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Exploratory Study on the Success Factors of Rehabilitation Medical Device Cluster*

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Abstract

Purpose - As Korea is reaching a post-aged society, the number of chronic illness is increasi ng, and the demand for rehabilitation medical device is growing. Although there is high pote ntial for the growth in rehabilitation industry, because most of the related companies in Kore a are relatively small, lacking capital or R&D resource, it is difficult for them to create an i nnovative product, and currently most of the high-tech equipments are imported. Therefore a medical device cluster, where business, research, medical institutes and universities may wor k cooperatively to enhance research development and solve issues is necessary for future dev elopment.

Research design, data, methodology – In this method we have done a literature review of the rehabilitation industry and industrial cluster. Based on the studies, we have conducted an ex ploratory factor analysis by studying examples of foreign and domestic medical clusters and drawing success factors in forming a medical cluster. Next based on the studies we have co nducted a survey to domestic medical device companies to find their difficulties and needs t o form a successful medical device cluster.

Results – This paper provides both theoretic review on success factors of forming a medical device cluster and practical analysis using case study and survey.

Conclusion – The significance of this paper is that based on the literature review, we have c ompared actual examples of domestic/foreign medical clusters and drawn difference and coinc idence between literature and actual cluster success factor. We were also able to conduct a s urvey on actual medical device companies and through the results we were able to search di fficulties and necessities of medical device companies.

Keywords: rehabilitation industry, medical device, industrial cluster, exploratory analysis

1. Introduction

Currently Korea is quickly approaching to a post-aged society. According to the Statistics Korea, our nation aging population(over 65) is prospected to grown from 13.8% in 2017 to over 30% in year 2040. Korea's life expectancy was lengthened by 20 years in the past 46 years, reaching the age of developed countries. However the average health age is 73, which shows 9 years gap compared to

* This study used the data of KIET's research project.

the growth of life expectancy. Along with the extended life expectancy due to the development of medical services, several chronicle diseases and sickness is also growing.

As we reach toward a more aging society, several problems and issues that need to be resolved may occur. However there are also positive factors to the society, such as the growth of rehabilitation industry as a new growth engine. The rehabilitation industry is usually established when per capita income reaches 10 thousand dollars, 1970s in USA and 1985 in Japan. In Korea, the rehabilitation industry market began to grow in 2006 (per capita income 16 thousand dollar), however the market size is relatively small.

The majority of medical device manufacturers in Korea size are petty, the sales of over 80% of companies in Korea under billion won. This causes difficulty for the companies to create innovative products, and most of the high performance equipment are imported from advanced countries. Therefore a medical device cluster, where business, research, medical institutes and universities may work cooperatively to enhance research development and solve issues is necessary for future development.

This research paper has conducted an exploratory analysis for the success factors of rehabilitation medical device cluster. First we have analyzed the characteristics and growth factors of medical device industry by literature review. Next we have compared actual examples of medical device clusters, domestic and overseas, to the facts we have derived from the literature review. Finally, based on the factors we have drawn from both literature review and actual samples of medical clusters, we have created and conducted a survey on domestic medical device manufacturers.

2. Literature Review

2.1. Rehabilitation Industry

Rehabilitation industry is generally defined by ‘an industry that provides products or services that enhances independent activity to the disabled and elderly which eventually provides improvement in life quality and productivity’. Currently there is no definite definition or law about rehabilitation industry, and it is partially differentiated by separate laws related to medical devices or handicapped welfare.

Until now, the definition of rehabilitation industry has been limited to a narrow definition related to the handicapped or the elderly. However, this definition must be redefined and expanded as the many governments are expanding their welfare territory and new futuristic products and market related to rehabilitation is created due to the development in medical techniques. For example the rehabilitation industry now covers wellness products, chronic disease care(bio rehabilitation), U-health care and so on.

Table 1:. Categorization of Rehabilitation device

Middle Division	Specific Division
Therapy & Diagnosis Device (16)	Intermediate therapy device Radiation therapy device Surgical therapy device Surgical Robot Oriental Medicine device other therapy device Chemical Chemistry and Biological analyze device Oriental Medicine therapy device Bio rhythm measurement / diagnostic device Molecule genetic therapy device Ultrasonic therapy device X-ray & CT, MRI Nuclear medicine & molecular image diagnostic device Intelligent decipher system Other therapy/diagnostic device

Functional restoration / Supportive and Rehabilitation Device (10)	Physical function restoration device Electronic Mechanical Artificial Organ Biomaterial/ Medical material Rehabilitation training device Movement support device Life support device and system Perception/sensory function support device Other Functional restoration / Supportive and Rehabilitation Device
Medical Information & System (6)	Oriental Medicine limit standard system Remote and in-home medical device Standardization of Medical Information U-EHR(Electronic Health Record) Hospital Medical Information system & facility Other medical information and system

Source : Ministry of Knowledge Economy (2010)

2.2. Industrial Cluster

"Clustering is the tendency of vertically and/ or horizontally integrated firms in related lines of business to concentrate geographically. (OECD, 1999: 29). The concept of cluster has been broadly acknowledged as Michael Porter has referred to the definition in his book, 'The Competitive Advantage of Nations'(1990). Afterwards cluster has been mostly mentioned and researched in the geographical-economic fields. The perspective that geographical factors are important to enhance a particular regional economic competitiveness has been proposed.

The theorization of the concept of cluster was initiated as the economist Alfred Marshall suggested that geographic nearness effects cost reduction and eventually enhances the local economy competitiveness. In the 1990s, after the global competitive economy was established, and nation's competitiveness has risen as an important topic, several new opinions appeared. Some of the noticeable researches at this time were 'Creating regional innovative clusters for competitive enhancement'(Porter, 1998) and 'Research on science-technology city'(Castells & Hall, 1992).

In order to establish the meaning of cluster, OECD analyzed the past theories and explained their interest on clusters economically. This paper describes that the economic interest on clusters was developed by externalities analyzation based on the Marshall theory, and the focus specified analyze on new-order economy transaction costs. They provide the result with several examples, explaining that a certain regional cluster should be designed to enhance its economic cluster effect.

In summary, the most important meaning of cluster is if companies or institutes in similar industries are located closely, this may cause cost-reduction and differentiation effects which may bring competitive advantage compared to companies in other regions. Also locating nearby creates several social cooperations, such as study effects synergies, and promoting innovation. The local innovation cluster may be defined as a product, service, knowledge network that is created by companies or institutes located in adjacent area, working in similar business.

Table 2: Definitions of industrial clusters

Research	Definition
Porter (1998: 199)	"A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities.
Crouch & Farrell (2001: 163)	'The more general concept of "cluster" suggests something looser: a tendency for firms in similar types of business to locate close together, though without having a particularly important presence in an area.'
Enright(1996: 191)	'A regional cluster is an industrial cluster in which member firms are in close proximity to each other.'

Feser(1998: 26)	'Economic clusters are not just related and supporting industries and institutions, but rather related and supporting institutions that are more competitive by virtue of their relationships.'
Van den Berg, Braun & van Winden (2001: 187)	'The popular term cluster is most closely related to this local or regional dimension of networks . . .Most definitions share the notion of clusters as localized networks of specialized organizations, whose production processes are closely linked through the exchange of goods, services and/or knowledge.'

Source : Martin, R. & Sunley, P.(2002)

Formers academic institutes have researched the success factors of bio cluster by literature review and examples of international bio-clusters, such as San-Francisco Bay and England Cambridge area. Through this review, they have drawn several success factors that are listed in the table 3, such as strong R&D foundation, human resource, funding. infrastructure, law/tax policy, networking, leadership, agglomeration, innovative culture, market research, and so on. The success factors given by each academic institute, such as OST, SRI International, OECD, Boston Consulting Group, USA Bio-Industry Association, and other experts (Givens, You-sang Koh) are organized in the table 3.

Table 3: Success factors of Bio-clusters

Success Factors	England OST (1999)	Givens (1998)	SRI (2002)	USA BIO (2002)	Yousang Koh (2003)	BCG (2001)
Strong R&D foundation	O	O	O	O	O	O
Excellent human resource	O	O	O	O	O	O
Abundant Funding	O	O	O		O	O
Advanced Infrastructure	O	O	O	O		O
Law/Tax policy	O		O	O	O	O
Networking	O				O	O
Leadership		O			O	
Industrial agglomeration	O				O	
Innovative company culture	O					
Huge Market research					O	
Law firms and consulting	O					

Source : Y.D. Lee, J.S. Kim (2003)

Grouping by the success factors, experts and institutes unanimously agreed on the importance of 'strong R&D foundation' and 'excellent human resource' to successfully form a bio-cluster. The majority have agreed the the factors 'abundant funding' 'developed infrastructure' 'law/tax policy' were also important. A few agreed that 'networking', 'company/institute leadership', 'industrial

agglomeration' were important, and there were minor opinions that 'innovative company culture', 'huge market research', 'law firms and consulting' were also important. The success factors of bio clusters which were suggested by experts or institutes are grouped below in the table 4. In the following chapter we will review on actual medical device cluster examples and compare the success factors reviewed in this chapter.

Table 4: Expert opinions on Success factors of Bio-clusters

Weight of Opinion	Unanimous opinion	Majority opinion	Partial opinion	Minority opinion
Success Factors	Strong R&D foundation Excellent human resource	Abundant Funding Developed Infrastructure Law/Tax policy'	Networking Company/Institute Leadership Industrial agglomeration	Innovative company culture Huge Market research Law firms and consulting

Source : Y.D. Lee, J.S. Kim (2003), rearranged by author

3. Domestic and Foreign Medical Cluster Examples

3.1. Foreign Medical Clusters

The major medical clusters located overseas are listed below. Some of the main examples are the medical/bio cluster located in US, and other countries such as China, Japan, Singapore and so on.

Most of the clusters listed in table 5 are bio/medical clusters, and there are a few clusters related to medical device, such as the Kobe cluster in Japan, and the Tuttlingen cluster in Germany. The Kobe medical industrial city was formed at the late 1990s, after 'Kobe Great Earthquake' occurred. Because the local industry was damaged by the incident, the government began to form a cluster related to medical welfare service to revive the industry and prepare the upcoming aging society. Kobe medical industry city was planned to cluster medical companies in order to create new business and revive the local economy at the Port Island area. They are specifically aiming to upgrade the existing industry by clustering, enhancing the medical service and establishing the next generation medical system. Currently over 340 medical companies, such as Takeda pharmaceutical industries, Fuji-film, are collaborating study and research in the Kobe medical city. The city is trying to provide a cooperative research environment by enhancing networking between companies, and the superior R&D infrastructure and facilities is working as a bridge for the clustering.

Table 5: Foreign Medical Clusters

	Name of Cluster	Main role
1	Houston Medical Cluster (US)	Development of new medicine, advanced medical techniques
2	Boston Medical Cluster (US)	Research development, mediation research support
3	San Diego Bio Cluster (US)	Research development & support in product commercialization
4	Tuttlingen Medical Device cluster (Germany)	Research development & support in product commercialization
5	Shanghai International Medical District (China)	Medical, Manufacturing, Education,

6	Kobe Medical Industry City (Japan)	Research development & advanced medical service
7	Singapore Bio-polis (Singapore)	Research development and production of new medicine

Source : Researched and organized by author

Tuttlingen is a small city located in the state of Baden-Württemberg, Germany. The cities' main industry was iron-mining, developed 300 years ago, but it was interchanged into surgery medical appliance industry such as knives and pin-sets in the mid 19th century. The world top surgical appliance company, Braun, established Aesculap Division in the city, and several other major and small companies such as Karl Storz are located in the city, total in 450 companies. The companies are exporting all products related to medical device, from simple medical appliance such as surgical tools to advanced, high tech equipment such as endoscopes and dental implant machines. Currently the southeast Asia companies that produce cheap medical device are rising as Tuttlingen cities' major theat. There are also several problems such as lack of funding, production line based on labor, isolated production structure due to weak connection between technology and market, and the absent of universities and research institutes. In order to overcome these issues, the Tuttlingen cluster has been actively resolving the issues, by contracting OEM/ODM with foreign countries, converging inward/outward technology, specifying product line, interchanging into knowledge based products and production line, networking between university, hospital, research institutes and so on.

3.2. Domestic Medical Clusters

The major bio-medical clusters in Korea that were developed by the government was Osong life-science complex and Daegu-Kyeongbuk medical complex, and other regional cluster that were formed organically are the Wonju medical device cluster and Gwangju life-medical resource and components center. Table 6 shows domestic medial clusters.

The Korean government planned to form a high-tech medical complex to develop advanced pharmaceutical products and medical devices from 2009, investing 5 thousand billion won over 30 years. Osong and Daegu were chosen as the final locations after 10 regions competed over the process with several preparatory researches. The final chosen locations were formed so the entire medical device production process, including education, licensing, research & development, manufacturing and sales, may be possible in the complex. These clusters were formed under a purpose to develop medical and life-science technology into a national strategy industry, by networking between companies, universities, research institutes and so on.

Table 6: Domestic Medical Clusters

	Name of Cluster	Main role
1	Daegu Medi-Valley	Bio Technology/Medical Device (Production/R&D)
2	Osong Bio-Valley	Bio Technology/Medical Device (R&D)
3	Daeduk Research Development District	Bio-Pharmaceutical (R&D)
4	Wonju Medical Device Cluster	Medical Device (R&D/Production)
5	Kyoungki Providence Techno-Valley	Medical, Manufacturing, Education,
6	Incheon Econmic Free Trade Area	Bio – Health (R&D/Production)
7	Gwangju Biomedical compenents center	Medical Device/Materials & Parts

Source : Researched and organized by author

While Osong and Daegu high-tech medical complex was composed in a top-down, hierarchy system by the government, the Wonju and Gwangju medical device cluster was formed naturally by cooperation between the local government and companies, universities. Wonju is a small city located in the middle of Korea with high growth potential. It is actually the only city which population is growing in the Gangwon providence. The city was searching for an industry that would work as the next growth-engine and decided to develop the rehabilitation/electronic medical device industry, by collaborating with Yonsei university Wonju campus, which was already training students to expertise in medical device. The city, university each provided infrastructure and technology, and also planned to work with production company. They aimed on providing total solution for medical device development, from training, tech support, incubating startups to production and marketing. This is named as 'MEDISTRY', which is the combination of Medical and Industry.

Gwangju has also been focusing on bio-material industry, which means producing and developing materials that may be applied on the human body for curing disease or exchanging damaged organs. In 2002, there were only 2 companies to start with, but as the city continuously invested and incubated several related companies, in 2016 there are now 190 companies with 1,925 workers, with the total revenue of 266.8 billion won. It has now become a new growth engine of the region, with the annual growth 11.1%. In 2014, Gwangju has founded the tech-support center for dental material and components, and they are expanding into dental medical device testing center and orthopedics convergence medical device center by 2019-2021. The Gwangju local government and techno-park is trying to provide a better environment for the companies by expanding the support program of the entire cycle of medical device development – from developing samples to marketing. As the related bio-material companies are growing and several companies have moved to Gwangju, the related hospitals and medical industry is also growing- such as dentists, orthopedics and ophthalmic clinics.

3.3. Summary of Cluster Examples

By analyzing domestic and foreign examples, the main factors to successively form a cluster are research strengths, professional personnel, infrastructure, networking, support of government, leading company, degree of agglomeration and so on. One of the important factors that differentiate the medical clusters are whether it was developed naturally, or government-driven. Examples of government driven medical cluster are Kobe medical complex, and domestically Osong & Daegu high tech medical complex. Examples of naturally formed medical clusters may be the Tuttlingen cluster in Germany, and the Wonju medical cluster.

There are both pros and cons for both cluster types, government-driven and naturally formed. For the government-driven type, because the cluster is formed in a top-down systematic method, it may be formed more quickly and efficiently, establishing the infrastructure under the support of national or local government's support. The cluster may acquire high-tech research facilities and infrastructure in a relatively short time. In the other hand, naturally formed clusters may lack a strong infrastructure or R&D support, and may show low performance in the beginning.

But in the long term, the naturally formed clusters shows higher performance and networking, degree of agglomeration than the government driven clusters. The Kobe medical complex, for example has established state-of-art R&D facilities and infrastructure, but the usage rate is low because of lack of personnel with expertise. Also the Osong and Daegu medical clusters are showing shortage of companies that are settling in the area, lower than 50% of the total capacity.

In order to revive the atmosphere and boost the networking between medical, research institutes, universities and companies, the presense of a leading company of institute is important. In the Tuttlingen cluster example, the Aesculap Division of Braun has done this central role in networking and also training, supporting R&D. In the Wonju example, the Yonsei Wonju campus done a leading role to enhance the cluster effect. This type of leadership from bottom-up is hard to appear in a government-driven cluster where everything is already planned out step by step. In order for the government-driven clusters to activate successfully, they must inhabit certain factors of the naturally formed cluster in the long term.

4. Survey on Cluster Effects of Medical-device Companies

4.1. Survey Overview

In this research, we have conducted a survey on medical device companies in Korea, in order to search the difficulties and necessary support that are needed from the companies. The survey questionnaires were about the general overview of the responding company, reason and advantage of current regional location, difficulties in production and necessary support for competitiveness enhancement.

The targeted survey groups were medical device companies with the appropriate industry code, located in Seoul, Daegu, Kyeong-buk, Ulsan and so on. The research was conducted on 200 companies in total, and was done by phone survey partially including fax and email research.

4.2. Current Location Benefits

The responds for the biggest reason for positioning at the current region was 'easy to secure factory site'(28.4%) 'traffic convenience - easiness to approach'(17.9%), 'related industry nearby'(15.4%), listed by rating orders. Other answers were 'easy to acquire related personnel'(9%), 'favorable facilities related to livelihood'(6%), 'support of local government'(5%), 'easy to acquire raw materials'(5%). Relatively low respondents replied 'Nearness of selling market'(3%), 'several universities and research institutes located by'(3%).

We also researched in a 5 point measures 'the benefits of the current regional location'. The highest ratings were 'traffic convenience - easiness to approach'(3.6), 'easy to secure factory site', 'favorable facilities related to livelihood'(3.5). The results show that respondents located in big cities such as Busan, Daegu answered higher points on 'easy to secure factory site'.

In theory, important factors for clustering are research foundations and infrastructure, capital and human resource, but the survey results show that acquiring factory site or convenience of traffic, degree of agglomeration s more important to the companies. This difference may be caused because the former theoretical view was formed in a more macroscopic perspective by the scholars, while the actual medical company respondents tend to choose their location by cost-benefits effects.

Table 7: Survey Results – Local Benefits

What is the most important reason of choosing your company location?		
No	**Survey Items**	**Respond Rate(%) (N=201)**
1	degree of industrial accumulation	**15.4**
2	easy to acquire human resource	9.0
3	easy to acquire raw material	0.5
4	factory site benefit	**28.4**
5	convenience of transportation	**17.9**
6	market accessibility	3.0
7	favorable livelihood facilities	6.0
8	several universities, research institutes	3.0
9	locals are favorable to company	0.0
10	support of local government	5.0
11	others	11.9

4.3. Difficulties and Supportive Needs

The responds for 'difficulties in producing or selling product'(measured by 5-point scale) showed highest points for 'cost burden in research and development (R&D)'(3.0), and 'shortage of research expert personnel' 'lack of equipment' 'aggravating profits' 'insufficient funding and opportunities to participate exhibition' 'shortage of marketing skills' 'lack of networking' (2.7) are the followed behind. Other opinions were 'lack of resource in self-resolve skills'(2.5), 'difficulty in acquiring licensing/permission'(2.4), 'low quality/process control'(2.3).

Table 8 shows the survey results of support methods that the companies want for increasing their competitiveness.

On the question of selecting three most important factors to enhance competitiveness, 'Technology and research development'(31.1%), 'Domestic/Foreign Marketing Support'(16.8%), 'Technology and market information provision'(13.5%) showed the highest ratings in reply. 'Capital Support'(12.8%), 'Support in acquiring permit process'(11.7%) also was answered by relatively high ratings.

Other factors such as 'Job training of employees'(4.5%), 'support in designing product(4.2%)', 'providing inexpensive industrial site'(4.0%) 'Networking between similar facilities/companies'(1.5%) showed relatively low ratings in the answers. 'Support factors to enhance competitiveness' showed similar results with the 'difficulties in producing/selling product', and support for research development and marketing was drawn as the main factor.

Table 8: Survey Results – Support Methods

What type of support does your company need to increase competitiveness? Choose 3.		
No	**Survey Items**	Respond Rate(%) (N=1,158)
1	R&D, technology development	**31.1**
2	Foreign/Domestic Marketing	**16.8**
3	Employee Training	4.5
4	Technology/Market Information	**13.5**
5	Product Design	4.2
6	Industrial Site	4.0
7	Capital funding	12.8
8	Networking with related institutes	1.5
9	Obtaining certification	11.7
10	Others	0.0

4.4. Survey Results Summary

Overall the beginning survey results show that companies primarily choose their location site by factors such as factor sites and approachable location that are more realistic reasons related to business results, such as cost-profit benefits. However, companies eventually are in need of support in research development and marketing in order to develop innovative products that would win the market, which is shown in the latter part of the survey. This coincides with the factors that were suggested by experts to form a successful medical cluster. Also 'networking between companies/institutes' has received low scores in the survey, but thinking that networking between

medical institutes, universities, industries and research institutes is the hidden factor behind forming a successful, innovative cluster, its meaning should be re-evaluated in the future.

5. Conclusion

In this research, we have theoretically analyzed the meaning and characteristics of rehabilitation medical device and draw success factors by analyzing examples of domestic and foreign medical clusters. Based on the drawn cluster factors (research foundation/ human resource/capital/ infrastructure / degree of industrial accumulation / networking) we have prepared and conducted a survey to search the difficulties and needs of medical device companies in forming a cluster. The overall summary from literature review, cluster examples and survey result is as the following.

First, in this paper we conducted a literature review to search the definition of cluster, and we were able to draw in conclusion that the main characteristic of cluster is 'companies or institutes that are in similar industries located nearby geographically may have competitive advantage by cost reduction and differentiation than companies located in different regions.'

Secondly, by comparing the major medical device clusters(domestic/foreign) with the literature review, we found that although the success factors of cluster defined by experts, such as advanced research foundation, human resource and infrastructure are important, also networking between related institutes, universities, research facilities and industries are equally important. We also found that in order to activate the clustering effects, the leadership in a certain company or institute of related industry is an important factor.

Finally, based on the survey results, companies tend to choose their location primarily by factors related to economic issues, such as factory sites, transportation and so on. But eventually companies are in need of support in R&D, marketing to create innovative products, which coincides with the theories on cluster.

The significance of this paper is that based on the literature review, we have compared actual examples of domestic/foreign medical clusters and drawn difference and coincidence between literature and actual cluster success factor. We were also able to conduct a survey on actual medical device companies and through the results we were able to search difficulties and necessities of medical device companies.

For a more precise research, we would need to explore on more examples of medical clusters to draw a generalized conclusion, and there needs to be additional in-depth research for each success factors. Finally along with general medical device survey, an additional interview of CEOs in medical device companies would seemingly add more depth and precise to the research in the future.

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