Identifying Opportunities for AI applications in Healthcare

- Renewing the National Healthcare and Social Services

1st Pasi Tyrväinen
Faculty of Information Technology
University of Jyväskylä
Jyväskylä, Finland
pasi.tyrvainen@jyu.fi

2nd Minna Silvennoinen
Faculty of Information Technology
University of Jyväskylä
Jyväskylä, Finland
minna.h.silvennoinen@jyu.fi

3rd Karoliina Talvitie-Lamberg
Faculty of Information Technology
University of Jyväskylä
Jyväskylä, Finland
karoliina.k.talvitie-lamberg@jyu.fi

4th Anniina Ala-Kitula
Faculty of Information Technology
University of Jyväskylä
Jyväskylä, Finland
anniina.e.ala-kitula@jyu.fi

5th Reija Kuoremäki
Faculty of Information Technology
University of Jyväskylä
Jyväskylä, Finland
reija.c.kuoremaki@jyu.fi

***Abstract*— A vast variety of artificial intelligence techniques have been deployed to specific healthcare problems during the last thirty years with varying levels of success while there is a shortage of systematic matching of AI capabilities with the breadth of application opportunities. In this paper, we describe the process of identifying opportunities for deploying artificial intelligence to healthcare and social services on regional and national levels in Finland. The project involved a large number of stakeholders from a variety of backgrounds ranging from governmental agencies to entrepreneurs. The process described includes idea generation of an application or solution and its elaboration in workshops using a design thinking method. The resulting idea pool was filtered down to 34 best use case descriptions, which went through an architectural design process identifying AI capabilities needed in the components of these designs reported in this paper. The potential ones of the use cases were selected for prototype development. The subsequent steps in the process include feasibility prototypes and evaluation of the economic and business value of the solutions and applications.**

Keywords— Health and social care renewal, citizen wellbeing, artificial intelligence capabilities, design thinking, use-cases, application prototype development, IBM Watson

I. Introduction

A. Finding Opportunities for AI in Health and social care and wellbeing

Digital transformation in healthcare seeks solutions to make healthcare safer, more affordable and more accessible, and has lately been a very rapidly growing area of research [1]. The expertise of medical professionals has made healthcare one of the first domains, to which new artificial intelligence technologies have been deployed, with varying levels of success. The early attempts to imitate human diagnostic behavior with expert systems using rules and fuzzy logic were followed with knowledge-based systems with frames, scripts, ontologies and various reasoning systems as well as natural language processing based question-answering techniques. The increasing digitalization of medical patient data and improved adoption of digital imaging and medical devices have shifted emphasis to technologies utilising high volumes of data for machine learning and deep neural networks. Altogether, a vast majority of the effort has been either technology driven, in deploying a specific AI technology, or data driven, in targeting a single medical issue. [2-4]

In the technology adoption and innovation research the dominant approach for a firm is to find a balance between the technology-driven and market/business-driven approach using a variety of approaches including variants of an innovation funnel and open innovation models [5-7]. In these approaches, the technologies available to the firm internally or externally are developed into products and services for the market. In the case of a health or wellbeing related device manufacturer this would mean new product innovations whilst for a hospital this would mean providing better medical services for the patients.

This paper addresses a wider scope than a single organization or a single application or product. Our target is to find opportunities for deploying the full variety of contemporary AI technologies to the social and health care services of a single country. This means that we do not address a single technology, service or a single organization. rather than look for opportunities in a network of multiple governmental and private sector healthcare, social and wellbeing services operators as well as a variety of devices and service vendors in the ecosystem. In this context, the goals of the stakeholders vary from the wish of individuals to live healthy lives and vendors' aim to create global scalable products and applications based on AI to the government's aim to provide better wellbeing for the citizens without an increase of the total direct and indirect costs for the government.

B. *AI for Finnish Health and Social Services*

In 2017, the Finnish government has decided to address the challenges of increased health and social security costs and population aging by a reform reorganizing the country into 15 health and social security regions. The objectives of this regional government reform include improved equality and reduced differences in health and social wellbeing, the renewal and digitalisation of services towards fluent functioning and cost effectiveness and promoting citizen participation through better information transfer and customer focus. There is an urgent need of slowing down the expenditure growth of health and social services to the level of 1,5% of GDP. Through digitalisation, the services will be provided in completely new ways, and processes will be enhanced. Digitalisation opens up more opportunities for the residents and encourages them to maintain their functional capacity and health. The basic principle of ICT solutions will be that client information can be used across the boundaries of organisations and regions. [8]

In Finland, the health care costs have risen to a level, which is economically unsustainable for the long term, and a reduction of rising costs through digital innovations is needed. According to the report of National Institute for Health and Welfare, the health care expenditure were 19,8 billion EUR in 2015, 3803 EUR per citizen [9]. In addition, the social protection expenditures were 66,3 billion EUR, 12083 EUR per citizen [10]. The ageing population is one of the main key groups to be addressed, when aiming to reduce the differences in health and wellbeing, because the elderly often need both health services and social support. Designing applications for enhancing independent living, such as smart home and IoT solutions is rapidly increasing in Finland. In addition, mortality differences between social groups are bigger in Finland than in most western countries in Europe. Prevention and treatment of diseases, social security is important for every individual [11].

In September 2016, IBM announced a partnership agreement with Tekes – the Finnish Funding Agency for Innovation – that will enable Finland to utilize an IBM AI platform, the Watson cognitive computing platform [12], across its health ecosystem. As part of the agreement, IBM will create in Finland a Watson Health Center of Excellence and the first National Imaging Center of Excellence outside of the US. The new centers will tap into the Watson Health Cloud and other offerings designed to enable individualized insights and a more complete picture of the many factors that can affect people's health. As the first step, IBM is working with the University of Jyväskylä with a portfolio of study projects that will pave the way forward. In addition, IBM and University of Jyväskylä started on 11.12.2017 a common innovation unit based on cutting-edge technologies. The unit is located in the IT faculty.

In this paper, we describe a project where the University of Jyväskylä and IBM are collaborating to discover ways to utilize Finnish health data with Watson cognitive computing in health and social services and promote citizens' wellbeing. Project funded by Tekes aims, also, to strengthen and develop the Finnish innovation and business ecosystem in this field. Opening new business opportunities for companies to enhance digitalisation and innovate new applications is seen as one of the focus areas. At the same time, there is an important aim to renew social and health care services towards the maximum impact and cost effectiveness. For the purposes of this paper, we limit our scope to the process of identifying the opportunities for new AI -applications and solutions for increased wellbeing and health. FIgure 1). This excludes prototyping and testing, analysis of the data infrastructure as well as the architectural design of future infrastructure of AI aided healthcare systems.

II. Process, Methods and Participants

A. *Scope, Aims and Participants*

The long-term goal of this project was to boost the Finnish economy and help companies create jobs; drive growth in both domestic and global markets and enable cost reduction for public organizations as well as improve citizen wellbeing. The overall approach follows the innovation funnel model (Figure 1), where a large volume of ideas generated based on the organizational needs and technology inspired ideas are collected, elaborated systematically and filtered until the most promising ideas are available for investment decision-making.

During this stepwise elaboration process, a user-centric approach was chosen to carry and elaborate the most valuable ideas for the future: how to utilize AI in the field of healthcare and wellbeing in the most engaging way for the end-user and reach savings in the healthcare costs for different stakeholders.

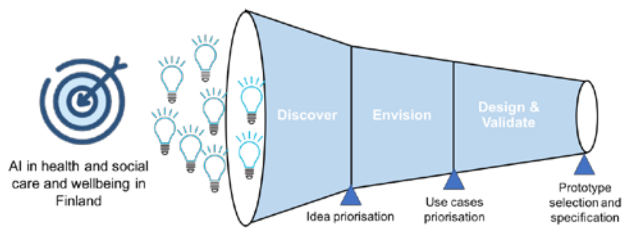


Fig. 1. Process to find, identify and construct great deal of ideas of using AI to several use-cases and to refine few promising ones for further prototype development

The project followed the design thinking method in several stages, which was tailored for the purposes of this project during the process. Figure 2 presents the scope of work described in this paper (on white background).

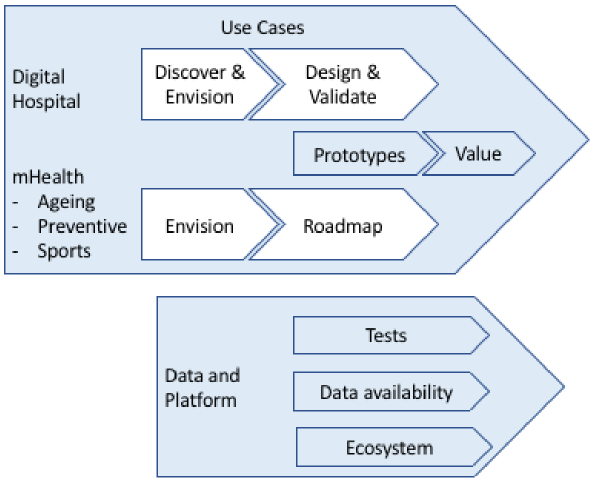


Fig. 2. The areas of work in the project. The scope of this paper is the process for identifying the use cases in the digital hospital area and in the three sub-areas (thematic sections) of mHealth (on white background).

The process of finding key focus areas and use cases started as two leading focus areas;a Digital Hospital and a Mobile Health (mHealth) which were executed on medically regulated and non-regulated activities, respectively. The mHealth part focused on three main thematic sections of Aging, Preventive wellbeing and Sports which referred to the use of sports and exercise data and their benefits on population health.

Actors participating in the project workshops included both public and governmental organizations, enterprises on the consumer market, third sector actors, non-profit organizations, citizens and public hospitals as well as firms providing products and services for them. Figure 3 presents the main stakeholder groups involved. The idea pool was generated and processed during several full day workshops to produce specific ideas as use cases. Next chapter presents the whole process in detail as well as methods used.

Fig. 3. Stakeholders in the workshops

B. Workshop Process

The general aim of the work conducted in the workshops was to innovate ways to improve treatment processes and wellbeing of citizens both from accuracy and efficiency perspectives and simultaneously reduce social- and healthcare costs with AI and digital solutions. The workshops were hosted by the University of Jyväskylä and moderated by IBM consultants and architects together with university researchers.

Workshops started with a kick-off in which the the starting point of a cognitive healthcare vision was created and discussed in Figure 4.

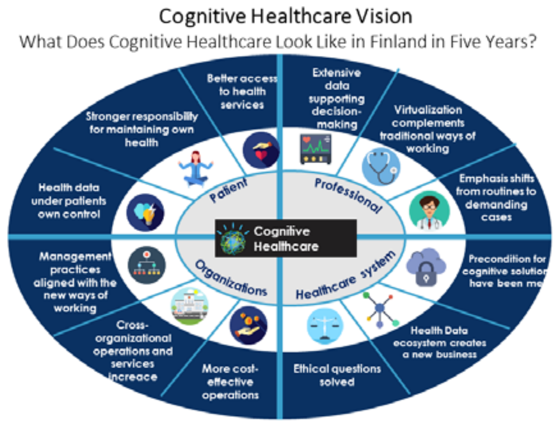


Fig. 4. The vision of cognitive healthcare produced in the kick-off workshops

The kick-off workshop was followed by discovery, envision and design workshops. The basic process followed the design thinking method in several stages, but was also tailored during the project according to the needs of the specific health and wellbeing domains. In the kickoff meeting, the goal of the process was framed as that of evaluating the suitability of artificial intelligence technology to the Finland's new digital social and health care system and to generate common understanding of AI suitability in the thematic sections. In a discovery workshop, the aim was to create a shared understanding of present problems, which could be solved, with the use of AI. In the envisioning workshop, the participants envisioned big ideas for solving the pain points. Of the big ideas documentation, the participants evaluated ideas and documented use cases. The workshops resulted the total of 34 validated use cases in the envisioning phase

C. Modified Design Thinking Method

The process of finding key focus ideas was facilitated through the IBM Design Thinking method, which is an adaptation of design thinking methodology. IBM's approach adds to the general design thinking allowing it to adapt to the scale and speed that modern organizations require. A framework for teaming and action helps teams to form intent and deliver outcomes that serve people. The method is designed to be used to provide user experiences and create user-centric outcomes.

Focusing on the user outcomes drives the design towards how much value the user receives, not how many features or functions there are. Empowering diverse teams instead of homogenous ones accelerates ideation, increasing the chance of innovations. Treating everything as a prototype enables constant improvement.

The method was used to discover pain points, explore new ideas in the field of health and wellbeing, and create a roadmap for the concepts expected to have the most potential to leverage IBM Watson and AI. The method was chosen for the study project in order to identify citizens' real problems and needs within the chosen focus areas (digital hospital, aging, preventive healthcare & wellbeing related to sports) and to support creative ideation. The value during the process comes from solving users' real problems rather than purely assessing the technical capabilities [12-13].

D. Identifying Cases Chosen for Next Steps

After producing a great deal of ideas in the envisioning phase workshops which focused on workshop meetings and on wide collaboration with expert participants, the later phases reduced the number of cases to a small number of ideas to be elaborated. The original plan aimed at producing 1-2 ideas for the two tracks, which would have been adequate for a single firm searching for a new product idea. However, for a large ecosystem with tens of stakeholders and interests we had to adjust the method to produce more use cases and designs satisfying the needs of the stakeholders. Relating digital hospital the total of 18 use cases was created on mHealth related cases, the selection was made during a joint process by university researchers and IBM staff. The aim was to find the most promising use cases for prototype development. The criteria were the maturity of the AI technology and the availability of the data (at present, in 1-2 years' time or in 5 years' time), the importance of the problem to be solved and the cost-benefits of the solution for the Finnish health- and social care system. In the end, the case lists of the tracks were merged. In addition, some of the closely related cases were merged.

III. Results and Further Steps

The workshop processes produced a total 34 use cases that were iteratively constructed by the participants from various health and wellbeing backgrounds and organisations. Titles of these use cases are listed in Table 1 together with use case ids. Letters in id (A, P, S and DH) refer to the tracks they relate to (aging, preventive, sport and digital hospital respectively).

TABLE I. ID AND NAME OF USE CASES

ID	UC name
A1	Mobile solution for home care coordination and communication
A2	Cognitive companion
A4	Interactive memory care solution
A5	Family caregiver risk assessment and early intervention
A6	Care option comparison tool
A9	Connected senior homes
P1	Watson for occupational wellbeing
P2	360 degree pupil wellbeing
P3	Identifying children and youth at the risk of social exclusion
P4	Parent support
P5	Lifestyle Coach
P7	Advisor for conscious shopping
P9	Workplace safety solutions
S1	Virtual Personal trainer powered by Watson
S2	Motivation via strengths
S4	Assistant Coach
S5	Sports Insight Hub
DH2	Personal coach for patients preparing for an operation or medical procedure
DH4	Virtual family doctor
DH5	Advanced triage with cognitive computing
DH6	Medical imaging and analysis combined with patient data
DH7	Care path optimization: Case cancer treatments of the future
DH8	Personal post-care virtual advisor
DH10	Personal avatar visualizing alternative futures
DH11	Remote monitoring of care effectiveness and learning from the results
DH12	Cognitive integrated operations center for a hospital
DH13	Overcoming data quality issues with cognitive computing
DH14	Identifying security and safety threats and preventing data misuse
DH15	Enabling patient centric care with cognitive computing
DH16	Resource optimization in hospital functions
DH17	Driving capacity evaluation
DH18	Total risk evaluation
DH19	Optimization of operating room utilization

The participants and researchers evaluated the use cases from multiple point of view, such as the economic value of the use cases for the national healthcare system and the business value of potential applications and services for vendors and service operators as well as their utility for the health and wellbeing of individuals.

The resulting designs included also architectural descriptions describing interactions of the main modules, where the required AI capabilities of the modules were identified and matched against the Watson cognitive capabilities. This matching is outlined in Table 2.

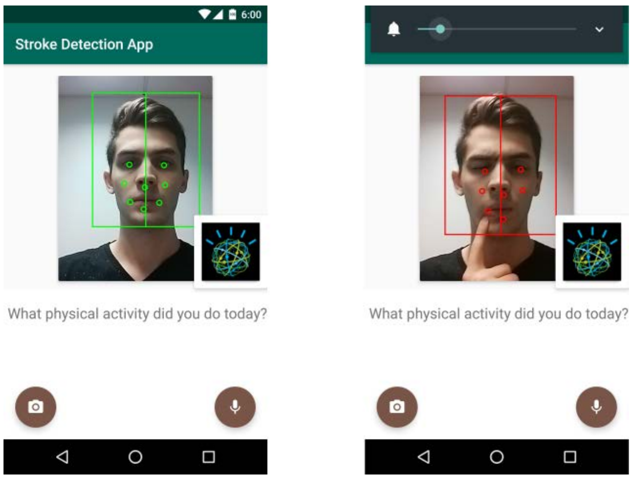
TABLE II. AI CAPABILITIES RELATING EACH OF THE USE CASES

	Analytical models	**Search and find relevant answers to questions. Train a machine learning model**	**Text analytics and natural language processing(NLP)**	**Conversation in Natural Language**	**Understands the contents of images**	**Similarity analytics and analytical models**	**Decision support model**
A1	x	x	x	x	x		
A2	x	x	x	x		x	
A4	x		x	x	x		x
A5	x		x				
A6	x		x	x			x
A9	x		x				
P1	x		x	x		x	
P2	x		x				x
P3	x		x				x
P4		x	x	x		x	
P5	x	x	x	x		x	
P7	x	x	x	x		x	
P9	x		x	x			
S1	x		x	x		x	
S2	x		x	x		x	
S4	x		x			x	x
S5	x	x	x				
DH2	x		x	x		x	
DH4	x		x	x	x	x	x
DH5	x			x	x	x	
DH6		x	x		x	x	x
DH7	x	x	x			x	x
DH8	x	x	x	x			
DH10	x	x			x		
DH11		x	x	x			x
DH12	x		x				x
DH13	x		x				x
DH14	x		x				
DH15		x	x		x		
DH16	x	x					x
DH17	x	x	x	x	x		x
DH18	x	x					
DH19	x	x	x				x
Total	***29***	***16***	***29***	***17***	***8***	***13***	***14***

The following steps for these 34 use case designs are the implementation of the feasibility prototypes and applications for the chosen use cases and the evaluation of the benefits, costs and value of these applications for the healthcare district and the estimation of the value of these use cases for the national health and social services system under construction.

After the use case designs were completed, the most potential ones were chosen for iterative prototype implementation involving experts of the field. Potentiality of the applications were decided based on the availability of the data, cost effectiveness, innovativeness and uniqueness of the idea.

Use cases selected for prototypes in the first phase were 1. Advanced triage with cognitive computing (Stroke detection app, see picture 1), 2. Driving capacity evaluation, 3. Personal post-care virtual advisor (Nutrition app) and 4. Home care coordination and communication app. The AI capabilities which were tested in these prototypes were text analytics and natural language processing, conversation, understanding contents of images, similarity analytics and decision support. Prototype development will continue to test the AI capabilities relating other use cases as well. Yet the initial results of the tests are very promising and at least image recognition, conversation and understanding capabilities are showing positive results.



Picture abowe presents a prototype developed to identify stroke symptoms and daily activity of patients with high risk of stroke.

IV. DISCUSSION AND CONCLUSIONS

In this paper, we described the process of identifying opportunities for deploying artificial intelligence to healthcare and social services nation-wide in Finland. The process included involving a large number of stakeholders from a variety of backgrounds for idea generation and elaboration in workshops using a design thinking method and resulted in 34 use cases and architectural designs identifying AI capabilities needed in the components of these designs. In addition, the potential ones of the use cases were selected for prototype development.

When looking at the use cases and the AI technologies needed for them, some observations can be made. First, many of the use cases require basic analytical data modelling capabilities and thus sufficient capabilities to train neural networks or models for that purpose. This further requires the availability of good quality data with consistent semantic encoding from the medical health records and other data sources. This underlines the importance of data infrastructure in hospitals and the standardization of national data infrastructures as well as fluent practices for data interchange between authorised stakeholders. [14]

Further, a large investment on a data infrastructure, such as the interoperation of health records systems, that ensure availability of formally and semantically homogeneous data cannot be done based on the benefits provided by a single AI application rather than on the benefits provided by data, tens of applications built on the infrastructure.

Another commonly used AI functionality is a combination of natural language processing (NLP) either with information retrieval capabilities and semantic models for collecting data from textual patient records into a case-specific understanding of a patient's situation or combining NLP with speech and textual interaction with healthcare staff and individuals. In both cases, the possible language dependency of the NLP and semantic models can add challenges for implementation for such systems in the global context.

Interestingly, the use of image analysis is less visible in the listing of required AI capabilities. The stronger visibility of image analysis could have been expected based on the showcases on using AI for radiology image analysis for oncology and other specific areas of medical care.

The process of producing knowledge on how AI and cognitive computing will enhance and assist digital social and healthcare solutions in Finland is a challenge for which we have not yet found all the needed answers. However, during this process we have identified several solutions and applications, which could be applied to gain significant efficiency and effectiveness improvements to health care operations and better services for citizens to enhance their wellbeing, including also monetary benefits for the society.

A recent review on previous research on Digital Hospitals [15] indicates that eHealth technologies improve the efficiency and appropriateness of care and safety, while the effects on mortality, readmissions, total costs as well as patient and provider experience still remain uncertain.

The process used the problem-based, user-centered approach for AI development in health-, and social care and involved a wide and active national level stakeholder group. This made the project unique but also had consequences for the process. Whilst evaluating the whole process, we encountered two main problems, the availability of data and the capabilities of AI technology, causing a delay for the prototype development. These problems were effects of the chosen user-centered, problem-based approach. In the more traditional AI development processes, those of straight technology driven or data driven nature, the problems encountered would have been different. However, the success of the project should not be measured based on the amount of distinct AI based applications created inside the chosen timeframe, but based on the national level understanding of the major objectives of the sectors' objectives and the joint solutions created to achieve them. This was the direct result of the chosen non-traditional user centered and problem based AI development approach and it is what makes the project unique, in defining AI technologies in the service of health- and social care. As most of the AI development takes place inside the platform economy, following the needs and means of the platform and market owners, such as Google, the work of defining the AI development of the future with real user ecosystem is a novel one. It shows the way for future AI development in health and social care and the need to take into account the user-driven, problem-based approach.

In short, the project showed that there is a definite and urgent need for wide national level, collaborative expertise working practices in health- and social care sectors for understanding AI opportunities - in order to create nationwide joint solutions, which integrate the benefits of cost-effectiveness, human-centric care and new business opportunities. The use case solutions of the project exceeded the estimated outcomes by the quantity and by the value. This shows that the modifications made during the process were necessary. That the timeframe for the envisioning phase turned out to be too limited indicates that in collaborative processes for AI solutions the creation of common understanding of AI technology benefits takes extra time but is a critical factor for success.

Next step is to focus on NLP technologies to be further tested with social and healthcare data using both languages English and Finnish. The need for using native language in healthcare services in Finland appeared to be crucial, since all the rich data gathered in Finnish health and social care services should be applied for developing better services for citizens.

REFERENCES

[1] R. Agarwal, G. Gao, C. DesRoches and A. K. Jha, "Research commentary—The digital transformation of healthcare: Current status and the road ahead," Information Systems Research, vol. 4, pp. 796-809, 2010.

[2] T. Winograd and F. Flores, "Understanding computers and cognition: A new foundation for design," Intellect Books, 1986.

[3] P. Szolovits and S. G. Pauker, "Categorical and probabilistic reasoning in medical diagnosis," Artificial Intelligence, vol. 1, pp. 115–144, 1978.

[4] R. Grishman and L. Hirschman, “Question answering from natural language medical data bases,” Artificial Intelligence, vol, 11, pp. 25–43, 1978.

[5] J. Utterback, “Mastering the Dynamics of Innovation: How Companies Can Seize Opportunities in the Face of Technological Change,” Harvard Business School Press, 1994.

[6] S. M. Dunphy, P. R. Herbig and M. E. Howes, “The innovation funnel. Technological Forecasting and Social Change,” vol. 53, pp. 279-292, 1996.

[7] H. W. Chesbrough, “Open innovation: The new imperative for creating and profiting from technology,” Harvard Business Press, 2006.

[8] T. Pöysti “Health, social services and regional government reform,” Presentation Helsinki 26.4.2017. Available online https://www.hanken.fi/en/about-hanken/organisation/departments-and-subjects/department-accounting-and-commercial-law/hccg-22

[9] P. Matveinen and N. Knape, “Health expenditure and financing 2015, Terveydenhuollon menot ja rahoitus 2015,” Tilastoraportti 26/2017, National Institute for Health and Welfare, Helsinki 2017. Available online http://urn.fi/URN:NBN:fi-fe201706307598

[10] N. Knape and A. Virtanen,” Social protection expenditure and financing 2015, Sosiaaliturvan menot ja rahoitus 2015” Tilastoraportti 7/2017, National Institute for Health and Welfare, Helsinki, 2017. Available online http://urn.fi/URN:NBN:fi-fe201703235602

[11] S. Koskinen, A. Aromaa, J. Huttunen and J. Teperi (eds.), ”Health in Finland,” National Public Health Institute, National Research and Development Centre for Welfare and Health and Ministry of Social Affairs and Health, 2006. Available online http://www.julkari.fi/bitstream/handle/10024/77611/hif.pdf?sequence=3

[12] D. Ferrucci, A. Levas, A, S. Bagchi, E. Gondek and E. T. Mueller, “Watson: beyond jeopardy!,” Artificial Intelligence, vol. 199, pp. 93–105, 2013.

[13] K. Clark and R. Smith, “Unleashing the power of design thinking,” Design Management Review, vol. 19, pp. 8-15, 2008.

[14] A. Couffinhal, J. Cylus, R. Elovainio, J. Figueras, P. Jeurissen, M. McKee, P. Smith, S. Thomson and U. Winblad, “International expert panel pre- review of health and social care reform in Finland,” Reports and Memorandums of the Ministry of Social Affairs and Health, vol 66, 2016. Available online http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/79070/RAP_2016_66.pdf?sequence=1

[15] J. Keasberry, I.A. Scott, C. Sullivan, A. Staib and R. Ashby, “Going digital: a narrative overview of the clinical and organisational impacts of eHealth technologies in hospital practice,” Australian Health Review, vol. 6, pp. 646-664, 2017.