

PRODUCTION MANAGEMENT IN THE CONTEXT OF DENTISTRY: CURRENT STATUS AND INVITATION TO FUTURE AGENDA

GESTÃO DA PRODUÇÃO NO CONTEXTO DE ODONTOLOGIA: ESTADO ATUAL E CONVITE PARA AGENDA FUTURA

GESTIÓN DE LA PRODUCCIÓN EN EL CONTEXTO DE LA ODONTOLOGÍA: ESTADO ACTUAL E INVITACIÓN A LA AGENDA FUTURA

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ABSTRACT

This research aimed to find, gather, and analyze what has been published over the last decade about production management in the context of dental service provision. The study follows a systematic literature review. Searches were conducted in Web of Science™ database with a period constraint of eleven years (2008-2018). A conceptual framework for crossing both disciplines was elaborated to support data analysis. The literature review identified 17 peer-reviewed articles that have addressed the topic. Therefore, little scientific work has been produced in this interdisciplinary field. The findings suggest that patient treatment and dentist's working time are what demand time the most and influence productivity the most. Productivity is commonly measured per patient seen or treatment delivered. However, there is no consensus among scholars and academics on what type of output measurement is better. In addition, a couple of different types of dental establishments have been identified, and among them, dental centers, dental hospitals, and university dental centers lack studies applying production management tools. The review brings an overview of the intersection of the disciplines consisted of 17 peer-reviewed articles and provides directions for future studies. Practitioners may benefit from information such as the current main ways of measuring productivity. The review shows a picture of the current situation in such an interdisciplinary topic that may contribute to the understanding of it by providing a structured overview that can be useful for academics and practitioners.

Keywords: Health management, dental clinic, literature review.

RESUMO

Este estudo teve como objetivo encontrar, reunir e analisar o que foi publicado na última década sobre gestão da produção no contexto da prestação de serviços odontológicos. O estudo segue uma revisão sistemática da literatura. As pesquisas foram conduzidas no banco de dados Web of Science™ considerando o intervalo de onze anos (2008-2018). Uma estrutura conceitual para cruzar as duas disciplinas foi elaborada para apoiar a análise de dados. A revisão da literatura identificou 17 artigos revisados por pares que abordaram o tópico. Portanto, poucos trabalhos científicos foram produzidos neste campo interdisciplinar. Os resultados sugerem que o tratamento do paciente e o tempo de trabalho do dentista são os que mais demandam tempo e influenciam a produtividade. Esta é comumente medida por paciente atendido ou tratamento administrado. No entanto, não há consenso entre acadêmicos e especialistas sobre que tipo de medição de output é melhor. Além disso, foram identificados alguns tipos diferentes de estabelecimentos odontológicos e, entre eles, centros e hospitais odontológicos e centros odontológicos universitários carecem de estudos que apliquem ferramentas de gestão da produção. A revisão traz uma visão geral da interseção das disciplinas, composta por 17 artigos revisados por pares e fornece direções para estudos futuros. Os profissionais podem se beneficiar de informações tais como as principais formas atuais de medir a produtividade. A revisão mostra uma imagem da situação atual em tal tópico interdisciplinar que pode contribuir para a sua compreensão, fornecendo uma visão geral estruturada que pode ser útil para acadêmicos e profissionais.

Palavras-chave: Gestão em saúde, clínica odontológica, revisão da literatura.

RESUMEN

Este estudio tuvo como objetivo encontrar, recopilar y analizar lo publicado durante la última década sobre la gestión de la producción en el contexto de la prestación de servicios odontológicos. El estudio sigue una revisión sistemática de la literatura. Las búsquedas se realizaron en la base de datos de Web of Science™ considerando el intervalo de once años (2008-2018). Se elaboró un marco conceptual para cruzar ambas disciplinas para apoyar el análisis de datos. La revisión de la literatura identificó 17 artículos revisados por pares que han abordado el tema. Por lo tanto, se ha producido poco trabajo científico en este campo interdisciplinario. Los hallazgos sugieren que el tratamiento del paciente y el tiempo de trabajo del dentista son los que más tiempo demandan y más influyen en la productividad. La productividad se mide comúnmente por paciente visto o tratamiento administrado. Sin embargo, no hay consenso entre los académicos sobre qué tipo de medición de salida es mejor. Además, se han identificado un par de tipos diferentes de establecimientos dentales, y entre ellos, los centros y hospitales dentales, y centros dentales universitarios carecen de estudios que apliquen herramientas de gestión de la producción. La revisión ofrece una visión general de la intersección de las disciplinas que consta de 17 artículos revisados por pares y proporciona instrucciones para futuros estudios. Los profesionales pueden beneficiarse de información como las principales formas actuales de medir la productividad. La revisión muestra una imagen de la situación actual en un

tema tan interdisciplinario que puede contribuir a la comprensión de este al proporcionar una visión general estructurada que puede ser útil para académicos y profesionales.

Palabras-clave: Gestión de la salud, clínica dental, revisión de literatura.

INTRODUCTION

Oral health is considered a prerequisite for people's well-being (BRASIL, 2004; PRASAD; VARATHARAJAN, 2011). The Brazilian health system provides oral health assistance through different ways, from *Sistema Único de Saúde* (SUS) to private clinics (FEDERAL DENTISTRY COUNCIL [CFO], 2005; REGIONAL DENTISTRY COUNCIL [CROSP], 2018; SÃO PAULO, 1999), but they are not enough to meet all people's demand yet (MATOS et al., 2002).

The *Pesquisa Nacional de Amostra de Domicílios* (PNAD) data show that private clinics are the modality of dental clinic most visited by patients (IBGE, 2000, 2010). Such clinics in turn have financial reasons to exist (for-profit), which means they need financial feedback for them to keep functioning.

A dental clinic, like any other dental establishments and organizations in general, needs managerial support to work and provide services (NERY-DA-SILVA et al., 2019; SAM; BONNICK, 2011; SLACK; BRANDON-JONES; JOHNSTON, 2015). There are many studies using technology to support dental activities, such as the use of 3D printers (BURDE; CONSTANTINIUC; CÂMPIAN, 2015) or computational aid (KIM; LEE, 2015; SAM; BONNICK, 2011). Economic and financial analyses to manage dental establishments have been increasing over the years as well (HETTIARACHCHI et al., 2018; O'CONNELL; GRIFFIN, 2011; TONMUKAYAKUL et al., 2015). Other management ways have been applied likewise, such as process analysis and mapping (AHMED; AMAGOH, 2014; NERY-DA-SILVA et al., 2019; TEKIN; EROL, 2016, 2017).

Yet some authors have affirmed that the number of studies on hospital management has overmatched the number of studies on dentistry management (MOHD-DOM et al., 2014; NERY-DA-SILVA et al., 2019; PRASAD; VARATHARAJAN, 2011). Although there are literature reviews in this regard, such as Hettiarachchi et al. (2018), who reviewed the usage of cost-utility analysis in oral health intervention, or Tonmukayakul et al. (2015), who investigated the quality of economic evaluations undertaken in dentistry, a large gap in several aspects remains to be seen.

So, despite the relevance of the studies mentioned above, a few questions remain unanswered: What is the current status of research on production management in dental establishments? What are the techniques that have been and practiced in dental establishments for them to keep working? When it comes to management techniques, as well as the concern with productivity and business continuity in dentistry, it seems they are not properly clarified with respect to their current status.

This research is part of a project that aims to gather and analyze what has been published over the last years about operations and production management in the context of dentistry. Here we focused on the production management part, seeking to build a picture of the current situation in such an interdisciplinary topic in order to contribute to the understanding of it by providing a structured overview that can be useful for academics and practitioners. Carrying out searches in Web of Science™ database, we found 17 peer-reviewed articles on the theme published over the last eleven years. Next, we systematically organized them and analyzed their contents, which resulted in a general view of their qualities, nature, and purposes. This gave us valuable information on opportunities for future research on

gaps we have detected, which are schematically addressed here. The results show that management in dentistry is an incipient field, fertile for breakthroughs, and relevant for future agenda.

METHOD

We conducted a systematic literature review aiming at summarizing and analyzing what has been published regarding production management applications in the context of dental service provision. This study reproduces Hofmann and Bosshard's (2017) research method, also following suggestions and methods found in Gil (2010), Rousseau, Manning, and Denyer (2008), Nery et al. (2018), Grupo Prisma (2015), and Gemelli, Fraga, and Prestes (2019).

Formulation of research questions and selection of the database

As Gil (2010) and Rousseau, Manning, and Denyer. (2008) argue, a literature review starts by formulating Research Questions (RQ). Therefore, the following RQs were elaborated:

RQ1. What is the current status of the existing literature on Production Management in Dental Service Provision?

RQ2. What are the possible areas for future research on Production Management in Dental Service Provision?

This literature review sought to find high-quality papers with the least possible bias. Therefore, the Web of Science™ database was chosen because of its relevance worldwide.

The Web of Science™ database was accessed via *Periódicos* CAPES, through the CAFE program, which allows users to have full remote access to the content available in the database through IP addresses of users who are affiliated to a university. The periodical constraint set was the last eleven years (2008-2018).

Inclusion and exclusion criteria

Inclusion criteria: as Slack, Brandon-Jones, and Johnston (2015) conceptualize, operations and production management (OPM) seeks to manage resources that create and deliver products and services. Traditionally, the literature defines the comprehensiveness of production management as being from planning production to monitoring operations to seeking improvements. Today, such a definition is called Production Planning and Control (PPC) (CORRÊA; CORRÊA, 2012; LAGE JR; GODINHO FILHO, 2012; MOREIRA, 2011; SLACK; BRANDON-JONES; JOHNSTON, 2015). Being such a comprehensiveness too wide to comprise a literature review, this research focused on the Production Control part, thus concentrating on a more specific part that could be better investigated.

Therefore, it was defined as inclusion criteria that the studies had to address environments already established, which were already working, and the study had to aim at least at:

- Managing or supporting dental practice in terms of resources management, operations management and/or service provision management; or
- Measuring productivity, efficiency and/or capacity, or studying aspects that might be linked to these variables.

Studies involving prosthetists (prosthesis) would be included only if it was identified in the study

that the prosthesis department was inside the dental clinic, according to CFO (2005) and CROSP (2018).

Like Hettiarachchi et al.'s (2018) study, inclusion was limited to articles written in English, Portuguese and Spanish and to human studies. In vitro and laboratory-based studies, letters, editorials, unpublished grey literature, guidelines, conference proceedings, case reports, methodology papers and literature reviews were excluded. To ensure the quality of the papers, only peer-reviewed ones were considered for review.

The keywords used in the research (Table I) also find many articles that belong only to the specific dentistry field, such as restoration techniques or analysis of the structure of dental materials, i.e. research that can only be performed by dental practitioners and related areas. Therefore, exclusion criteria included studies of exclusive dental practitioner nature.

Literature review process

The Health Sciences Descriptors (HSD, 2018) was visited to select the keywords to be used in the literature research. Each researcher selected the keywords on HSD separately and elaborated a keywords list separately too in order to reduce subjective bias. The descriptors used by Hettiarachchi et al. (2018) were also considered because of the similarity with the research purpose. Next, the keywords were critically discussed to be adjusted to the research purpose.

Altogether, 300 keyword combinations were used (Table I). Each researcher conducted the searches separately to increase the chances of finding works and reducing subjective bias. Two technical aspects of this process were the use of the search operator "AND" to link the two disciplines and the use of the wild card character "*" at the end of some search phrases to ensure that similar terms could be found (HOFMANN; BOSSHARD, 2017). This research step was conducted from July to August 2018.

Table I - Keywords used in the literature research

Production Management	Relationship	Dentistry
Production	Analysis	Dental
Productivity	Application	Dental Care
Production Management	Capacity	Dental Clinic
	Effectiveness	Dental Hospital
	Efficiency	Dental Office
	Loss	Dental Service
	Measurement	Dental Service Hospital
	Use	Dentistry
	Using	Health Service
	Utilization	Oral Health

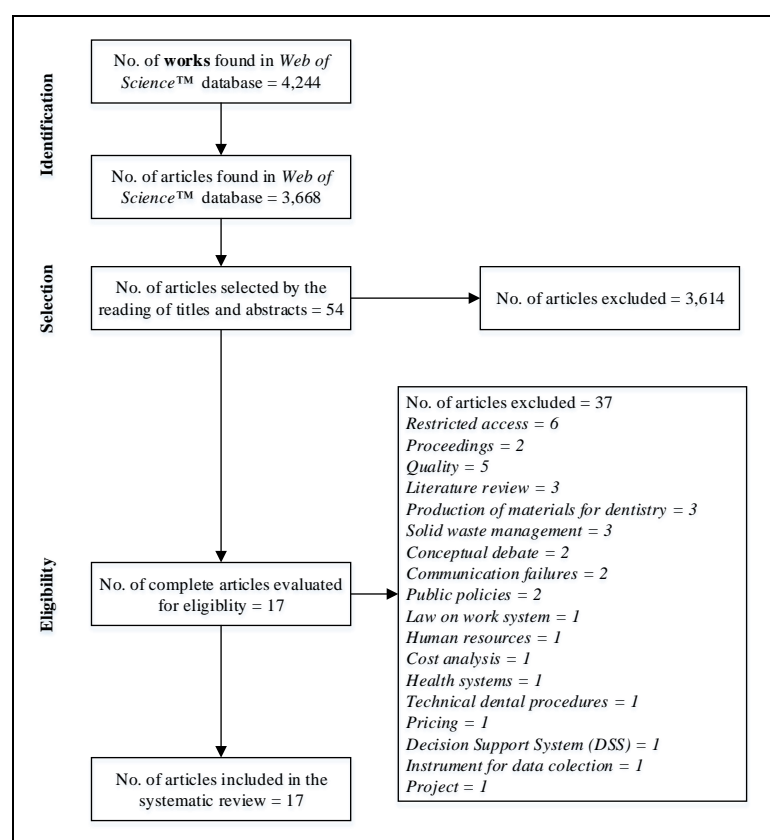
Altogether, 4,244 works were found, including letters, editorials, unpublished grey literature,

guidelines, conference proceedings, case reports, methodology papers and literature reviews. The filter “article” available on the database was set and it resulted in 3,668 articles (86.4%).

For triage, the reading of the papers’ titles and abstracts was done and 54 items that corresponded to the research questions were found, which were selected for a more in-depth reading.

Six papers were excluded due to restricted access (11.1%) and two papers were excluded due to being published in proceedings (3.7%), and as such, they are not peer-reviewed. Next, as Gil (2010) suggests, the step of reading the material was taken and 29 papers were not related to the topic of this literature review (see Figure I for details) and therefore were excluded. Thus, this systematic literature review is based on 17 peer-reviewed scientific papers published over a period of eleven years. All papers correspond to 31.5% of all matching items (54) found in Web of Science™.

Figure I - Literature research process



Source: Elaborated by the authors based on Grupo Prisma (2015).

Results organization and classification

Each researcher examined separately, autonomously, and independently the 17 selected papers and organized them into distinct variables in a Microsoft Excel spreadsheet, going up to 20 variables for analysis and extraction of contents that were pertinent to the research topic, such as main results, methodological characteristics, settings where the studies were conducted and suggestions for future research. To have a bibliometric view, the papers’ titles, abstracts and keywords were used to create a word cloud (GEMELLI et al., 2019) that shows the main terms related to the topic.

Journals organization and classification

The scientific journals were organized according to the impact factor (IF) indicated in the 2017 Journal Impact Factors® list (CLARIVATE ANALYTICS, 2018) and the *Qualis-Periódicos da Classificação de Periódicos Quadriênio 2013-2016* (PLATAFORMA SUCUPIRA, 2019), as well as according to the disciplines in which the journals are classified in the respective systems.

Studies organization and classification

The papers were organized according to their methodology, study design, method of data collection, type of result analysis, main results, installation or department where they took place, production management dimension they address, and suggestions for future research.

Crossing OPM and dentistry

To cross the disciplines and identify such intersecting literature, a matrix relation with a conceptual integration was necessary, which was possible through the conceptualizations of OPM and dentistry. By addressing these concepts, it was possible to create an organizing framework where the matrix relation could rest on. Moreover, as Senivongse, Bennet, and Mariano (2017) state, the concepts determine the organizing framework of a systematic literature review. Additionally, the classification criteria for the analyzed papers were partially based on that matrix. Hence, some points of both disciplines are presented in the following sections to support such integration.

OPM: conceptualization

OPM is the activity of managing resources that create and deliver products and services (SLACK; BRANDON-JONES; JOHNSTON, 2015). In this present research, production management means the ways (systems, resources, methods, techniques) which the dental clinic's manager relies on to assign continuity to the business, as well as reaching productive targets such as efficiency, capacity, utilization, service expansions, among others.

Depending on the maturity degree of an organization, its level of management and strategic techniques will fluctuate from the simplest to the most complex ones, ranging from a singular activity or department to the entire company and even outside it, including its whole supply chain (BALLOU, 2006; PIRES, 2014). It is similar to process management concepts, where you can classify the processes hierarchically, then manage and control all of them, both the macro-process (the entire organization) and the micro-processes (departments, activities, etc.), create Key Performance Indicators (KPIs) and assess performance to find opportunities for improvements (NERY-DA-SILVA et al., 2019; OLIVEIRA, 2014). Such a vision allows us to identify the level of applications of production management in a determinate place, i.e. the production management dimension. Thus, for instance, the study dimension can address the entire organization (e.g. PATTERSON, 2010; TEKIN; EROL, 2017) or a specific activity or department (e.g. BEAZOGLOU et al., 2012a; JONKER et al., 2011), or neither of them, which in this case will be classified as generic (e.g. CONRAD et al., 2010; HILL et al., 2017).

Dental service provision: conceptualization

As mentioned, dental service provision, as well as other industry or service segments, also needs a physical setting, i.e. an installation prepared and structured for the activity to occur (SLACK; BRANDON-JONES; JOHNSTON, 2015). Such places are predominantly hospitals, ambulatories,

clinics, and offices (CFO, 2005; IBGE, 2000, 2010; SÃO PAULO, 1999).

Slack, Brandon-Jones, and Johnston (2015) clarify the various existing forms of production function. They also clarify the possible name variations to define the one who is responsible for the operations of an organization. In the case of dental establishments, *administrative manager* is understood as the most applicable name.

In Brazil, provision of dental assistance takes place through different ways, such as SUS (BRASIL, 1988, 2004; MATOS et al., 2002), which is a result of the public initiative provided by law (BRASIL, 1988), or through private initiatives (BRASIL, 1998). The latter is carried out by private dental clinics, which are legal entities with profit motives (BRASIL, 1998; PRASAD; VARATHARAJAN, 2011; SORIA; BORDIN; COSTA FILHO, 2002). Additionally, there are also the clinics associated with syndicates (AGÊNCIA NACIONAL DE SAÚDE SUPLEMENTAR [ANS], 2006; NERY-DA-SILVA et al., 2019; PIETROBON et al., 2008) and university dental clinics (ELGEZAWI et al., 2017; MARTINS et al., 2016; ZILLI et al., 2017).

All these kinds of clinics are options for people to look for oral health assistance. In this sense, such clinics suffer competition between one another, which means they have to dedicate their efforts to ensuring that their services will be looked, and more than that, to ensuring that their services will be provided and carried out efficiently and effectively (NERY-DA-SILVA et al., 2019).

Organizing framework: matrix relation between study dimension and setting

Having presented the production management dimensions, as well as the types of dental installations and modalities a study may address, a two-dimensional matrix can be created in order to cross production management and study setting (Table 2). Such a cross will determine the state of knowledge regarding the intersection between the two disciplines, allowing us to understand how broadly or how narrowly it extends. Indeed, we tried to cover a wide range of varieties on both the *x*-axis and *y*-axis by basing on the literature and the law, trying at the same time to keep a broader group where the studies could belong because of their similarities. However, a modality or dimension other than the ones included in the matrix in Table 2 could undoubtedly exist, so both the last row and last column of the matrix were reserved for such situations. Table 2 is a framework for classification purposes, then.

Table 2 - Organizing framework: Matrix relation of production management dimension versus study setting

		Study setting			
		(Public/Private/University) Dental Clinic	(Public/Private/University) Dental Centre	(Public/Private/University) Dental Hospital	Others
Study dimension	The entire organization				
	Specific department or treatment				
	Specific function or activity				
	Analysis of general data (generic)				

RESULTS

Studies included in the systematic literature review, years when they were published, and countries where they were conducted.

Altogether, 17 peer-reviewed scientific articles corresponded to the research criteria. Table 3 shows the articles included in the systematic literature review.

Table 3 - Studies included in the present literature review

No.	Author(s)	Title	Journal	Year
1	Chacon, Chacon, and Berrios	Productivity in the Emergency Medical-Dental Services at Public Universities	Revista de Ciencias Sociales	2010
2	Conrad et al.	Estimating Determinants of Dentist Productivity: New Evidence	Journal of Public Health Dentistry	2010
3	Patterson	Patient and Provider Population Dynamics Analysis in a Large Dental Organization-A Tool for Management	Military Medicine	2010
4	Jonker et al.	Mechanical exposure among general practice dentists in Sweden and possible implications of rationalization	Ergonomics	2011
5	Beazoglou et al. (2012a)	Expanded Function Allied Dental Personnel and Dental Practice Productivity and Efficiency	Journal of Dental Education	2012
6	Beazoglou et al. (2012b)	Impact of Dental Therapists on Productivity and Finances: II. Federally Qualified Health Centers	Journal of Dental Education	2012
7	Tuominen, Eriksson, and Vahlberg	Private dentists assess treatment required as more extensive, demanding and costly, than public sector dentists	Community Dentistry and Oral Epidemiology	2012
8	Jonker et al.	Rationalization in public dental care – impact on clinical work tasks and mechanical exposure for dentists – a prospective study	Ergonomics	2013
9	Jurasic et al.	Leading determinants of efficient dental care delivery	Journal of Public Health Dentistry	2013
10	Rolander et al.	Working conditions, health and productivity among dentists in Swedish public dental care - a prospective study during a 5-year period of rationalization	Ergonomics	2013
11	Ahmed and Amagoh	Process analysis and capacity utilization in a dental clinic in Kazakhstan	Competitiveness Review	2014
12	Gutacker et al.	The determinants of dentists' productivity and the measurement of output	Social Science & Medicine	2015
13	Brocklehurst et al.	Determining the optimal model for role substitution in NHS dental services in the UK: a mixed-methods study	Health Services and Delivery Research	2016
14	Robinson et al.	Improving a Dental School's Clinic Operations Using Lean Process Improvement	Journal of Dental Education	2016
15	Arevalo et al.	An Analysis of Pediatric Dentistry Residents' Productivity in the Operating Room	Pediatric Dentistry	2017
16	Hill et al.	Productive efficiency and its determinants in the Community Dental Service in the north-west of England	Community Dental Health	2017
17	Tekin and Erol	The Internal and External Customer Focused Process Improvement and the Performance Analysis Studies in Healthcare Systems	Journal of Industrial Engineering and Management	2017

Although the periodical constraint had included the years 2008, 2009 and 2018, no article related to the research topic was found in any of these years. The years 2012-2013 stand out as being the ones when most of the studies on the theme were published (Figure 2). Overall, the data show an average of 1.5 studies per year.

Figure 2 - No. of articles found in the database from 2008 to August 2018

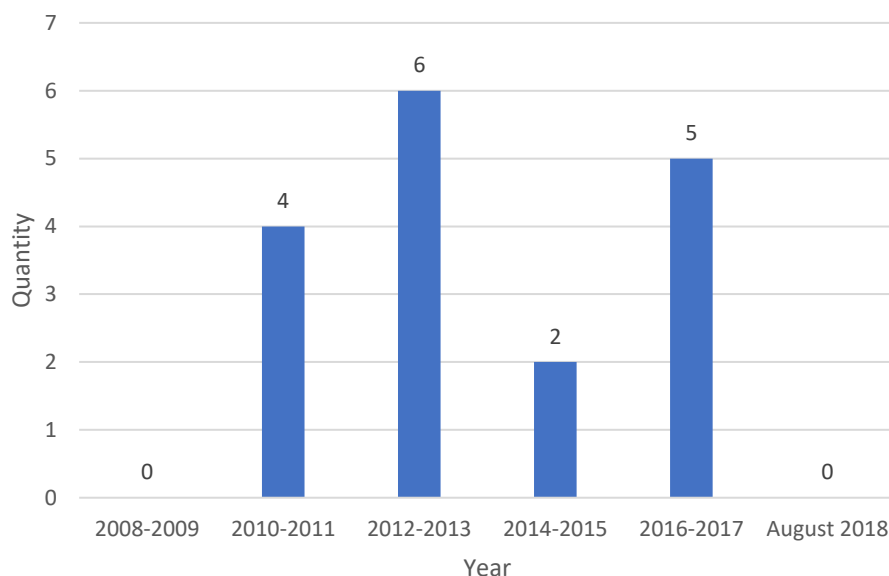
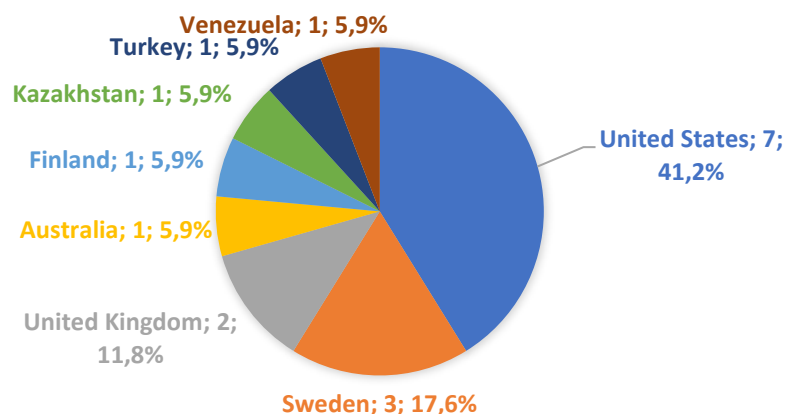


Figure 3 shows the countries where the studies were conducted. The predominance of studies is in the United States (41.2%), Sweden (17.6%) and the United Kingdom (11.8%). Australia, Finland, Kazakhstan, Turkey and Venezuela produced 5.9% of the studies each.

Figure 3 - Countries where the studies were conducted and the proportion of each country



Journals ranking

The three journals that published the most on the theme (47%) were the following: Ergonomics, classified as Industrial Engineering; Journal of Dental Education, classified as Dentistry, Oral Surgery & Medicine; and Journal of Public Health, classified as Dentistry, Oral Surgery & Medicine and Public Environmental & Occupational Health (Tables 4 and 5). Such classifications are based on the 2017 Journal Citation Reports® of the InCites™ Journal Citation Reports® database (CLARIVATE ANALYTICS, 2018) and on the Qualis-Periódicos of (PLATAFORMA SUCUPIRA, 2019). Of all journals, 26.32% are classified in the Dentistry, Oral Surgery & Medicine category (Table 5). Being most of the journals classified in health disciplines corroborates the fact that the intersecting literature of Production Management and Dentistry does exist.

Table 4 - Sources of the articles examined

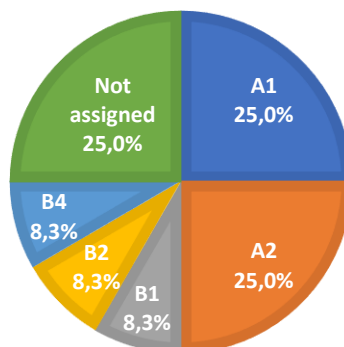
Source	No. of articles
Journal of Dental Education	3
Ergonomics	3
Journal of Public Health Dentistry	2
<i>Revista de Ciências Sociais</i>	1
Journal of Industrial Engineering and Management	1
Competitiveness Review	1
Community Dental Health	1
Pediatric Dentistry	1
Community Dentistry and Oral Epidemiology	1
Military Medicine	1
Health Services and Delivery Research	1
Social Science & Medicine	1

Table 5 - Examined articles according to the journal disciplines

Discipline	Quantity	Percentage
Dentistry, Oral Surgery & Medicine	5	26.32%
Public Environmental & Occupational Health	3	15.79%
Economics	2	10.53%
Administration	1	5.26%
Business	1	5.26%
Business, Management and Accounting	1	5.26%
Industrial Engineering	1	5.26%
Medicine, General & Internal	1	5.26%
Pediatrics	1	5.26%
Psychology	1	5.26%
Strategy and Management	1	5.26%
Not indicated	1	5.26%

Regarding the ranking of the journals, their average IF is 1.49 ± 0.84 (mean \pm SD, $n = 9$). Of them, 25% do not have IF available in the 2017 Journal Impact Factors® list and therefore were not considered for calculation. About Qualis-Periódicos, half of the journals score from Qualis A1 or A2 (50%) to Qualis B4 at minimum, and 25% of them are not assigned to any Qualis (Figure 4). Overall, the data suggest the studies are high quality.

Figure 4 – Proportion of quality of the scientific journals according to Qualis-Periódicos



Studies ranking

The findings can be classified into four main dimensions, which are as follows: the entire organization (23.5%); specific department or treatment (11.8%); specific function or activity (23.5%); or analysis of general data (41.2%). By basing on the definitions provided by law (BRASIL, 1988, 1998, 2004), the installations to provide oral health assistance were classified into the following three main sectors: public, private, and university. Three types of dental installation were identified: clinic, center, and hospital. These classifications allow us to determine the state of knowledge regarding the management dimension and type of organization studied, i.e. the dental service provision installation. Table 6 shows the matrix relation between study dimension and study setting.

Table 6 - Matrix of study dimension versus study setting

		Study setting											
		Public Dental Clinic	Private Dental Clinic	University Dental Clinic	Public Dental Centre	Private Dental Centre	University Dental Centre	Public Dental Hospital	Private Dental Hospital	University Dental Hospital	Mixed, general or not specified ones		
Study dimension	The entire organization	2		1							1	4	Total
	Specific department or treatment							1		1		2	
	Specific function or activity	1						1			2	4	
	Analysis of general data	1	1		1						4	7	
		4	1	1	1	0	0	2	0	1	7		
		Total											

Different from what we expected, few studies have been conducted in private clinics. A large gap in all areas can still be filled, as shown in Table 6. Dental centers and dental hospitals stand out as needing more studies, so do university dental centers. Therefore, any study conducted in any of them could likely be a novel one, at least if we consider only the periodical constraint.

The examined articles also resemble one another as to the method of data collection, which are as follows: empirical (29.4%); questionnaire or interview (35.3%); and analysis of secondary data (35.3%). Figure 5 shows the matrix relation between method of data collection and study design/approach.

Figure 5 - Matrix of method of data collection versus study design and/or approach.

Method of data collection	Empirical	<ul style="list-style-type: none"> • 120 days following all processes of a hospital, carrying out process mapping, simulations and interventions • Five days collecting data at dental clinics to verify, through regression statistics, the dentist's influence on productivity • Lean process application at a university dental clinic supported by monitoring, management, interventions, measurement and questionnaires for 90 days • Statistical inference of dentist's activities that add value (through recordings and inclinometer) • Following the clinic's routine: process mapping and line balancing
	Questionnaire or Interview	<ul style="list-style-type: none"> • Perception of doctors regarding the use of resources • Regression analysis of the influence of variables on productivity • Descriptive statistics of clinics that practice Expanded Function Allied Dental Personnel and the influence of such a practice on productivity • Verification of the proportion of the practice of role substitution in NHS and its correlations • Statistical inference of VAW and non-VAW while the dentist is working • Statistical inference of the effect of rationalization on productivity and on other variables
	Analysis of secondary data	<ul style="list-style-type: none"> • Three ways to measure output based on longitudinal data from LSDPA • Economic and productivity analysis of data from FQHC • Data envelopment analysis and regression statistics of data from CDS • Statistical analysis of the dental services system database of the city of Turku • Descriptive analysis (univariate and bivariate) and regression statistics of data provided by the Dental Department of VA • Descriptive, multivariate and regression statistics of retrospective data from NCH

NHS: National Health Service; **VAW:** Value-adding working; **LSDPA:** Longitudinal Study of Dentists' Practice Activity; **FQHC:** Federally Qualified Health Center; **CDS:** Community Dental Service; **VA:** Veterans Affairs; **NCH:** Nicklaus Children's Hospital

Terms word cloud

The word cloud has evinced the predominance of terms, indicating the questions more often mentioned. As shown in Figure 6, the words “dental” and “productivity” are the most mentioned and used. Both words may be considered the main descriptors of the intersection between production management and dentistry. Other words often mentioned are: “service”, “dentist(s)”, “function”, and “treatment”. Such subjects seem to be prior concerns in current academics’ agendas.

Figure 6 - Terms word cloud created from the studies' titles, abstracts and keywords



DISCUSSION

This research aimed to gather studies on production management in the context of dental service provision and has demonstrated that such intersecting literature is incipient as few studies were published

on the theme during the period considered. It also provides a structured overview of the intersection of the two disciplines that allows one to have a picture of the current situation in such an interdisciplinary topic. As far as we can tell, this is the first literature review on production management in dental service provision.

According to our findings, the priority concern of the analyzed studies is over investigating correlations between establishments' resources and the generated outputs (e.g. CONRAD et al., 2010; PATTERSON, 2010; HILL et al., 2017), which is a common way to check what variables interact with productivity and influence it more strongly. Naturally, empirical studies tend to try to solve specific problems of specific ongoing situations (e.g. AHMED; AMAGOH, 2014; ROBINSON et al., 2016; TEKIN; EROL, 2017), whereas the other approaches tend to investigate whether what has been practiced in dentistry so far is being satisfactorily done or whether there might be a better way to do it (e.g. BEAZOGLU et al., 2012a; JONKER et al., 2013; JURASIC et al., 2013; ROLANDER et al., 2013; TUOMINEN et al., 2012).

Current status of the existing literature on Production Management in Dental Service Provision

With the variables, the existing literature and current research gaps can be identified, thus *RQI* can be addressed.

As expected, patient treatment is what demands time the most and influences productivity the most, together with dentists' working time (CONRAD et al., 2010; BROCKLEHURST et al., 2016; GUTACKER et al., 2015; JONKER et al., 2011). This indicates that both variables require priority when managing dental establishments, planning, or making decisions. Academics and practitioners may benefit from this information.

The use of non-dentist function (personnel) to comprise and support dental teams seems not to be clear whether it has positive or negative impacts on the system since a study argues that there are benefits of using it (BEAZOGLU et al., 2012a), whereas another one published by the same authors says the opposite (BEAZOGLU et al., 2012b). In addition to this, a third study is concerned with the impact, effects and usefulness of such personnel, suggesting that they can be useful provided they are strategically led and their function is not deviated (BROCKLEHURST et al., 2016).

Goldratt and Cox's (2014) axiom seems still to hold true with respect to optimizing a part of a system does not optimize the whole system (PATTERSON, 2010). In an age where everything directs toward integration, teamworking, and automation, being aware of and reminded about this condition remains a decisive key to strategizing, running an organization, or making decisions.

Although the results have given us a picture of the current status of such intersecting literature, they should be considered partial as we have not addressed the *Operations* part of OPM. In fact, since dental service provision fits in the service segment rather than in industry, a literature review on operations management in dentistry could provide even more insights into the field. To give one an idea of it, the word cloud shown in Figure 6 does not carry the word "Operation(s)". Therefore, we hypothesize that a large part of the descriptors used in our research belongs particularly, or at least predominantly, to the *Production* part of OPM in dentistry and thus we argue that a literature review on operations management is necessary. This is indeed part of our project, as we mentioned in the introduction.

This research contributes to the field by providing more information on how management practices, productivity analyses, and similar concerns in dentistry have been. The results can be added to prior studies such as O'Connell and Griffin (2011), Tonmukayakul et al. (2015), Mohd-Dom et al. (2014), and Hettiarachchi et al. (2018) to help form a solid knowledge on the theme.

Possible areas for future research on Production Management in Dental Service Provision

The answer to *RQ2* can be addressed as follows. Firstly, as far as production management is concerned, there is a lack of studies addressing private dental center, private dental hospital, and university dental center, as shown in Table 6.

Despite the studies investigating non-dental function (personnel)'s effects (BEAZOGLOU et al., 2012a, 2012b; BROCKLEHURST et al., 2016), such a small number of studies is not enough to reach any conclusion about it yet, so more studies on the topic are necessary.

Different types of output measurements need to be investigated for better accuracy. Conrad et al. (2010) urge academics and practitioners to measure output by taking into account the contribution to oral health, instead of measuring it per patient visit. The authors argue that other production models need to be developed in order to better measure variables such as workers' skill level, utilization of dental technology, and patient mix (demography and oral health). Interestingly, Jurasic et al. (2013) analyzed productivity rate by using relative value units¹ (RVUs) and calculated them based on time and complexity, not on costs. So, interesting findings could likely be found if future research combines what both studies suggest. In fact, Jurasic, et al. (2013) did use some Conrad et al.'s (2010) variables in their study, which means some connections between the studies are possible and true. Besides, Arevalo et al. (2017) showed that RVUs are more appropriate to indicate complexity.

Notwithstanding, Gutacker et al. (2015) have also given their contribution to this point by comparing three different types of output measures and showing different utilities of each depending on what one is seeking. So, be it a combination of all or a completely novel method, other output measures offering better accuracy will certainly be relevant for the field.

CONCLUSION

Patient treatment and dentist's working time are what demand time the most and influence productivity the most as well. Productivity is commonly measured per patient seen or treatment delivered. However, there is no consensus among scholars and academics on what type of output measurement is better, and some argue that variables such as treatment complexity should be taken into account for a more qualitative and accurate measurement.

Dental management is an incipient field and there is still a long way to go, which makes it fertile for breakthroughs and relevant for future agenda.

We hope the information surveyed in this systematic literature review can contribute to the understanding of the current status of the intersecting literature of production management and dentistry.

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¹RVUs seek to estimate the relative amount of doctors' work that contributes to the service they provide. The definition of average work takes into account the doctors' time, their mental efforts, judgment, technical skills, physical efforts and psychological stress.

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