Governance, and Shared Development – Local adaption/ customization

- One respondent recommended for a maximum standardization without too much localization to work defining guidelines incrementally from narrative to structured format. The same respondent proposed a layered organization of rules.

- Respondents also agreed on clinical guidelines to be built via consensus, and once their content is agreed, they should be pushed to the EHR with the consent from clinical users.

- Respondents recommended to start with non- controversial content and develop reusable CCDS modules from parts that are not dependent on the local context. These modules will become the building blocks of more complex CCDS to be adapted in the local context.

D. Knowledge Base and Inference Engine

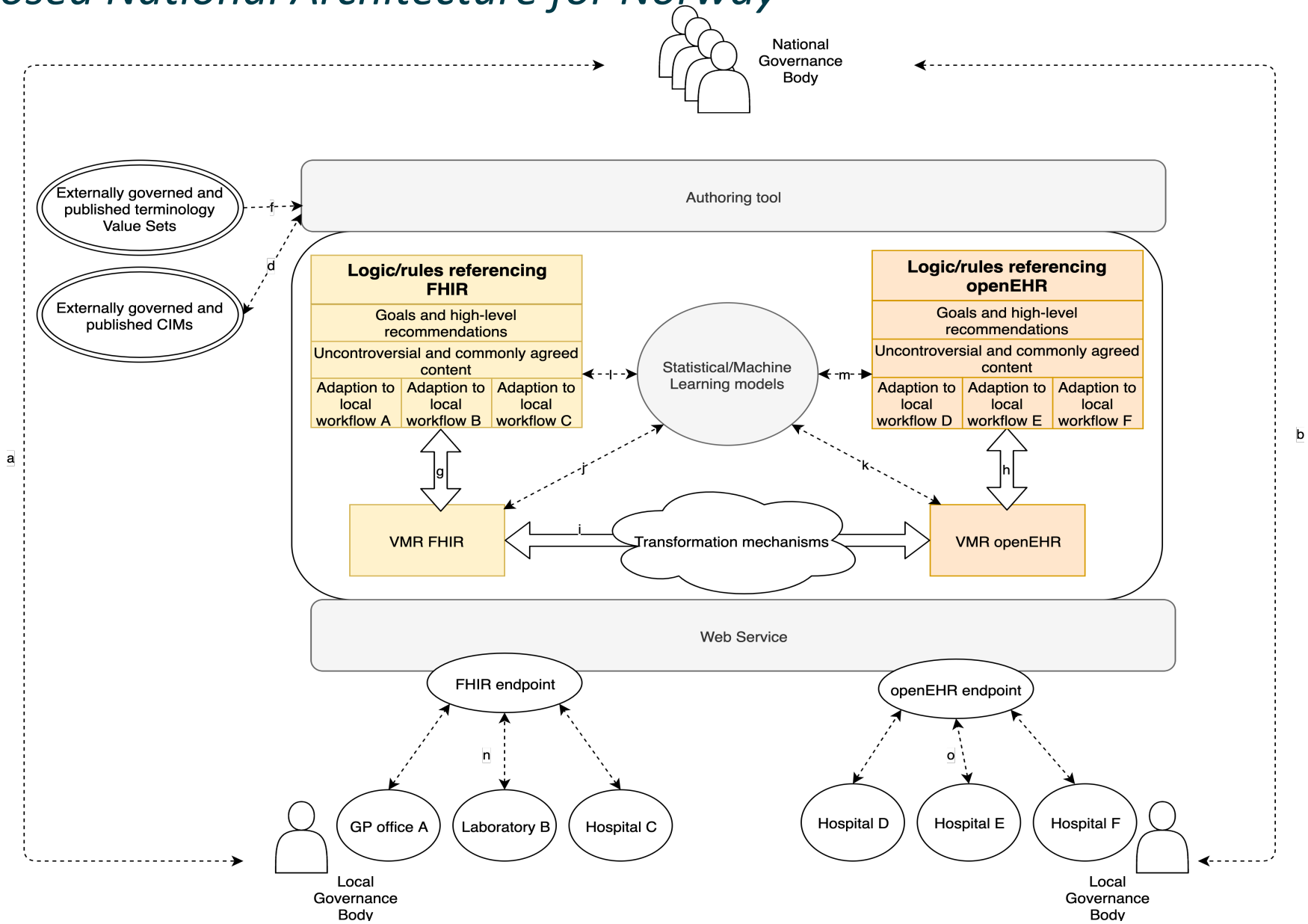
- Rule-based and logic-based methods (i.e., rules- based and ontology-based ones) are seen as the most intuitive and efficient ones. Respondents considered logic- based methods as intuitive and simpler for knowledge management.

- Graph structure formalisms such as GLIF were considered difficult to implement and integrate. In addition, latest approaches such as FHIR Plan Definition are considered more flexible and easier to translate to different inference engines.

- Several respondents considered that the formalism of specification could be the one provided by the technology to perform the inferences (e.g., JBoss Drools). To that end, it should be hosted in a Web service, and it should be made accessible through a standard API.

- Respondents considered statistical methods to be important but more effort intensive for certain scenarios. Some systems report to use rules but trigger the invocation of a statistical model when necessary.

Proposed National Architecture for Norway



Conclusions

- The proposed architecture attempts to agree with many of the principles for already published best practices.
- A multi-standard CCDS framework is needed.
- Regarding the internal structure of CCDS modules, the layered architecture of CCDS modules is based on the concepts proposed by Boxwala et al.
- Machine-learning has recently received lots of attention, however our respondents considered that for CCDS there are some “low hanging fruits” to be focused on before building complex artificial intelligence frameworks at national scale.
- We still need to be able to deploy large-scale CCDS frameworks where the most pressing challenges are related to governance, adaption to local contexts, and different information and knowledge representation formats.
- We believe that once these requirements are clear and a proper edition and governance framework is in place, most machine-learning algorithms will fit in the framework. They will complement logic-based CCDS modules when required, thus leveraging the best from both logic and statistical methods.

Thank you

Luis Marco-Ruiz
Luis.Marco.Ruiz@ehealthresearch.no

Kristian Malm-Nicolaisen
kristian.nicolaisen@ehealthresearch.no

Alexandra Makhlysheva
alexandra.makhlysheva@ehealthresearch.no

Rune Pedersen
rune.pedersen@ehealthresearch.no