

Virtual reality improving businesses in healthcare industries – a meta-analysis

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Abstract

Aim: To analyse how virtual reality improves businesses in healthcare industries.

Methods: Qualitative meta-analysis design, purposive sampling and thematic data analysis were used. The PICO guide helped focus the research question. Search engines were used to select studies/articles from *Google Scholars*, *Scopus* and *Researchgate*. Biases in selecting studies are discussed. Inclusion and exclusion criteria on selecting studies on virtual reality supporting healthcare businesses helped control biases by eliminating other studies found on search engines. A critiquing framework analysed the studies selected.

Outcome: Of the 100 studies found on search engines, only 10 were used to compare with the core areas of healthcare businesses. Odds ratio showed 100% of the 10 studies on virtual reality that gave a significant improvement on healthcare industries.

Keywords: Meta-analysis on virtual reality, Virtual reality, Virtual reality improving healthcare, Qualitative and quantitative meta-anlysis, Virtual reality and healthcare business

I. INTRODUCTION

Businesses in healthcare industries need to be improved. It starts with business planning [1]. A chain reaction leads to selecting, training and coaching employees as a strategic plan of business owners to make business successful [1]. Lastly, autonomy in marketing, advertising and innovating healthcare products are important to be improved to generate business funds [2]. These factors significantly affect success in small and medium healthcare industries [2]. In Turkey, it is important to maintain business stability by enhancing its autonomy [3]. About 320 national companies situated in the European side of Istanbul autonomously monitors Istanbul Stock Exchange (ISE) – the ISE black market, the ISE price indices and the ISE data source index as the main indicator of national market [3], in order to maintain business stability.

However, knowledge of the interaction between companies, financial institutions and the government to integrate economic aspects in improving business is done using computer-based tools [4]. Computer-based tools as technology is advancing at a faster rate, changing how business lives and works [5].

Video conferencing and meeting done through virtual spaces where most business entrepreneurs send their avatars (a virtual representation of themselves) maintain business stability in a manner where autonomy can be exercised in a professional way [5]. Three-dimensional (3D) visualization technologies are increasingly applied in visualization of virtual product for marketers and advertisers with the help of devices such as 3D glasses, head/helmet mounted displays (HMDs), stereo projectors, holographic displays, swept volume displays and other volumetric displays [6].

Virtual reality (VR) using these devices as technologies help business improve because they allow viewers (in this case business customer) to explore various aspects of products, evaluate healthcare business concepts and investigate on human capabilities to run business [6; 7].

On account of these issues, this meta-analysis aims to analyse how virtual reality improves business administration. Citations of other literatures, studies and researches done on VR improving businesses are aimed to be used in this meta-analysis. The purpose of this study is to provide a qualitative paradigm on how to improve business using VR. The qualitative paradigm used the PICO (Population, Intervention, Comparison and Outcome) guide (t.1) to help focus the research question: Do virtual reality improve healthcare businesses? A conclusion is offered.

Table – 1.
The PICO guide.

Guide	Keywords	Search Engines	# of studies applicable
Population	Business administrators	<i>Researchgate</i>	40
Intervention	Healthcare using virtual reality		

Comparison	Virtual reality in healthcare	Google Scholars	55
Outcome	Virtual+reality+improving+healthcare	Scopus	05

II. SEARCH STRATEGIES

The search engines are *Scopus* (5 studies), *Google Scholars* (55 studies) and *Researchgate* (40 studies). 100 studies were extracted from search engines by typing text words and in-texts as keywords (t.1). Boolean phrases used sign options (+) i.e. virtual+reality+improving+healthcare typed in as in-texts on *Scopus*.

Studies identified through search engines were screened that spanned from years 2000 to 2014. Eligibility aside from the year of publication also includes English language studies. The method of eliminating other studies compliments with the study design – qualitative studies are used.

III. METHODS

This meta-analysis used a qualitative paradigm and a thematic data analysis as its method. Purposive sampling techniques used inclusion and exclusion criteria on selecting studies guided by the PICO. No additional records identified through other sources, aside from search engines.

Primarily, a critiquing framework was used to analyze the studies selected. Secondly, the ten core areas of business administration contributed in the critiquing of the 10 selected studies on VRs. The core areas of business administration integrated with healthcare management using VRs as the qualitative paradigm are enumerated as:

- Business plan that critically analyses VR by evaluating economic, financial and organizational viability in healthcare industries;
- Economics monitoring that critically analyses VR by monitoring fluctuations of healthcare industrial economy both macro and micro;
- Human resource that critically analyses VR by investigating capacity and capability of potential healthcare industrial employees using virtual environments;
- Human development that critically analyses VR in training healthcare employees;
- Business operations that critically analyses VR in collaborative tele-operating devices with videos and audios;
- Product analysis that critically analyses VR in enabling healthcare product concepts visualization;
- Product marketing that critically analyses VR in marketing healthcare products;
- Product advertising that critically analyses VR in healthcare product usability sing HMDs and sensing gloves;
- Product innovation that critically analyses VR in exploring viability holographic displays for healthcare product visualization; and
- Business valuation that critically analyses VR for healthcare entrepreneur services.

Lastly, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guideline helped in eliminating other studies until only 10 studies remained to focus the integration of the independent variables. Of the 100 studies, 50 were potentially relevant and 40 were eliminated. The 40 literatures eliminated were used as supporting evidences (literature/studies as cited) and validated the thematic analysis and the qualitative paradigm. Reasons for eliminating other studies are: focused on healthcare business without VR, focused on VR without healthcare business perspectives and year of publication.

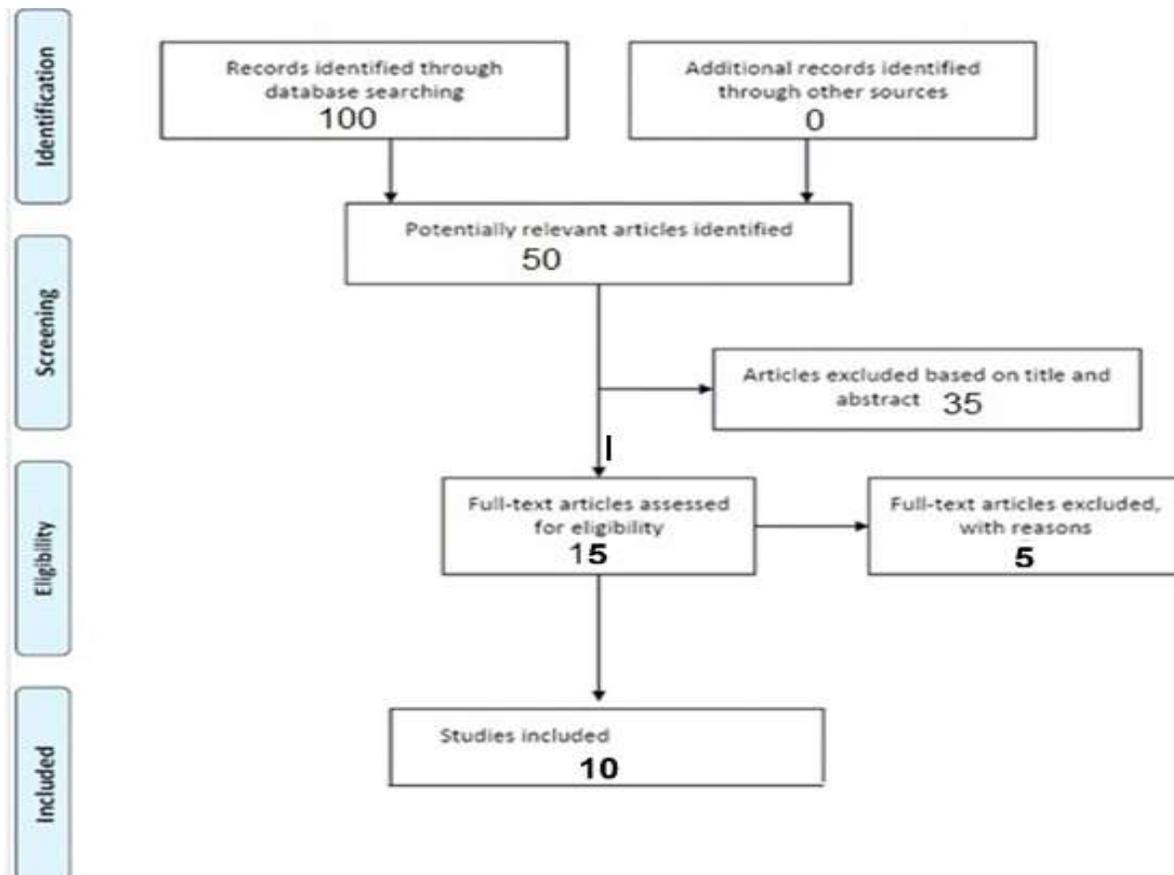


Fig.1: PRISMA guideline

IV. RESULTS

Of the 50 relevant studies or articles identified using the PRISMA guideline, only 10 were used to be integrated with the core areas of the business domain (t.2). Odds ratio shows 100% of the 10 studies on VR gave a significant improvement on healthcare industries.

Healthcare plans business using VR to have a 3D image of the business projection [8]. Economic monitoring using VR is also important to visualize the fluctuation of money value and foreign exchange rate [9]. Because the value of money is monitored, human resource can have a projection on the salary rates of potential employees before hiring [7]. Work appraisals are also important [10]. VR helps in developing capacity and capability of healthcare employees by having a 3D imagery of the company’s plan for providing employees with continuous professional developments leading to salary increase and work appraisals. Employees who are developed and equipped with skills, can make business operate smoothly [11]. Quality services provided by employees can also be operationally networked receiving audio and video signals simultaneously in a virtual environment [11]. A chain reaction leads to an easier way of analyzing healthcare business products because healthcare employees provide quality services through audio and video networking in a virtual environment [12].

Enabling visual content adaptation for product concepts visualization using technologies of VR will be easier for it to be marketed by healthcare employees [13]. Customers can also have a better conversation with marketers using HMDs and inquire about business products in a virtual environment [13]. While healthcare advertisers on the other hand use VR to promote holographic product [14]. If there be any consumer recommendations to improve the product, VR helps in innovating new designs for customer satisfaction [15]. Entrepreneurs and international businesses in healthcare will then be attracted to franchise businesses and/or value the healthcare products [16]. This will extend to branching of the initially planned business because VR is devised as a tool to have a 3D visualization on how to plan the same business which healthcare entrepreneurs are interested on valuing [8; 16].

Table – 2.
Qualitative results guided by the PICO

Comparison	Population	Intervention	Outcome
Fernandez-Guero et al, 2012	Business administrators	Using computer based tools	Business are planned
Bray & Konsynski, 2009	Economists	Using high speed VR generator	Economic fluctuations are

			monitored
Hartanto et al, 2014	Human resource	Using a virtual environment	Employees achieves business plans
Duffy & Salvendy, 2000	Human resource	Using virtual environment when training employees	Employees are trained
Martinez-Vargas et al, 2006	Operations managers	Using audio and video signals	Businesses are operated
Opiyo and Horvath, 2012	Product analysts	Using virtual environment, layout planning and holographic displays	Business products are analysed
Hertkorn et al, 2013	Marketers	Using virtual environment with force feedback	Business products are marketed
Falcao and Soares, 2013	Advertisers	Using HMDs, stereo projector and 3D glasses in ads	Business products are advertised
Opiyo and Horvath, 2010a	Product specialists	Using holographic and volumetric displays	Products are innovated
Kossecki, 2011	Entrepreneurs	Using virtual avatars and virtual environments	Businesses are franchised and branched

V. ETHICAL ISSUES

The benefit of VR offers a promising solution for man-machine interface problems [17]. Healthcare business prospects and an anticipated economic success drives more funding [17]. Since 1999, Machover says that the market for VRs hardware, software, systems and services used in healthcare shoots to about 3 billion United States Dollars (USDs) [18]. 200 billion USDs in year 2000 were used in telecommunication services that markets at about 700 billion USDs. Engineering animations gain 100 million USDs and big information and technology companies like AT&T, Compaq or Cisco gained billions of USDs found in economic data in 1998 [17; 18].

The Cyworld includes 25% of the total populations of South Korea as registered participants with an average of 20 million daily unique visitors garnering a revenue estimated to be around 300,000 USDs daily in 2005 [19; 20].

However, VR for use in healthcare financial information is difficult to manage because analytic programmes do not enable healthcare employees to view trends in large amounts of financial information in a superior graphical form [21].

The harm done among healthcare financial analysts using VRs can be outweighed by benefits of its profits. This justifies the ethical feasibility of having VR giving impact on businesses.

VI. DISCUSSION

In the attempt to analyse how the 10 core areas of business domains improve healthcare using VR, other studies extracted from search engines found to be non-eligible to be used in this meta-analysis, hence eliminated using biases. Advantage of biases on selecting 10 out of 100 studies extracted from search engines are acknowledged on t.3. These are selection allocation biases – random sequence and concealment biases.

Table – 3.
Advantages of selection biases

Comparison	Population	Random sequence	Concealment
Fernandez-Guero et al, 2012	Business administrators	Permits judgment of high risk significance	Foreseeing interventions
Bray & Konsynski, 2009	Economists	Categorizing approaches	Foreseeing assignment comparison
Hartanto et al, 2014	Human resource	Categorizing and comparing participants	Foreseeing sequential appearance
Duffy & Salvendy, 2000	Human resource	Permitting judgment process	Foreseeing methods of intervention
Martinez-Vargas et al, 2006	Operations managers	Obvious approaches to signify studies	Foreseeing assignments with comparison
Opiyo and Horvath, 2012	Product analysts	Permitting judgment process	Foreseeing methods of intervention
Hertkorn et al, 2013	Marketers	Obvious approaches to signify studies	Foreseeing assignments with comparison
Falcao and Soares, 2013	Advertisers	Allocation by preferring populations	Foreseeing participants
Opiyo and Horvath, 2010a	Product specialists	Categorizing participants	Foreseeing possible intervention significance
Kossecki, 2011	Entrepreneurs	Signifying intervention outcome	Foreseeing outcomes

Validating business planning to be effectively improving business using VRs, Menck et al [22] developed a qualitative research on planning phases to help several planning specialists to determine capabilities of business to plan projects.

In decision making, a collaborative visualization of 3D scientific data sets (COLLAVIZ) and virtual factory manager (VFM) applying 3D immersive representation and interaction with digital models are used; while in problem introduction of exchange of ideas, the virtual collaboration arena (VirCA) enables high level collaboration between humans and intelligent agents in a virtual environment, in addition to the use of COLLAVIZ and VFM [22]. COLLAVIZ, VFM and VirCA are computer based tools used by business administrators in planning businesses.

In the central process of planning, unexpected changes in volatility of economic time-of-the-month stock market returns must also be monitored using a generalized auto-regressive conditional heteroskedasticity (GARCH) model in an empirical research design. To make a test of the time-of-the-month (t) effect in mean, a classic formula [23] is used: $R1\beta0 + \beta1day2t + \beta2day3t + \sum1$ where R1 is the mean return of stock index in day; the dummy variable dit indicates the day on which the return is observed $\beta1$ measures the mean return and $\beta2$ the average differences between individual months and $\sum1$ is the error termed assumed by the null hypothesis ($H0: \beta=0$). The day2t attains a value of 1 if the return is observed on the first-third-of-the-month days, 0 otherwise; similarly, day3t attains a value of 1 if the return is observed on the second-third-of-the-month days, 0 otherwise [23].

With this formula, high speed computer processors and specialized graphics hardware can create a continuous modified financial trading group [21], i.e. stock and commodity brokers and foreign exchange traders testing the calendar effect in a financial market to examine variances compensated by higher mean returns [3]. The present invention uses VR techniques to allow healthcare financial analysts to easily view manageable amounts of complex information and in particular, financial information about healthcare financial markets such as information about equities, commodities, currencies, derivatives and phenomena of calendar effects in variances at stock exchanges [3]. When there is real-world money being exchanged in virtual worlds, healthcare businesses are improved [9].

However, the use of VRs to allow a healthcare financial analyst to view, manipulate, structure and travel through a 3D VR world of financial information is not known nor is it known to VR techniques to carry out healthcare financial analysis [21]. That is why human resource managers need to hire healthcare employees.

In order for the human resource managers to easily hire employees from a far distance, a virtual environment uses the Delft Remote Virtual Reality Exposure Therapy (DVRET) system to allow participants to engage in a true speech dialogue with virtual character [7] while a cooperative learning environment (CLearE) are used for interviewing that can utilize hypermedia data model [24; 25]. Both can detect mentally disturbed and psychologically incapacitated interviewees. Furthermore DVRET and CLearE (fig.2) can also detect past criminal records since it has an eye scanning and fingerprinting device that can be wired from security intelligence to during interviews [7; 24; 25]. Blood pressures, heart rates and voice intonations can be analysed through the interviewees' avatars and can also be a lie detector device using VRs [7]. VRs constitute the immense majority of the business sector and represent a fundamental element in the employment structure to increase business size [8].



Fig. 2: CLearE and DVRET [7; 24; 25].

In African countries, the use of human capital is a mediator in increasing a business size and increase economic competency of countries [1]. Spain emphasizes the importance of job creation since it increases size of firms [1] and VR helps in visualizing employability [8].

After doing employment interviews, human resource gives the employees their training to maintain their continuous professional development.

Both DVRET and CLearE are used during trainings to allow people to network together and can analyse function of network latency in a 67x50 inch rear-projected screen at a 45 degree angle having scenes rendered on a silicon graphics and the position data for the users' head and hand was obtained by using Ascension Motion Star Extended Range tracking system in a virtual environment [24; 25]. Fig.3 shows a collaborative virtual environment providing a reasonable quality of service in terms of throughput and latency to perform tasks [24; 35].



Fig.3: Collaborative virtual environment [35]

When healthcare employees are fully trained using the conventional VR systems in a 3D projective technologies, HMDs and computer augmented virtual environments (CAVE) [26], tangible virtuality can function in operating healthcare businesses in a paradigm of VR and augmented reality (AR), such as the use of synthetic objects, volumetric displays or hybrid environments [27]. Elasticity morphological information with colors, sounds and smells are important to be collected to analyse the human products that leads to an effective business operations to achieve the business plan [28].

Healthcare operations managers use VR by testing a set of 50,000 inputs taken from the VR robotic operators and tested operation sequences representing virtual laboratories where operations managers can tele-operate interconnected devices through networked interfaces [29].

When conveying images on virtual interfaces, it has to be supported by various 3D display technologies, virtual volumetric elements (Voxels) representing 3D image data, holographic elements, analogous to pixels and Voxels and stereographic displays [30].

Healthcare operations managers easily execute business operations and so as product analysts as they work hand-in-hand.

Nowadays, visualization devices allow healthcare product developers to simulate and evaluate their designs in a way that is almost comparable to using physical prototypes. Visualization of healthcare products provides knowledge and global pictures of various aspects [31]. Functionality, manufacturing and assimilability advances using VR [12].

Marketing healthcare products will then become easier with the help of VR.

Enhanced tele-presence system in marketing healthcare products uses the advantages of VR by allowing human to human interaction with a remote virtual environment with force feedback with an intuitive interface that visualizes its environment [13]. However, marketing and advertising has its differences and the advantages of advertising healthcare products using VRs still enables healthcare product developers use AR principles that can be seen by healthcare consumers [15]. That is why it is also important to use VR in advertising healthcare products to improve healthcare businesses [33; 35].

Creativity in design can make the difference for healthcare product launch in the market [14]. The contribution of VR to healthcare product design improves healthcare product advertising and greatly benefits the prototyping phases [31; 35].

However, visualization interaction depends on healthcare product developers' or designers' work (software) which is sometimes non-user friendly hence needing further assemblies from experts on the software itself [30].

In order for VR healthcare product innovators to visualize designs during assemblies in an AR, who are not experts on the designed software, they may wear head-worn translucent goggles, helmets, or any other stereo viewing – to enhance healthcare product visualization [15].

Healthcare product innovation for business owners can be advantaged and/or improved with the help of VR (fig.4).



Fig.4: Sample VR of a healthcare product [9].

From a business perspective, the new environment challenges existing management theories creating new opportunities [32; 34] especially for healthcare entrepreneurs and calling for developers of new healthcare management [2] – VR creating opportunities.

Healthcare entrepreneurs use avatars to interact with other avatars and use virtual services by wearing virtual apparels, gloves and HMDs [16]. That is why VR among healthcare entrepreneurs improve their healthcare businesses because client can collect orders; receive client-service in a virtual market [16].

VII. CONCLUSION

Of the 100 studies found on search engines, only 10 were used to compare with the core areas of businesses and eliminated other studies/articles found on search engines in a biased approach. Advantages of using biases on eliminating other studies are justified in order to critically analyse how VRs improve healthcare industries in all their platforms and/or areas of its administration. Odds ratio showed 100% of the 10 studies on virtual reality gave a significant improvement on businesses.

Healthcare industries using VR helps improve all the core areas of businesses – the 10 platforms – primarily starting with business plan and ending in entrepreneurship. However, it is also concluded that businesses can improve all its areas/platforms using VR if it is effectively and efficiently administered by VR experts.

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