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Ecosystem-Driven State-of-the-Art Investigation for Social Workers' Back Pain

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Abstract— The state-of-the-art investigation is important in new product development. It can avoid wasting time and effort on developing solutions that has already been patented or introduced in the market. However, there is lack of a systematic approach for the state-of-the-art investigation. This paper introduces an ecosystem-driven approach for the state-of-the-art investigation. With the example of social workers' back pain, this paper demonstrates a three-step process of the state-of-the-art investigation (Step 1- ecosystem mapping, Step 2- patent and literature review, and Step 3- gap analysis). Each step includes several activities and produces outcomes for the next step. The contribution of this ecosystem-driven approach is a state-of-the-art investigation that helps innovators to identify gaps where state-of-the-art fails to meet unmet market needs.

Keywords—ecosystem-driven, state-of-art, patent review, literature review, social worker, back pain

I. INTRODUCTION

According to the State Institute for Public Health (SIF), the yearly societal cost of back pain in Denmark is almost 17 billion DKK (Danish Kroner), 5.6 billion DKK for the treatments, 2.3 billion DKK for the payment of leave of absence, and 8.9 billion DKK for the early retirement [1]. One reason causes back pain is due to incorrect lifts and pushes.

The Research Center for the Working Environment in Denmark conducted a questionnaire with over 50.000 workers in 2012, 2014 and again in 2016 to investigate the working environment and health with a focus on muscle and skeletal problems. They conclude that there has been an increase in muscle and skeletal problems, from 9.7% in 2012 to 11.1% in 2016, a total increase of 14.8%, with the biggest increase attributed to "fatigue after work" and "limitations at work due to pain" [2]. These attributes are mainly related to manual labour, and it is a serious issue in Denmark with a total of workers in Denmark of a little more than 2.7 million people [3].

Data from the Danish Working Environment Authority (AT) supports this conclusion and describes the majority (40-45%) of work-related injuries are sprains and joint displacement [4]. The most affected type of work is in the water, sewers and garbage industry (478 yearly injuries per 10.000 workers), and the top of that list primarily consists of craftsmen and home care; people who need to do heavy lifting in their everyday jobs. AT further shows that the number of incidents increases steadily for ages 35-54 [5]. One of the performance requirements in the 2017 strategy of AT is to bring down the number of reports within this area by 5% by

2017 and 8% by 2020, within construction, metal and machinery, and residential- and home care [6]. The problem is relevant to both workers and society. Solutions for the back pain due to incorrect lifts and pushes can reduce the risk for workers and in return avoiding sick-days.

The problem is especially serious to social workers. The amount of affected social workers is around 17.000 for sprains and joint-displacements in 2016 [5]. Many solutions potentially can solve the problem from different aspects (e.g. change the regulation, implementation of new technology), and it is important to investigate the existing solutions before the new solution development for not wasting resources and effort. However, which aspect should be focused and how to conduct a systematic state-of-the-art investigation is still lack of research. Therefore, this paper aims to provide a systematic approach for the state-of-the-art investigation with the example of the social workers' back pain. An ecosystem approach is used in this paper for the investigation of the related stakeholders and their relationships in the social workers' back pain. Meanwhile, this approach can help to identify and allocate the focuses/issues in the ecosystem.

The rest of the paper is organized as follows: Section II presents the ecosystem mapping of the social care industry. section III presents the state-of-the-art patent and literature review based on the ecosystem mapping results. The gap analysis is presented in Section IV. Finally, discussion and conclusion are presented in section V.

II. ECOSYSTEM MAPPING OF THE SOCIAL CARE INDUSTRY

The ecosystem of the social care industry is shown in Fig. 1 with the information, money, and product flows. The social care industry is a complex system, involving regions and government, for simplicity, this paper simplifies the boundary for the money flow to be at the municipality. Each stakeholder has a specific role in the ecosystem as described in TABLE I, and the interactions among stakeholders are described in TABLE II.

Based on the ecosystem mapping and the investigation of the stakeholder roles and their relationships, this paper identifies the industry community for work environments and equipment manufacturer as the prime actors in the ecosystem, because the equipment manufacturers optimize existing products and develop new products, the industry community for work environments provides valuable information and guidance to the workplaces and recommends products by different equipment manufacturers to the whole ecosystem.

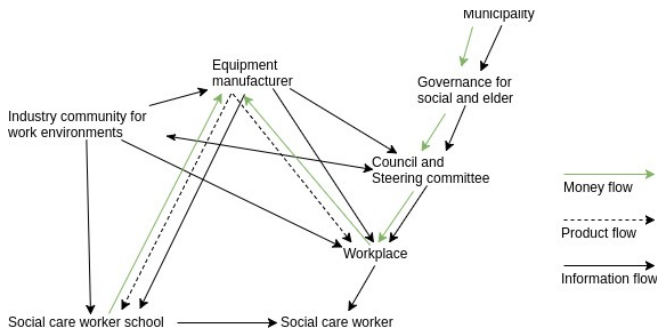


Fig. 1. Ecosystem mapping for the social care industry with money, product and information flow

TABLE I. STAKEHOLDERS' ROLES IN THE ECOSYSTEM OF THE SOCIAL CARE INDUSTRY

Stakeholder	Role
Social care education	An institution in charge of different educations within the social care field.
Municipality	Responsible for the overall budget, and for allocating money to different areas
Governance for social and elder	A selection of people within the municipality in charge of a specific area
Council and Steering committee	Comprised of relevant people from different organizations and companies within the relevant areas. Making a decision for the budget allocation
Industry community for work environments	Subsided group working towards a better work environment for their industry
Workplace	Where social care workers conduct their work
Equipment manufacturer	Continuously invent and improve new equipment to assist social workers in their work environments

TABLE II. STAKEHOLDERS' RELATIONSHIPS IN THE ECOSYSTEM OF THE SOCIAL CARE INDUSTRY

Stakeholder	Offers	TO
Social care education	Education	Social care workers
Municipality	Financing /budget	Governance for social and elder
Governance for social and elder	Financing /budget/ Ddelegates to	Council and Steering committee
Council and Steering committee	Guidance, rules and regulations and (nancing / budget)/ grants	Workplace
	Work environment insight	Industry community for work environments
Industry community for work environments	Exposure to market through recommendations and conferences	Equipment manufacturer
	Information pamphlets, guides, equipment reviews and recommendations	Workplace, social care workers education, council and steering committee
Workplace	Work and service training	Social care workers
Equipment manufacturer	Assistance products such as lifts	Workplace, social care education, council and steering committee

III. PATENT AND LITERATURE REVIEW

The state-of-the-art patent and literature review covers the identified prime actors in the ecosystem mapping: the industry

communities for work environments and equipment manufacturers.

1) State-of-the-art from the perspective of industry communities for work environments

There are two important industry communities in this area. One is called Forflyt created by the industry community for work environments, and it offers solutions, e.g. pamphlets and e-learning videos of correct lift, it also provides news about research in welfare technologies and the applications across the country [7]. Furthermore, it offers a guide for equipment selection and utilization and funding application.

Another one is The National Board of Social Services called Hjælpemiddelbasen [8] (English: aid portal) spans over 5 main product areas in the social care industry:

- Treatment and training,
- Home, household and hobby,
- Communication,
- Mobility and transfer (person), and
- Personal care, clothing and shoes

The area of mobility and transfer includes other 10 sub-areas, one of the sub-areas is the lifting, transfer and tools to turn a person around. This sub-area has 3 product categories:

- Slings and stretchers
- Transfer and turning tools
- Person lifts

Each of these product categories (except the transfer and turning tools which are empty) lists a number of product groups. For instance, in person lifts, there are 372 different products in the group of 'aids to lift persons', e.g., mobile person lifts to slings.

2) State-of-the-art from the perspective of the equipment manufacturers

B. Literature Review

To investigate the existing solutions for the social care workers' back pain, this paper firstly conducts a literature review in the subjects of consumer health, health care, lifting and injury in the databases of ACM and IEEE, and 4 articles are founded directly related to the paper's interest (shown in Table III). Two out of the four articles are in the robotics field, therefore, this paper broadened the searched results with three categories of robotics, tools, and algorithms. Three articles are found partly related to the paper's scope. For instance, [9] and [10], like many others, focus on the care workers who are required to be present and operate the robot. [11] is similar to [9] and [10], but focus on offloading tasks for hospital staff, not direct care workers.

The other three articles that partly related to the paper's scope aim to solve the issue of patient lifting for wheel-chair users, but not directly related to the care workers. However, the proposed solutions could be applied to assist the care workers by improving lifting capabilities. For example, the solution proposed in [12] is a chair to assist wheelchair users to move around independently and reduce back pain by doing the lifts of the person. [13] put sensors on the position and rehabilitation (HLPR) chair that can move indoor, and avoid

obstacles, [14] tries to solve some issues in the software and sensors.

TABLE III. EXISTING SOLUTIONS TO SOCIAL WORKERS' BACK PAIN

Proposed solution	References
Solving the back pains with a robot	[15]
A study on correcting the lifts of direct care workers	[16]
Mapping human motions in a robot, to do human lifting tasks	[10]
A feedback system that analyzed lifting posture and alerted the worker if it was incorrect	[17]

C. Patent Review

The literature only covers the developed solutions or the proof of concept, therefore, this paper does a patent review to identify potential solutions. The patent review is conducted by searching Espacenet (the European Patent Office), in the categories: A61B or A61G or A61H or A63B or G09B, with the keywords of patients, posture, back, pain, lift. 555 results are found, and 41 patents are related to the paper's scope (e.g., TABLE IV). The 41 relevant patents can be grouped into 5 categories:

- Neuroscience
- Medical device/apparatus or methods
- Characteristics mapping
- Exercises
- Webservice

Back pain can be both physical and psychological, neuroscience could be relevant. The patents regarding neuroscience include Early Detection of Neurodegenerative Disease, Patent US2017258390 (A1) which describes how to prevent the brain of degenerative disease by measuring cognitive and behavioral features. Non-jacketing side-entry connectors and prosthetic disorder response systems, Patent US2017197028(A1), is a way to treat chronic comorbid diseases with devices in the brain. None of these can be associated with back pain, or incorrect lifts, so they are not relevant to the scope of this paper.

Many of the patents are considered as a medical device/apparatus or method. This category includes devices used both in medical surgery to prevent injuries, but mostly to rehabilitate an already injured part of the body. Body alignment and correction device, Patent US2017189758(A1), is a device to attach around the waist, that can correct the alignment of the body. This device forces its users to have a more correct posture, but also to prevent further damage to injuries. Posture feedback system and method, detachable traction system, and traction safety belt combination, Patent US2012245491(A1), is a belt/apparatus for measuring the posture of the user by various sensors. It is able to alert users when a posture is outside the determined acceptable range. This device can also be used to prevent injuries. Some patents regarding medical devices/apparatus or methods are also of less relevance, such as methods and devices to decrease tissue trauma during surgery, Patent WO2016200757(A1), is a fluidic system for deforming a biological tissue, which is not directly related to back pain or incorrect lifting.

Patents concerning characteristics mapping, map either the entire or part of the body of the user. This mapping can be

used to create a 3-dimensional mapping of the body which users can analyze, and act accordingly. A system, apparatus and method for measuring body characteristics, Patent US2017020301(A1), provides a system for using optical mapping for producing a 3-dimensional mapping of the characteristics of a body. Foot typing method, Patent US2008167582, is a method for classifying/typing feet, by measuring the position of the rearfoot supination end range of motion.

Exercises are usually used in rehabilitation and the patent is also characterized. Methods and apparatus for rehabilitation and training, Patent US2014296750(A1), is a method of rehabilitation using an actuator type that includes a movement mechanism capable of applying a force that interacts with a motion of a patient's limb in a volume of at least 30 cm in diameter, in at least three degrees of freedom of motion of the actuator and capable of preventing substantial motion in any point in any direction in said volume, in which the same movement mechanism is used at two different places of rehabilitation. Generation of personalized training regimens from motion capture data, Patent US2014228985(A1), is using prehistorical recorded videos to create more individual exercises, based on individual performance.

Some patents describe a web service to collect information and provide information used across multiple systems. System and methods for monitoring physical therapy and rehabilitation of joints, Patent US2017143261(A1), is a system that monitors the patient at home by sensors to detect behaviors. Systems and methods for use in fall risk assessment, Patent US2013303860(A1), describes a computer system, to detect if a person has fallen. The sensors report to a web service which can be consumed in other applications.

TABLE IV. SELECTED PATENT LIST FOR SOCIAL WORKERS' BACK PAIN

Patent number	Patent Name
US2017258390 (A1)	Early Detection of Neurodegenerative Disease
US2017197028(A1)	Non-jacketing Side-Entry Connectors and Prosthetic Disorder Response Systems
US2017189758(A1)	Body Alignment and Correction device
US2012245491(A1)	Posture feedback system and Method, Detachable Traction System, and Traction Safety Belt Combination
WO2016200757(A1)	Methods and Devices to Decrease Tissue Trauma During Surgery
US2017020301(A1)	A System, Apparatus and Method for Measuring Body Characteristics
US2008167582	Foot Typing Method
US2014296750(A1)	Methods and Apparatus for Rehabilitation and Training
US2014228985(A1)	Generation of Personalized Training Regimens from Motion Capture Data
US2017143261(A1)	System and Methods for Monitoring Physical Therapy and Rehabilitation of Joints
US2013303860(A1)	Systems and Methods for Use in Fall Risk Assessment

IV. GAP ANALYSIS

The state-of-the-art investigation shows that there are sufficient solutions in the ecosystem with the perspectives of the industry communities for work environments and equipment manufacturers. The result also can be confirmed by the product list of Hjælpemiddelbasen [8]. Meanwhile, the welfare technology in the area is quite advanced, and the technology adoption in the field is high.

However, this paper finds out that lack of time is not mentioned in any of the solutions, and it is a huge issue for the social care industry. A quick Google search for ‘Social care workers have too little time’ in Danish results 80.000 hits. It means that it is a huge issue in Denmark today, and it is much debated in the media. An article by the Danish newspaper JyskeVestkysten [18] analyzes statements from care workers with a survey about their stressful daily work. Some social care workers state that they simply do not have the time to give the service to patients. Another article by FOA (Denmark's third-largest trade union) [19] claims that what social workers provide is unworthy in regard to their life quality. [20] also points out that there is an increasing demand for more social care workers in Denmark for a long time.

Therefore, solutions that potentially improve the current situation of the social workers’ back pains might come from other stakeholders in the ecosystem, e.g., training or regulatory authorities.

V. CONCLUSIONS

With the example of social workers’ back pain, this paper demonstrates a three-step process of the state-of-the-art investigation (shown in TABLE V). Each step includes several activities and produces outcomes for the next step. This ecosystem-driven approach provides a state-of-the-art investigation that can identify shortcomings of existing solutions to meet market needs. Meanwhile, this approach allows evaluations at each step to secure the quality of the results.

This paper mainly focuses on the introduction of the three-steps, and the following up steps, e.g., the step- minimum viable product development, are not discussed in this paper. A future study that introduces and integrates the extended steps with the three-step ecosystem-driven approach are recommended.

TABLE V. THE ECOSYSTEM-DRIVEN APPROACH FOR THE STATE-OF-THE-ART INVESTIGATION

Step	Activities	Outcome
Step 1- Ecosystem mapping	Identify stakeholders and their roles Identify relationships between stakeholders with three flows (monetary, product/service, and information)	Identify the prime actors who are strongly related to the solution providing for the identified issues
Step 2- The state-of-the-art patent and literature review	Conduct a literature search Conduct a patent search Evaluate the search results	Identify related existing solutions and patents
Step 3- Gap analysis	Evaluate whether the Identify related existing solutions and patents can solve the identified issue	If the evaluation result is no, go to Step- minimum viable product development If the evaluation result is yes, go to Step 1, and re-identify the prime actors

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