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"CAROL DAVILA" FROM BUCHAREST

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DENTAL MEDICINE FIELD

"THE DENTAL DOCTOR-PATIENT RELATIONSHIP DURING AN EPIDEMIC/PANDEMIC"

SUMMARY OF THE DOCTORAL THESIS

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"Progress is impossible without change,

and those who cannot change their thinking,

cannot change anything."

George Bernard Shaw

Introduction

Change has always been one of the driving forces of human evolution. From environmental adaptation to social and technological transformations, the ability to change and innovate has driven the progress of civilization. Throughout history, some changes have occurred gradually, but others have been catalyzed by sudden and disruptive events.

An example of a transformative crisis is the Industrial Revolution. In the late 18th and early 19th centuries, this period fundamentally changed the way people lived. Although it initially caused social tensions, rapid urbanization, and uncertainty for traditional craftsmen, in the long run the Industrial Revolution generated remarkable technological advances, leading to improved quality of life and wider access to resources for the population. In the face of great challenges, society has always demonstrated its capacity to adapt and reinvent itself.

Similarly, major health crises – pandemics – although initially met with fear, have over time spurred the development of medical knowledge and public health measures that have saved countless lives.

A contemporary example of disruptive change is the Covid-19 pandemic, a global crisis without precedent in the modern era. In the healthcare sector, the effects have been particularly pronounced, questioning the traditional paradigm of the doctor-patient relationship, as well as the ways in which medical services are delivered. Thus, the pandemic has contributed, similar to the industrial revolution, to a radical transformation and an exponential acceleration of the adoption of digital technologies, marking the beginning of a digital revolution in healthcare and in all aspects of contemporary life.

Dentistry, an integral part of the healthcare system, has felt these changes strongly. Managers and teams in dental practices have had to apply *change management principles* to rethink their objectives and strategies, which in order to generate progress, subsequently had to be transformed into principles and competencies specific to an organizational culture.

In this context, the need for a detailed analysis of how the pandemic influenced the financial performance of dental practices is undeniable. The topic of the thesis *" THE DENTAL DOCTOR-PATIENT RELATIONSHIP DURING AN EPIDEMIC/PANDEMIC "* is particularly relevant, as it allows an understanding of the coping mechanisms that led to both initial financial downturns and subsequent economic recovery in post-pandemic conditions. After the pandemic, dental practices

understood the paradigm shift and adopted elements of change management, emphasizing growth through effectiveness, efficiency and digitalization, in contrast to the pre-pandemic period, where the focus was on growth through expansion.

The importance of this study is underlined by the financial indicators analyzed (turnover, number of employees, profit, expenses, debts), which are essential for assessing the economic resilience of dental practices, and by the analysis of these parameters in three distinct periods (prepandemic , pandemic and postpandemic), which provides insight on the real impact of the crisis generated by Covid-19. The study brings a new perspective both by analyzing the impact of the Covid-19 pandemic on the financial aspects of dental practices in Bucharest, but also by developing new financial indicators, the T/E ratio (a turnover / number of employees ratio) and the DPRI (dental practice risk index), a topic unexplored until now in the dental state of the art literature. The timeliness of the topic is emphasized by the continuing need to adapt healthcare services to pandemic challenges and the importance of improving the quality of interactions between doctors and patients under conditions of increased risk.

The research hypothesis argues that the Covid-19 pandemic affected the dental sector economically, causing imbalances on financial indicators through initial declines, but also the opportunity for recovery in the post-pandemic period.

To achieve the proposed objective, the doctoral thesis is structured as follows:

I. ***The General Part*** presents an analysis of current state of the art on the research topics and consists of three chapters

II. ***The Special Part*** includes personal contributions to the research topic and is structured into seven chapters.

GENERAL PART – CURRENT STATE OF THE ART

Chapter 1, entitled ***"The Doctor-Patient Relationship in the Healthcare System and the Covid-19 Pandemic in Dentistry",*** presents a brief history of pandemics and epidemics over time, with a focus on the influence that pandemics have on the healthcare system and the economic implications. This chapter presents the doctor-patient relationship, the core element of the healthcare system, in the context of the Covid-19 pandemic and refers to factors that can influence this relationship. The chapter concludes with a national and international perspective on the Covid-

19 pandemic from the point of view of the changes that have occurred, preparing the next chapter that presents change management.

Chapter 2 entitled ***"Change management in the context of the Covid-19 pandemic "*** presents change management in dental practices in the context of Covid-19 pandemic. Management and leadership concepts are explained, emphasizing the importance of a clear vision, strategies and shared values for effective implementation of change. The pandemic prompted practices to adopt stringent safety measures, digitization and team management and patient resistance to change. The chapter continues with elements of the learning curve describing the steps taken by medical doctors in adapting to the new paradigm, highlighting the need for leadership and organizational culture. The chapter concludes with the acceptance of change, which involves medical doctors, patients, and the health care system, with the success depending on active collaboration among them and effective leadership to transform the vision into concrete results.

Chapter 3 entitled ***"Financial indicators",*** emphasizes the importance of financial indicators in dental practice management. This chapter presents five key indicators: turnover, profit, expenditure, debts and number of employees, that are analyzed in the special section part. In the context of the financial vulnerabilities generated by the pandemic, the impact that these indicators have on the doctor-patient relationship is presented. The chapter emphasizes the interdependence of these indicators and the importance of considering them as a whole and how they influence each other in the face of major changes. Thus, effective financial management becomes an essential tool for the resilience of dental practices in times of crisis.

SPECIAL PART – PERSONAL CONTRIBUTIONS

Chapter 4 presents the general objective of the thesis, which is to analyze the influence of the Covid-19 pandemic on dental offices in Bucharest, Romania through four ***research directions***:

- Study I - determination of the relevant financial parameters that were analyzed to determine the resilience of dental practices
- Study II – comparative analysis of financial indicators between the prepandemic /pandemic/ postpandemic periods and the effects on the doctor-patient relationship
- Study III – comparative analysis of financial indicators between dental practices according to the number of employees and the effects on the doctor-patient relationship

- Study IV – development of new financial indicators for analyzing the performance of dental practices.

The objective of this study is to understand the parameters that helped some dental practices withstand the effects of the pandemic and what made them more resilient in the face of this type of crisis. Through interpretations of the financial performance of dental practices observed in this study, future strategies will be provided to increase economic resilience in the event that crises similar to the Covid-19 pandemic re-emerge.

Working hypothesis - given that over time pandemic crises have affected society in all areas, the working hypothesis of this thesis argues that the Covid-19 pandemic has affected the Romanian dental sector from an economic point of view, causing imbalances in key financial indicators (turnover, profit, expenses, debts, number of employees).

Chapter 5 presents the general research methodology, which in order to be able to have a holistic perception of the topic, a research methodology has been approached in this study that focuses on collecting and analyzing numerical data in order to be able to identify patterns, relationships, trends.

Chapter 6 Study I – Establishing relevant financial parameters to determine the resilience of dental practices in a pandemic

6.1 Introduction

In December 2019, a new coronavirus emerged in China, an event that culminated in the declaration of the Covid-19 pandemic in March 2020. The virus is transmitted mainly through Flügge droplets released during coughing or sneezing, and the risk of contamination led to widespread closures of dental practices in 2020. The pandemic disrupted face-to-face dentist-patient consultations, leading to increased time between treatments and the introduction of online consultations, which added both emotional and economic stress. In Romania, the state of emergency started in March 2020 and led to the closure of dental practices, with some dental practices remaining open for emergencies.

Financial indicators such as turnover, profit, debts, number of employees and expenses are essential for assessing the resilience of an economic agent, in this case a dental practice, during periods of economic stress.

In Study I we answer the research question: which are the most relevant financial parameters to evaluate for a dental practice in a crisis situation and what are the vulnerability thresholds for these parameters.

6.2 Materials and Methods

In Study I, we started from the collected data and wanted to observe what were the causes of the closure, in the pandemic year 2020, of dental offices active in 2019. We also wanted to observe what were the financial causes for the closure of some dental offices in the post-pandemic year 2021, at the level of dental offices that were active in the pandemic year 2020.

Five financial indicators were analyzed: *Turnover, Profit, Expenses, Debts and Number of Employees,* which will be presented one by one in the results section.

6.3 Results

To determine the financial indicators and their relevance, as well as the vulnerability thresholds for each parameter, in relation to the resilience of dental offices, we started this analysis from public data on the website of the Ministry of Finance of Romania.

This subchapter presents the analysis of financial data for dental practices active in 2019 but closed in 2020 and the analysis of financial data for dental practices active in 2020 but closed in 2021. The results from all studies are presented in the form of pie diagrams.

6.4 Discussions

Analyzing the financial data of the dental practices that closed during the pandemic period in 2020 and then in the post-pandemic period in 2021, we can conclude that these analyzed financial indicators, Turnover, Profit, Expenses, Debts and Number of employees, had a direct influence on each other, creating a chain effect. The pandemic was a turning point, and practices reacted differently depending on whether they were prepared or not in terms of financial management and acceptance of change. These findings are echoed in other research in the literature which shows that only a small proportion of dental practices were financially resilient to a pandemic

Dental practices that closed in both 2020 and 2021 had a low **turnover** (under 100.000 RON/year). These were financially vulnerable and prone to closure due to insufficient revenues and additional expenses.

Dental practices with low **profit** or at a loss, did not have sufficient financial reserves to adapt quickly to the pandemic and were unable to invest in protective equipment or digitization, a

fact also confirmed in the literature. About half of the practices closed in 2020 and then in 2021 had a losses or low profits.

Expenses reduced are an indicator of insufficient investment in modernization and adaptation. Thus, the new costs imposed by the pandemic have accentuated the financial vulnerability of these financial practices and increased their risk of closure.

A low **debt** level may indicate a lack of major investment in dental practice development. Also, the lack of investment to adapt to change in the pandemic year 2020 became even more evident in 2021, when patients started to shift to practices that offered increased safety and services better adapted to the new conditions.

Finally, **the number of employees** complement the interdependence of these indicators. Small practices with fewer employees (less than three) were the most vulnerable. The low number of employees may suggest a fragile internal organizational structure with limited capacity to adapt quickly to change.

6.5 Conclusions

From a change management perspective, those dental practices that had a response plan and understood that change was inevitable and embraced it, that were able to apply specific elements of change management, were the most resilient. In contrast, practices that were financially and organizationally unprepared were caught in a vicious circle. Low turnover led to low profits, low profits to lack of investment, and lack of investment in inability to adapt quickly. This chain reaction led to the closure of these practices. In contrast, practices that already had sound financial management practices in place and quickly adopted change management through efficiencies such as going digital or improving health protocols, were able to weather the critical period and even emerge stronger from the crisis.

In conclusion, financial indicators are interconnected and influence each other. The resilience and sustainability of a dental practice can only be achieved if the management understands the link between these financial indicators and according to their trends applies proactive measures for efficiency and growth in order to be prepared for a new crisis.

As a result of analyzing this chapter, we have extracted certain limits for financial indicators, limits that show the vulnerability of a dental practice. Among them, we will mention the limits of turnover and number of employees, limits of financial indicators that we will use in the following studies:

- Turnover: vulnerability limit – turnover less than 100,000 RON/year
- Number of employees: - vulnerability limit – number of employees less than 3 employees

This study shows that the proposed parameters, *Turnover, Profit, Expenses, Debts and Number of Employees* are relevant to determine the resilience of a dental office in a crisis such as the Covid-19 one. Therefore, these parameters will be analyzed in future studies as a measure of resilience and vulnerabilities in such a pandemic crisis.

Chapter 7 Study II – comparative analysis of financial indicators between the prepandemic /pandemic/ postpandemic periods and the effects on the doctor-patient relationship

7.1 Introduction

In this study, starting from the relevant financial indicators established in study I in Chapter 6, *Turnover, Profit, Expenses, Debts and Number of Employees*, we will analyze these financial indicators between the prepandemic /pandemic / postpandemic periods (years 2019/2020/2021) and the effects on the doctor-patient relationship.

7.2 Materials and methods

Statistical analysis was performed using IBM SPSS Statistics 25 and data visualization was performed with Microsoft Office Excel 2013. Variables were categorized as quantitative or qualitative; qualitative data were presented as frequencies or percentages, and quantitative data were subjected to the Shapiro-Wilk normality test. Results were presented as mean ± standard deviation or median with interquartile range, depending on the data distribution. Friedman and post-hoc Dunn-Bonferroni tests were used to analyze groups by time, and the Mann-Whitney U test was applied to independent groups. In situations with large data dispersion, box-plot representations were rescaled for better interpretation. The statistical significance threshold was set at $p < 0.05$..

7.3 Results

This subchapter presents general data of the analyzed dental practices and the comparison of the analyzed financial indicators between the pre-pandemic /pandemic/ post-pandemic periods

7.4 Discussions

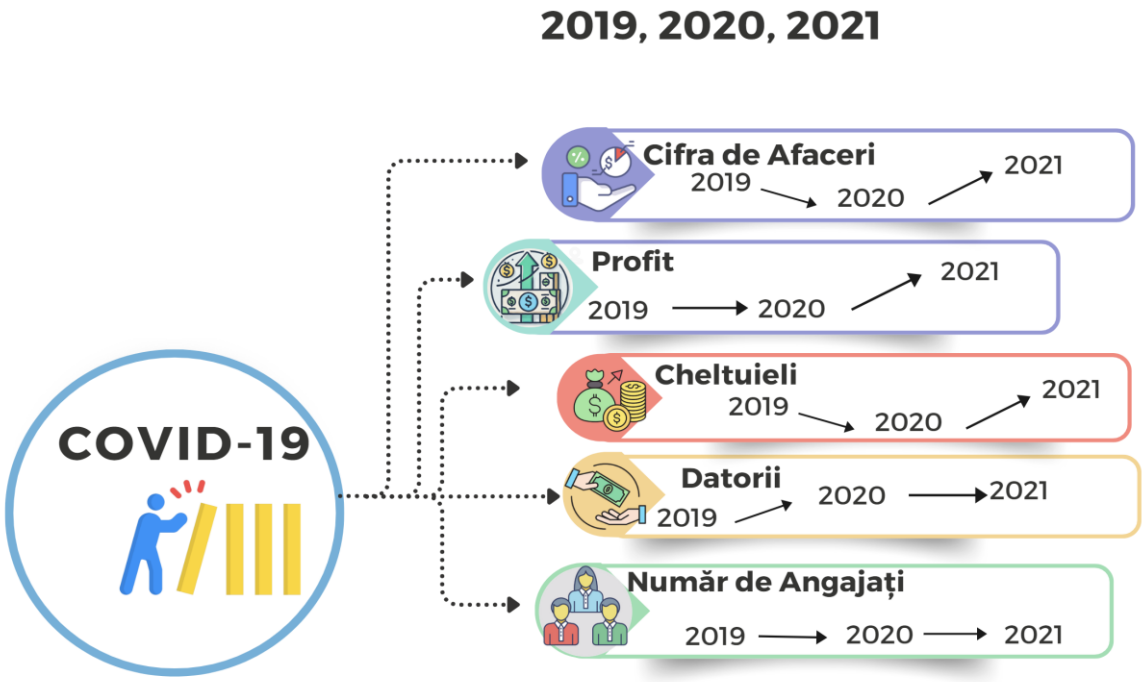

Figure 7.6 Effects of the Covid-19 Pandemic on the analyzed financial indicators

The Covid-19 pandemic has been a watershed moment for dental practices, significantly impacting the way they operate and manage resources. Figure 7.6 graphically summarizes the results of this chapter and the effects of the pandemic on the financial indicators analyzed, *Turnover, Profit, Expenses, Debts and Number of Employees*, for the years 2019, 2020 and 2021. A decrease in financial indicators *(turnover, expenses)* is noted from 2019 to 2020, followed by a major increase in 2021. Profits do not have major differences from 2019 to 2020, but has a large increase in 2021. Debts increase from 2019 to 2020, to remain constant in 2021, and the number of employees remains constant over the three years analyzed. These findings are also supported by the literature which shows the significant recovery of dental practices financially in the post-pandemic period.

Turnover of dental practices decreased in 2020, reflecting the initial adaptation of practices to the pandemic context. Turnover increased significantly in 2021 due to effective management strategies, digitization and investment in safety and quality of service, building patient confidence and ensuring practices thrive in the post-pandemic period.

Next the ***profit*** was analyzed, and we observe that it remained stable in 2020 due to the reduction in expenses. Maintaining profit levels constant, but without an increase in turnover, means a limitation in investments for adaptation. However, in 2021, profit increased significantly, reflecting the benefits of rapid adaptation, digitization implementation and process streamlining, demonstrating the importance of change management in capitalizing on the opportunities that have emerged in the post-pandemic setting.

According to Figure 7.6, ***the expenses*** of private practices have decreased in 2020 thanks to the cost's control, but they have increased significant in through strategic investments in technology and safety measures, reflecting a development of practices to strengthen patient trust, and directly associated with better financial outcomes for practices that implemented efficiencies.

In 2020, dental practices have accumulated additional **debts** to overcome the initial shock of the pandemic, but in 2021 they stabilized, indicating prudent and responsible financial management, strategic investments in modernization and digitalization to regain patients.

The number of employees remained constant in all three periods, but practices have optimized these resources through digitalization and internal reorganization, achieving financial increases without additional hiring, demonstrating the effectiveness of change management.

As we see in the study, the dentist was already in the context of defensive medical practice, and the Covid-19 pandemic only amplified the anxieties about possible medical errors that the dentist already had, contributing to the growth of existing defensive medical practices. The fear of malpractice coupled with the pandemic context led physicians to adopt excessive preventive behaviors to protect themselves legally and reputationally in addition to virus protection. Social distancing measures and the extensive use of protective equipment have reduced direct interaction and made communication between doctors and patients more difficult. This phenomenon of defensive practice has been aggravated by the additional uncertainties and pressures generated by the Covid-19 crisis, negatively affecting both doctors' professional performance and their relationship with patients.

7.5 Conclusions

Another important aspect is the impact that these economic changes have had on the doctor-patient relationship.

After the experience of the pandemic year, many doctors have become aware that closeness to patients and their active involvement in their care are decisive for maintaining and increasing

the performance of their own practices. Patients have also better understood that dental problems left unresolved in time can worsen and regular visits to the doctor are essential for oral health.

During the pandemic, the doctor-patient relationship underwent radical changes. Patients' fear and uncertainty about the risk of infection led to an emotional and physical distancing from dental surgeries and the dentist. The low number of face-to-face consultations and limited human contact have profoundly influenced the quality of the doctor-patient relationship. Successful dental practices have been those that have effectively managed this radical change by developing digital communication systems and online patient monitoring, strategies that have come with increased costs. These practices have maintained the trust and loyalty of patients through transparency, frequent communication and solutions tailored to their needs for safety and comfort.

On the other hand, practices that failed to implement these changes quickly and did not understand the need for new strategies, lost contact with patients and experienced a decline in activity. In these practices, patients' fear and uncertainty were not effectively addressed, leading to a decline in the number of consultations and, consequently, in turnover and profit. This dynamic underlines the importance of the doctor-patient relationship and highlights the direct influence it has on the financial stability and resilience of the dental practice.

The interlinked analysis of financial indicators provides insight into the fact that the resilience of dental practices during the Covid-19 pandemic was directly proportional to their ability to adapt to change. Quickly accepting the need for digitization, optimizing expenses and adapting organizational culture were key to financial success and maintaining a healthy relationship with patients. The adaptation and change strategies resulted in increased turnover and profit for 2021.

Practices that hesitated or were unable to accept the change were caught in a difficult situation where negative financial indicators amplified each other: low turnover led to low profits, low profits limited investment, lack of investment made it impossible to adapt quickly, ultimately leading to low activity.

Comparative analysis of pre-pandemic, pandemic and post-pandemic financial indicators highlights how dental practices were affected by the Covid-19 pandemic. It provides an overview of the transition from growth through expansion characteristic of the 2019, pre-pandemic period to growth through efficiency characteristic of the post-pandemic, 2020 period. The initial negative impact of the pandemic was successfully managed by practices that applied effective change

management principles, invested in digitalization, and rapidly adopted a performance and efficiency-oriented organizational culture. Thus, the pandemic, although initially seen as a major threat, has turned into an opportunity for strategic development, streamlining and improving the doctor-patient relationship, bringing long-term benefits to both practices and patients.

In conclusion, the lesson of the pandemic for dental practices is a valuable one: resilience and success depend largely on acceptance of change, effective change management and an integrated approach to financial indicators. This approach will remain relevant for future challenges, strengthening the doctor-patient relationship and ensuring the long-term sustainability of dental practices.

Chapter 8 Study III – comparative analysis of financial indicators between dental offices depending on the number of employees and the effects on the doctor-patient relationship

8.1 Introduction

In this chapter, study III is developed with the aim of deepening the analysis from the previous chapters and granulating the information, comparatively analyzing the financial indicators of dental practices according to the number of employees. This approach allows the identification of critical thresholds, specific vulnerabilities and, implicitly, a better understanding of how these factors influence the doctor-patient relationship. Considering the connection between the area of financial indicators and the two actors, doctor-patient, the role of the doctor in generating services offered to patients can be observed. The doctor is the one that can satisfy the needs of the patient, thus the pacient will be satisfied and these will translate into an increase in the income.

8.2 Materials and methods

Chapters 5 and 7.2 presented the general framework for the materials and methods chapter, namely the methods of data collection, inclusion/exclusion of data in the study, and statistical analysis. We will not repeat these methods in this chapter.

Performance indicators:

The average number of employees calculated for each practice was ***2.36***. Therefore, the dataset was divided into small and large private practices, based on the average number of employees considered to be ***3***. Furthermore, in Chapter 6 we observed and confirmed the additional

relevance of this numerical threshold, the number of 3 employees proving to be a critical point that significantly influences the ability of dental practices to effectively manage crisis periods and to quickly implement specific change management measures. Thus, this threshold becomes an essential additional benchmark in future assessments of the vulnerability and resilience of dental practices.

8.3 Results

This subchapter presents data related to the dynamics of financial indicators of dental practices with ≤ 3 employees in 2019, analyzed between 2019, 2020, 2021, and data regarding the dynamics of financial indicators of dental practices with > 3 employees in 2019, analyzed between 2019, 2020, 2021.

8.4 Discussions

Figure 8.11 Comparative analysis of the dynamics of financial indicators for small (≤ 3 employees) and large (> 3 employees) dental practices

Figure 8.11 compares the evolution of the differences in the medians of financial indicators *(Turnover, Profit, Expenses, Debts and Number of Employees)* between the periods 2019-2020 and 2020-2021, depending on the size of dental practices (≤ 3 employees and > 3 employees). The comparative analysis of financial indicators reflects clear differences between small and large dental practices, highlighting how each category has managed the Covid-19 pandemic and the post-pandemic period, each having a specific dynamic influenced by size and managerial education. The results of the study are also consistent with other studies conducted in other

countries, for example Denmark, where the size and resources of a clinic have proven to be relevant factors in determining financial resilience.

In Figure 8.11, the comparative analysis of ***turnover*** *is observed*. From 2019-2020, small practices maintained their turnover steadily, while large practices experienced a slight decrease. However, in 2020-2021, large practices rebounded spectacularly due to the rapid implementation of digitalization and streamlining, while small practices had modest increases, reflecting limited adaptation and a less flexible structure to radical change, adopting old strategies of growth through expansion rather than streamlining

As can be seen in Figure 8.11, ***profit*** reflects the same trend observed for turnover. Between 2019-2020, both types of practices maintained relatively constant profits, with a slight increase for small practices and an insignificant decrease for large practices. In 2020-2021 the large practices experienced significant growth, due to strategic financial management and rapid adaptation to the new economic and medical context, in contrast to the small practices, constrained by low resources and insufficient investment in technology.

The comparative analysis of ***expenses*** in Figure 8.11 reflects a similar dynamic to profit and turnover. Between 2019-2020, large practices reduced their spending to tightly control costs and made significant investments in modernization and digitalization between 2020-2021. In the initial period of the pandemic (2019-2020), small practices experienced a relative stagnation in spending. Subsequently, small practices also increased their spending, but at a much lower rate, constrained by reduced financial resources and more difficult access to investment.

Figure 8.11 shows the difference in strategy between the two types of practices in terms of the ***debt indicator***. Between 2019-2020, small practices increased their debt to survive, limiting investment and growth. In contrast, large practices reduced and then stabilized their debt, adopting a balanced financial strategy that allowed them to invest without major long-term risk.

The comparative analysis of ***the number of employees indicator*** in Figure 8.11 reflects major structural differences between the two types of dental practices. Small practices have maintained their staff over the period under analysis, while large practices have significantly reduced the number of employees in 2020, shifting from development through expansion to development through strategic optimization of human resources in the context of the new economic and health and digital conditions.

8.5 Conclusions

According to Figure 8.11, it can be seen that large dental practices performed better in managing the pandemic and the post-pandemic period compared to small practices. They applied advanced change management strategies more quickly and effectively, adopted digitization extensively, and made strategic investments that enabled them to recover quickly and dramatically after the pandemic. Small practices, on the other hand, have had a more limited capacity to adapt and grow through streamlining, due to scarce financial resources and limited access to technology and digitization, reflecting modest results with slower growth and fragile financial stability.

This comparative analysis underlines the importance of understanding the new context created by a crisis. It is very important that the acceptance of change is immediate so that adaptation to the new context can be fast, in order not to miss important starting milestones. Strategic flexibility is also important. All these elements have made the major difference between the modest success of small practices and the much better performance of large practices in the pandemic and post-pandemic period.

The analysis of financial indicators shows a perspective on the dentist-patient relationship that is directly influenced by the complex interrelation of these indicators and the size of dental practices. Rising expenses, low turnover, low profit and legal regulations in the pandemic period have put pressure on small practices, forcing doctors to take measures that have led to an emotional distancing from their patients negatively affecting empathy and mutual trust, thus practices acting reactively rather than proactively.

Large practices, on the other hand, which have managed to implement change more effectively through a strategic vision and a strong organizational culture, have managed to maintain a better relationship with patients by adapting quickly and investing in technology. Although they initially experienced a decreases in their activity, they quickly recovered, managing to meet the new demands of patients, who have become more attentive and demanding. These investments have kept turnover and profitability high. The doctor-patient relationship has thus remained stable, with patients trusting the services offered and perceiving the practices as transparent and professional.

The interconnection of financial indicators (turnover, profit, expenses, debt and number of employees) shows that an adoption of change management can turn crisis into opportunity. The effective implementation of change management, through a clear vision, well-defined strategies

and the promotion of values and competencies that have increased the maturity of the medical team, contributes significantly to increased patient trust in doctors and thus to better financial and relational outcomes. Thus, dental practices that adopt an integrated approach between management and leadership can turn economic challenges into opportunities to improve the doctor-patient relationship, which is essential in today's context.

In conclusion, the results of the study emphasize the important role of financial education of dental practice managers in overcoming the economic difficulties caused by Covid-19. Although large practices experienced a greater financial shock at the beginning, they recovered more quickly, taking advantage of their initial financial reserves. Smaller practices, although less affected in the first phase, did not have the same resilience, again showing the importance of having a management plan in place and implemented. By adopting management strategies and learning lessons learned during the pandemic, dental practices could find ways to be more resilient in the long term.

Chapter 9 Study IV – development of new financial analysis indicators that provide the minimum sustainable value for a dental office

9.1 Introduction

The purpose of this study is to analyze the influence that the Covid-19 pandemic has had on certain economic aspects of the activity of private dental practices in Bucharest, Romania, and to develop two new financial analysis indicators that provide the minimum sustainable value for a dental practice and can determine their resilience.

The first of them is a linear indicator, defined as T/E – a ratio formed by turnover/number of employees (from English - Turnover / Employees**)** .

The second of them is a composite indicator formed by the weighted sum of all the other indicators in the thesis, an indicator that we will call *the Dental Practice Risk Index* (DPRI). For this indicator, a machine learning algorithm was also used to predict the degree of resilience of a dental office before the onset of a crisis like Covid-19.

9.2 Materials and methods – T/E

In addition to the classic financial indicators already mentioned, a new financial indicator was developed, an individual indicator, defined as T/E – a ratio formed by turnover/number of employees (from English - **T** urnover / **E** mployees). The development of the T/E indicator is an aid in evaluating the performance of dental practices, providing a clearer picture of the efficiency of using human resources in generating turnover. The importance of the T/E indicator lies in its ability to provide a detailed picture of employee productivity. In the dental sector, where direct interaction with patients and quality of services are very important, T/E allows identifying the efficiency of the medical team in managing the volume of patients and the dental services provided. A high T/E indicates that each employee contributes to the formation of a high turnover, ultimately determining the financial performance of the dental practice.

The T/E report provides a detailed analysis of the average turnover and the average number of employees within dental practices. The average number of employees was set at 3, and the reason for this choice is detailed in the research section in subchapter 8.2.

The value of 100,000 RON/ employee, established as an average representative for the year 2019, is used for standardization the T/E indicator, facilitating compare performances cabinets regardless of their size and proving importance this numerical threshold in evaluation vulnerability and resilience cabinets dental in periods of crisis.

9.3 Results – T/E

This subchapter presents the analysis of practices with T/E < 100,000 RON/employee in 2019 and the analysis of practices with T/E ≥ 100,000 RON/employee in 2019.

9.4 Discussions – T/E

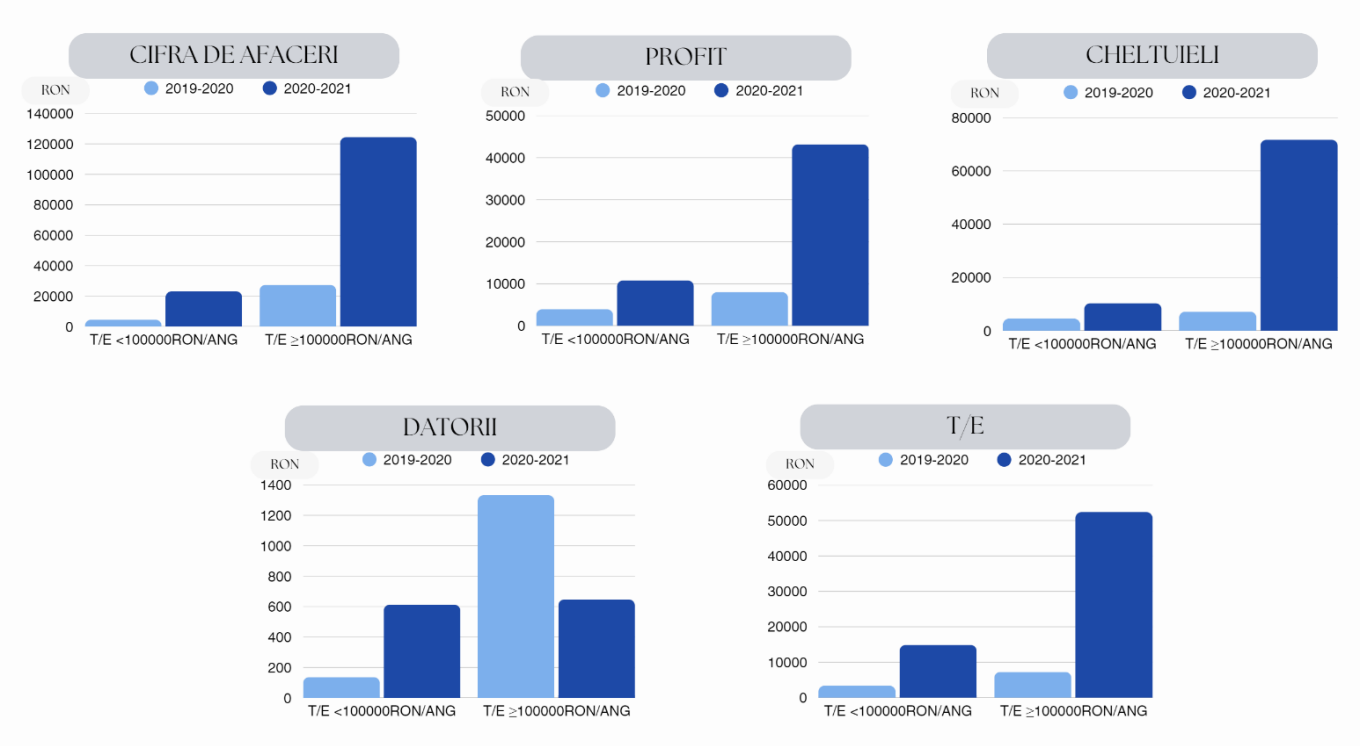

Figure 9.13 Dental practices performance by T/E

Figure 9.13 compares the evolution of the median financial indicators between 2019-2020 and 2020-2021 for dental practices, according to the economic performance measured by the T/E ratio (turnover per employee), showing that higher values of this indicator reflect a more efficient use of human resources and superior economic performance

Analyzing ***turnover***, practices with T/E ≥ 100,000 RON/employee saw a moderate decrease in 2020 compared to 2019, followed by a significant rebound in 2021, demonstrating their ability to adapt quickly by implementing change management and investing in digitalization. In contrast, practices with T/E < 100,000 RON/employee had a much more modest evolution, with stagnation during the pandemic period and limited recovery thereafter, indicating difficulties in adapting to the new economic and digital paradigm.

In terms of ***profit***, the best economically performing practices (T/E ≥ 100,000 RON/employee) maintained relative stability in 2020, followed by substantial growth in 2021, thanks to the fast and efficient implementation of cost reduction strategies and workflow optimization. The less performing firms had a slight increase in profit, but were insufficient for a

strong comeback, reflecting limited managerial capacity in managing resources under crisis conditions.

Expenses analysis highlights the same strategic difference between the two categories: large T/E practices cut costs in 2020 to survive financially, but resumed significant strategic investments in 2021, reflecting the shift from growth through expansion to growth through efficiency. In contrast, small practices had a moderate increase in spending in 2021, suggesting limitations in investment capacity and difficulties in adopting effective change measures.

In terms of ***debts***, we can see that those practices with a high T/E also increased their debt in 2020 to cope with the pandemic pressure and the need for external financing. But in 2021, the debt level decreased, which means that they managed to become more resilient and overcome the impact of the pandemic. Unlike large practices, small practices did not have a large increase in debt, being more conservative in terms of investments and, thus, did not have a long-term development plan.

In the case of the ***T/E indicator***, practices with a higher T/E had a greater decrease in the analyzed indicator in 2020 compared to 2019 but had an increase in this indicator in 2021, which translates into a post-pandemic streamlining of operations and costs per employee. By contrast, those practices that had a lower T/E also recorded a smaller increase in the T/E parameter in 2021, which means that they failed to adapt and implement long-term strategic resilience measures.

9.2 Materials and methods – IRCS

Together with a team of engineers, we wanted to figure out how we could predict, using machine learning algorithms, how resilient a dental practice is before a Covid-19 crisis and what its possible vulnerabilities are.

In this research we have tried to find a way to determine the vulnerabilities and risks of a dental practice before a crisis, based on the interconnectedness of the financial indicators analyzed previously. Thus, the research started by defining a composite indicator, Dental Practice Risk Index (DPRI) and then, we used machine learning algorithms to determine, based on the DPRI of a cabinet in 2019 (pre-pandemic), the estimated IRCS in 2020 (pandemic) and the prediction of failure or success in 2021 (post-pandemic).

The initial stage consisted of processing the raw financial data, collected according to chapter 5.

In order to determine the IRCS, a series of new parameters were derived based on the fundamental parameters: turnover, profit, expenses, debts, number of employees, calculated annually for each firm. These metrics are:

Profit Margin = (Profit / Revenue)* 100 %, ***(9.1)***

Debt / Turnover Ratio = (Debt / Turnover), ***(9.2)***

Turnover / Number of Employees Ratio = (T / E), ***(9.3)***

Cost Efficiency = (Expenses / Turnover) * 100%, ***(9.4)***

Profit per Employee = (Profit / No. of Employees), ***(9.5)***

A central element of this stage was the construction of a composite index called *the Dental Practice Risk Index* (DPRI), presented in formula (9.6).

DPRI = (0.30 * Profit Margin) + (0.25 * Cost Efficiency) + (0.20 * Debt/Turnover) + (0.15 * T/E) + (0.10 * Profit per Employee) ***(9.6)***

Second stage focused on developing a predictive model for forecasting future financial risk quantified by the scaled DPRI. The specific objective was formulated as a regression problem: to predict the scaled DPRI for the target year 2020, using the financial metrics of the previous year (2019) as predictor variables.

In order to understand how financial indicators in a crisis year can predict the future trajectories of dental practices in the event of economic disruptions, we conducted a detailed analysis comparing post-2020 financial performance with pre-2020 baselines. This analysis was conducted separately for dental practices with three or fewer employees and those with more than three employees, using the Covid-19 pandemic of 2020 as a simulated crisis scenario. For the analysis performed, we established specific operational definitions: 'Failure' ('Failure') was defined as a firm whose 2021 profit fell below 30% of its 2019 profit level, thus representing a significant and potentially unsustainable decline. In contrast, "Growth" ("Growth") was defined as a firm whose 2021 profit exceeded the 2019 profit level, thus indicating a full recovery and positive trajectory after the down year. These definitions allowed us to quantify the relationship between the 2020 financial indicators and the relevant outcomes of dental practices.

9.3 Results – DPRI

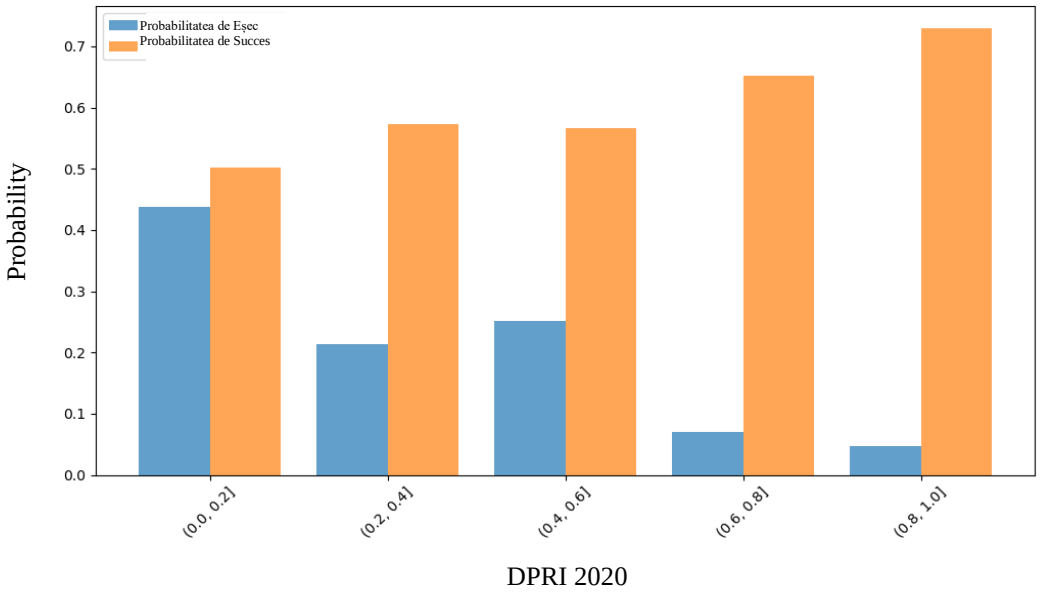

Figure 9.14 Probability of Failure or Growth in 2021 using the predicted DPRI in 2020, based on 2019 data, for practices with less than 3 employees

DPRI analysis revealed a strong relationship between scaled DPRI values from 2020 (estimated by our machine learning model) and subsequent probability of failure or growth, valid for both categories of dental practices, as illustrated in Figure 9.14 and Figure 9.15. In the case of practices with more than three employees, an inverse correlation is observed between IRCS values and probability of failure.

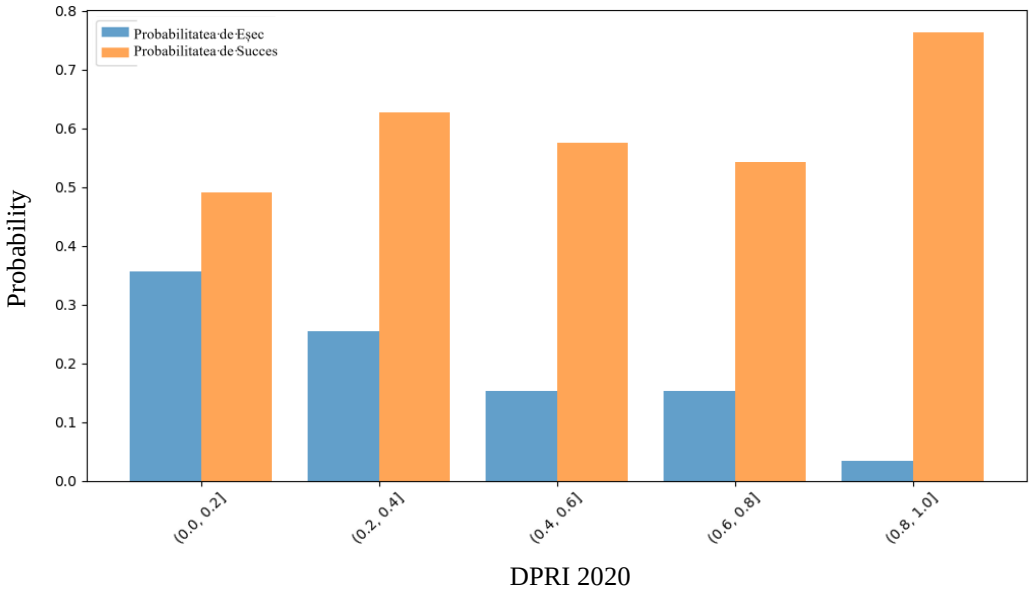

Figure 9.15 Probability of Failure or Growth in 2021 using the predicted DPRI in 2020, based on 2019 data, for practices with more than 3 employees

As seen in Figure 9.14 and Figure 9.15, practices with DPRI scores in the lowest range (0.0-0.2) had a 43% probability of failure for those with three or fewer employees and a 35.5% probability of failure for those with more than three employees. For practices with IRCS in the higher range (0.8-1.0) the failure rate was approximately 3% for both categories of dental practices. At the same time, the probability of growth increased substantially in both groups analyzed, with the margin being more pronounced for practices with more than three employees, as seen in Figure 9.15. In this case, the probability of growth increased from 49.1% in the lower range of the IRCS to 76.3% in the upper range. This steep gradient suggests that the IRCS effectively captures fundamental aspects of financial resilience.

These results indicate that the DPRI index is a robust predictor of a dental practice's ability to overcome economic disruptions and subsequently recover, with higher scores correlating with dental practices' resilience and growth potential in post-crisis periods.

9.2 Discussions – IRCS

The demonstrated ability of the Dental Practice Risk Index (DPRI) to predict post-crisis economic trajectories suggests that this index could be used as an early warning system, allowing practices to identify and address financial vulnerabilities before they manifest as failure during economic crises. The determination of vulnerability thresholds is also present in recent literature

that shows the essential role of vulnerability metrics and thresholds in assessing the resilience of healthcare organizations.

The DPRI study makes two essential contributions to the field of dental practice management and is correlated with other studies that show that composite financial indicators are a viable indicator to determine the probability of survival in a crisis context. First, DPRI represents a multidimensional metric for financial resilience. Second, and perhaps more importantly, our machine learning-based prediction algorithm provides a practical, easy-to-implement tool that allows for the dynamic assessment of the financial resilience of dental practices without requiring manual data processing. The strong correlation between the DPRI values predicted by the algorithm and subsequent economic outcomes, demonstrated by our statistical analysis, validates this approach both theoretically and practically.

Practices can implement this predictive system for periodic assessments of financial health, paying particular attention to practices that achieve low predictive values of IRCS, as they present considerably higher probabilities of failure in crisis scenarios. These assessments can inform targeted interventions in areas of dental practice management that have a higher weight in the DPRI calculation such as: Increasing the number of employees, streamlining expenses or hiring a larger number of medical staff. The predictive algorithm can continuously monitor financial indicators and provide early warnings when practices begin to move towards higher risk categories of IRCS, facilitating sound financial management.

Models such as the one proposed by Kotter , successfully applied in various medical scenarios during Covid-19, provide a framework as follows: (i) use DPRI to assess the resilience of the practice; (ii) form an operational team from top management; (iii) the team must generate and implement solutions to increase current resilience (e.g., improving the doctor-patient relationship to increase patient retention); and (iv) repeat this exercise at least quarterly.

Also, according to Figures 9.14 and 9.15, DPRI can be used as an early warning tool for predicting resilience in the context of pandemic crises. For example, for practices with ≤ 3 employees, exceeding the DPRI threshold of 0.40 reduces the estimated risk of failure from 45% to approximately 25%, while for practices with more than 3 employees, the critical threshold seems to be closer to the value of 0.35. Thus, when a practice observes that DPRI falls below the relevant threshold, management can activate predefined protocols for cost control and liquidity reserves. They can also start working more on patient retention strategies and implementing new protocols

for developing the doctor-patient relationship. Such risk signals are preferable to alerts based on single indicators (e.g., only a decrease in turnover), because the composite index integrates multiple metrics (Equation (9.6)), reducing false alarms and improving sensitivity for resilience to future crises.

9.2 Conclusions

The T/E ratio is a tool that can assess individual efficiency. The comparative analysis illustrated in Figure 9.13 of the two categories of practices highlights the fact that those dental practices with T/E ≥ 100,000 RON/employee in 2019 had a better financial performance. By contrast, practices with a lower initial performance, with T/E < 100,000 RON/employee in 2019, had major difficulties in managing the crisis and implementing the necessary measures for development through efficiency, reflecting the need for financial education, improving strategic and financial management. Thus, the success of post-pandemic adaptation is directly linked to the ability of practices to quickly understand the newly created economic context and to effectively apply the principles of change management.

What is interesting to note, however, is the evolution of the practices with T/E ≥ 100,000 RON/employee in 2019. It can be seen in Figure 9.13 how the indicators increased in 2021, leaving the other years, but also the other category of practices, far behind. These practices, having even before the pandemic a better T/E than the others, also had the financial resources, but also the education and information to evolve. They quickly applied the principles of change management to adopt an organizational culture based on values and team maturity, and thus got through the crisis easily.

Thus, corroborating the results obtained in this chapter, it can be stated: practices with a T/E value ≥ 100,000 RON/employee in 2019 prove to be more efficient in terms of financial performance. According to the data in Table 9.1 and Table 9.2 and Figure 9.13, they generate a higher turnover per employee, compared to practices with a T/E < 100,000 RON/employee in 2019, indicating higher productivity and efficient adaptation to the new conditions.

The DPRI index is a tool that can assess institutional efficiency. Regarding the DPRI indicator, the results and discussions validate not only the DPRI as a descriptive tool for current financial health, but also our predictive algorithm as a powerful tool for anticipating economic outcomes in difficult economic environments. This index can be used as a change management tool, which, when used in a timely manner within a management strategy, can help anticipate a

potential crisis, providing the opportunity to avoid the crisis by applying personalized management strategies to each individual firm depending on the fluctuations it faces.

The predictive power of an index like DPRI will only lead to resilient practices if management teams use data-driven approaches. Thus, the prediction of the DPRI model can be used in a dental practice change management context to make dental practices more resilient to future crises. Also, having a machine learning model to predict DPRI can lead to "what-if" simulations that allow managers to test the resilience of the practice under various shock scenarios (e.g., a 25% drop in revenue or a sudden 15% increase in equipment costs). These simulations can indicate the best strategy for maintaining resilience in the long term.

The development of the DPRI for dental practices addressed a critical gap in dental practice management, providing a quantitative tool for preparing against future economic crises.

Together, the two prevention and diagnostic tools, T/E and DPRI, can assess both the individual and institutional status of a practice, offering the possibility of improving development strategies and proactive action.

CONCLUSIONS AND PERSONAL CONTRIBUTIONS

Study I followed the evolution of practices which, although initially active, subsequently suspended their activity. The analysis showed that turnover below RON 100 000 and a staff of less than three employees were consistently associated with closure. These were elements of vulnerability, and when these two elements were overcome, closure became guaranteed. Low profits, low expenses not commensurate with rising health care costs, and lack of investment reflected in low debt, completed this vulnerable profile. The overall conclusion of the first study validates the initial hypothesis and supports that economic resilience depends on a minimum volume of activity, the presence of financial reserves and the ability to quickly finance change measures, which confirms the role of proactive financial management in the survival of a practice in times of crisis.

Study II compared the evolution of indicators in the pre-pandemic, pandemic and post-pandemic periods. Turnover fell in 2020, but increased significantly in 2021, and profit followed the same trajectory, suggesting a rapid recovery after the resume of activity. Expenses initially fell, then rose as investment resumed, while debt remained stable, evidence of a prudent financial policy. The number of employees decreased slightly in the pandemic year and remained the same

after the crisis, a sign that the internal reorganization during the pandemic period was an example of good practice, maintained post-pandemic. The analysis concluded that the shift from growth by expansion (dominant before 2020) to growth by streamlining in 2021 enabled superior performance with lower financial risk.

Study III segmented the analyzed practices into small practices (≤ 3 employees in 2019) and large practices (> 3 employees). Large practices felt the initial downturn more strongly, but recovered, surpassing the pre-demand level in turnover and profit, thanks to their complex organizational structure, equity and early acceptance of digitalization. Small practices went through the 2020s almost unchanged, but evolved modestly thereafter, constrained by resources and a culture still geared towards physical expansion rather than optimization. The conclusion of this study was that team size influences the speed of implementation of change strategies and thus the quality of the patient relationship in turbulent times.

Study IV introduced two new indicators. T/E expresses turnover per employee and measures the individual efficiency of the physician as a revenue generator. In 2021, T/E increased sharply, showing that, after the 2020 restructurings, practices were getting more from the same team. DPRI, a weighted composite index, shows institutional performance and was combined with machine learning models to predict the risk of closure. The results confirmed that a high DPRI score identifies those practices that can successfully absorb future shocks.

Taken together, the four studies are linked by a common thread: each examines the same set of indicators, but from complementary angles. Study I isolates critical limits, Study II tracks dynamics over time, Study III explores the influence of staff structure, and Study IV proposes synthesis and prediction tools. The interdependence is clearly visible; vulnerability thresholds from Study I become stratification variables in Study III, annual trends from Study II feed into DPRI models, and the increase in T/E in 2021 explains why practices with a turnover of more than 100,000 RON/year have overcome the period of uncertainty more quickly. This corroboration shows that post-crisis performance does not depend on a single factor, but on how turnover, profit, expenses, debt and human resources simultaneously adjust to change.

At the level of the doctor–patient–system triad, the general conclusions indicate that patients remain the main source of income, and their behavior changes when they perceive high safety and transparent communication. Doctors have adapted through stricter protocols, digitalization and investments in equipment, elements that have strengthened trust. The health

system, however, has remained a limited observer; if it had been able to selectively finance vulnerable practices, some of the closed units could have survived, and patients' access to basic services would not have been reduced.

Three complementary perspectives are further synthesized—preventive, financial diagnostic, and managerial treatment—which aim to provide dental practices with benchmarks to strengthen their resilience and increase their performance.

From a preventive perspective, a truly proactive approach requires a dental practice to anticipate periods of crisis. Anticipation can be achieved by monthly monitoring of individual and institutional instruments, T/E and DPRI, in order to prevent imbalances before they have a major impact. These elements can be used in the development strategy at the practice level. Another example of a proactive approach could be the early establishment of financial reserves. On the other hand, a delayed, purely reactive reaction catches the practice unprepared and does not lead to increased performance after the shock.

From a financial diagnostic perspective, annual monitoring of the T/E ratio and the DPRI score allows for early identification of deviations and their correction before performance is affected.

From a treatment management perspective, rapid adoption of digital solutions and continuous updating of safety protocols limits losses, optimizes processes, strengthens patient trust, and leads to process-level efficiency within the dental office.

The pre-pandemic period was defined by growth through expansion: more dental chairs, more staff, and larger spaces. The pandemic-driven revolution abruptly interrupted this direction, forcing practices to embrace growth through efficiency; those that quickly internalized this new paradigm achieved superior performance with fewer resources. This new strategy showed the advantage of a proactive approach, instead of a reactive, late approach in response to external shocks.

The conclusions from an educational point of view show that university and continuing education programs should include financial management skills, risk analysis, leadership elements and change management. The integration of these modules can stimulate intrapreneurship among young dentists, preparing them to manage both the clinical and economic side of the profession, both in normal times and in times of crisis, playing a preventive role in absorbing shocks.

Finally, the comparison between T/E and DPRI highlights the need to simultaneously assess individual efficiency and institutional efficiency. A doctor may produce exceptional turnover per employee, but if the expenses structure, debt level and internal organization remain fragile, the practice remains exposed. Conversely, a good DPRI with a low T/E may indicate a solid but underutilized practice . Analyzing the two indicators side by side provides a complete picture and helps dental practices better understand how to organize resources.

In conclusion, the thesis shows that the resilience of dental practices in Bucharest in the face of the Covid-19 pandemic depended on clear activity thresholds, a shift from expansion to efficiency, proactive rather than reactive action, team maturity and the use of new analytical tools. The main lesson is that a practice that is financially prepared, driven by modern leadership principles and supported by an active public system not only survives the crisis, but can emerge more competitive, strengthening the relationship with the patient, providing guaranteed access to dental services and contributing to a better health system.

Personal contributions

The own contributions of this thesis are found in several chapters, and will be listed as follows:

In **Chapter 6,** we conducted an analysis of practices that were active in 2019/2020 but closed in 2020/2021. Dental practices with turnover below 100,000 RON/year, less than 3 employees, low investments or high expenses were the most vulnerable in the pandemic and failed to maintain their activity or grow in the post-pandemic period.

In **Chapter 7,** we conducted a detailed analysis of the differences that existed between financial indicators in the pre-pandemic, pandemic and post-pandemic time periods. Following the comparison in **Subchapter 7.4**, we demonstrated how the Covid-19 pandemic had a real impact on the financial indicators, leading to decreases in most of these indicators, but also to the beginning of a new phase in which practices were able to reorganize much more efficiently for the post-pandemic year.

In this thesis we also analyzed the impact of the pandemic by number of employees, which can be seen in **Chapter 8**. The comparative study of financial indicators for practices with ≤ 3 employees versus those with > 3 employees is presented in **Chapter 8, subchapters 8.3**. This analysis provides a new perspective on how the size of a dental practice, determined by the number of employees, influences its ability to react to a crisis.

By developing the financial indicator T/E (Turnover / Employees), I was able to make a valuable contribution to the analysis of the financial performance of a dental office. These data are detailed in **Chapter 9, subchapters 9.2, 9.3 and 9.4.**

The results in section 9.3 show that, in 2021, certain practices recorded a very large increase in the T/E value, thus demonstrating that after the Covid-19 pandemic, certain dental practices managed to optimize the use of human resources in generating turnover, becoming much more profitable compared to 2019, 2020, an aspect detailed in **Figure 9.13** and discussed in **Chapter 9, Subchapter 9.4**.

Also in **Chapter 9**, we defined the Dental Practice Risk Index (DPRI), a composite index that we used to train a machine learning algorithm on the performance of dental practices during the crisis. Using the newly created algorithm, we were able to determine which parameters can predict the resilience or failure of a dental practice in the face of a pandemic crisis. This Artificial Intelligence tool can be used by dental practices to predict how resilient they are in the face of a new pandemic crisis. These aspects were detailed in **Chapter 9, Subchapters 9.5, 9.6 and 9.7.**

To form the entire thesis, we collected resources, organized data, and finally synthesized complex statistical data by applying statistical techniques (normality tests, analysis of variables using the Friedman test, post- hoc Dunn- Bonferroni and Mann- Whitney U test), mentioned in the methodological sections of **Chapter 5.** This type of methodology allows for the establishment of meaningful results. Also, together with a research group in machine learning algorithms we were able to develop, based on the data collected by me, a new resilience measurement parameter and train a machine learning algorithm that can predict the resilience of a practice in a future crisis.

Through this thesis, we have achieved the proposed research objectives. In this work, we have highlighted both the advantages and the technical and economic limitations, and the data obtained can open directions for further research, especially regarding the long-term adaptation of dental offices to crisis conditions and the evolution of the doctor-patient relationship. Our own contributions represent original elements that can be used as a basis for further research directions and for outlining future strategies.

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List of published scientific papers

The thesis is based on the following published scientific papers:

As first author:

Delia Rădoi , Mihaela Pantea, Marina Imre, Alexandra Ripszky Totan , Ana Maria Cristina Țâncu , Ana Cernega , Silviu Mirel Pițuru . " *Aspects regarding the impact of the Covid-19 Pandemic on private dental practices in Bucharest , Romania"* Romanian Journal of Oral Rehabilitation vol 15, issue 4, pp 312-322, Dec 2023 WOS:001128394100052 *(study included in Chapters 3 (pp. 34-43), 5 (pp. 47-49) ,7 (pp. 65-79))*

ISI indexed - with impact factor 0.6, https://rjor.ro/aspects-regarding-the-impact-of-the-covid-19-pandemic-on-private-dental-practices-in-bucharest-romania/

Delia Rădoi , Mihaela Pantea, Marina Imre, Alexandra Ripszky Totan , Ana Maria Cristina Țâncu , Ana Cernega , Miruna-Maria Apetroaei , Silviu Mirel Pițuru . 2024. " *Economic impact of covid-19 on Romania's capital dental practices* " Romanian Journal of Oral Rehabilitation vol 16, issue 4, pp 164-173, Dec 2024 doi: 10.6261/RJOR.2024.4.16.16, WOS:001435013800008 *(study included in Chapters 3 (pp. 34-43), 5 (pp. 47-49) ,8 (pp. 80-103))*

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Delia Radoi, Silviu Mirel Pituru " *Economic resilience of dental practices in the COVID -19 pandemic: Analysis of the T/E (Turnover / Employee) indicator* ” *Mædica – a Journal of Clinical Medicine* 2025, 2025; 20(1): 39-47, doi https://doi.org/10.26574/maedica.2025.20.1.39 *, (study included in Chapter 3 (pp. 34-43), 5 (pp. 47-49) ,9 (pp. 105-131))*

PubMed indexed ,

Sent for evaluation to the journal:

Delia Radoi , Dan Curavale , Silviu-Mirel Pituru " Anticipating the Financial Impact of Crises on Dental Practices : A Machine Learning-Based Resilience Model” – submitted for review to a journal *(study included in Chapter 9 (pg. 131-137)*

As a co -author

Cernega , A.; Meleșcanu Imre, M.; Ripszky Totan , A.; Arsene, AL; Dimitriu, B.; **Radoi, D** .; Ilie, M.-I.; Pițuru , S.-M. Collateral Victims of Defensive Medical Practice. *Healthcare* **2023** , *11* , 1007. https://doi.org/10.3390/healthcare11071007 , WOS:000969414100001 *ISI indexed with impact factor 2.4. PubMed indexed (study included in Chapter 7(pp. 74-77))*