

"At-home tooth bleaching, effectiveness and adverse effects analysis"

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Dissertação conducente ao Grau de Mestre em
Medicina Dentária (Ciclo Integrado)

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Trabalho realizado sob a Orientação de Prof. Doutor ARNALDO
SOUSA



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RESUMO

Introdução: O branqueamento dentário, realizado pelo médico dentista no consultório dentário, também pode ser feito no domicílio. De facto, permite um protocolo mais flexível e adaptável à rotina, e alguns pacientes têm demonstrado preferência por esta técnica.

Objetivos: Comparar e analisar a eficácia e os efeitos adversos do branqueamento no domicílio.

Material e Métodos: Efetuou-se uma pesquisa bibliográfica na base de dados Pubmed utilizando as seguintes palavras-chave: *“Tooth bleaching, Home, Effectiveness, Tooth Sensitivity”*

Resultados: Foram selecionados 9 artigos entre abril 2012 e maio 2022 com interesse para este trabalho.

Discussão: A utilização do branqueamento dentário no domicílio é uma opção válida, em alternativa ao branqueamento dentário no consultório. O branqueamento dentário no domicílio apresenta vantagens consideráveis, permitindo um branqueamento eficaz que pode ser modificado com concentração de gel, tempo e métodos de aplicação. No entanto, a sua utilização apresenta alguns riscos como a sensibilidade dentária que podem variar de acordo com a adição de agentes dessensibilizantes, a concentração, o tempo e métodos de aplicação.

Conclusões: Uma maior concentração de gel branqueador aplicado por vários períodos de tempo mais curtos pode reter melhor a cor no início do tratamento do que gel de baixa concentração aplicados por períodos de tempo mais longos ou uma concentração alta aplicada por um curto período de tempo. Enquanto a sensibilidade dentária seja leve e transitória, ela pode variar com a concentração, o tempo e métodos de aplicação, e pode ser reduzida pela adição dos agentes dessensibilizantes.

Palavras-chave: “Branqueamento Dentário”, “Domicílio”, “Eficácia” e “Sensibilidade dentária”

ABSTRACT

Introduction: Tooth bleaching is usually performed by a dentist in the dental office, but this treatment has become more common to be achieved at home. Indeed, it allows for a protocol more flexible and adaptable to routine, and some patients have demonstrated a preference for this technique.

Objectives: Compare and analyze the effectiveness and adverse effects of at-home bleaching.

Material and Methods: A literature search was performed on the Pubmed database using the following keywords: "Tooth bleaching, Home, Effectiveness, Tooth sensitivity".

Results: We selected 9 articles between April 2012 and May 2022 that were relevant to this work.

Discussion: At-home tooth bleaching is a valid option as an alternative to in-office bleaching. At-home tooth bleaching has considerable advantages, providing an effective bleaching efficacy that can be modified with gel concentration, time and methods of application. However, its use presents some risks that can vary according to the concentration, time application and the addition of desensitizing agents such as tooth sensitivity.

Conclusions: High concentration bleaching gel applied for several shorter periods of time can retain color better at the beginning of treatment than low concentration gel applied for several longer periods of time or an extremely high concentration gel applied for a short period of time. While tooth sensitivity is mild and transitory but can vary with the concentration, time application or delivery methods of bleaching agents, it can be reduced by the addition of the desensitizing agents.

Key-words: *"Tooth bleaching", "Home", "Effectiveness" and "Tooth sensitivity"*

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FIGURE INDEX

Figure 1 - PRISMA flow chart 5



LIST OF ABBREVIATIONS

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PICOS – Patient, Intervention, comparison, outcome, study design

Gr – Group

CT – Controlled Trial

RCT – Randomised Controlled Trial

1. INTRODUCTION

Tooth bleaching is usually performed by a dentist in a dental office, but this treatment has become more common in-home use. Indeed, it allows for a protocol more flexible and adaptable to routine, and some patients have demonstrated a preference for this technique.⁽¹⁾

The etiology of teeth staining reveals intrinsic or extrinsic stains or both. This phenomenon can appear uniformly over the whole dentition, a yellowish colour covering over the whole enamel surface or locally on one or a set of teeth.⁽²⁾

Intrinsic stains have diverse origins. First, they can be due to childhood pathologies (congenital porphyria) or medication (tetracycline, ciproflaxine, chlorhexidine). Furthermore, ageing causes a hypomineralisation of the enamel, which becomes thinner due to natural abrasion, leading to increase the visibility of the dentine, producing a yellowish tooth discoloration. Finally, these intrinsic stains may be the consequences of certain diseases, such as dental fluorosis, namely an alteration of the teeth hard tissues, resulting from the excessive ingestion of fluoride in childhood.⁽²⁾

Extrinsic stains usually affect the entire dentition and are located on the enamel surface, more noticeable in areas where the enamel is more porous and rougher. Most of the time, these stains are caused by a combination of extrinsic factors such as poor oral hygiene, smoking, or excessive consumption of coffee or tea.⁽²⁾

This study will focus on, "chemical teeth bleaching", which is defined by the International Organization for Standardization as "the elimination of intrinsic or acquired changes in the colour of natural teeth using chemical products, sometimes combined with the application of external energy". It is therefore a chemical process involving an oxidising product. This chemical will then modify the nature of the light absorption or reflection of the oral structure, thus increasing the perception of bleaching. It will thus change the intrinsic colour of the enamel.⁽³⁾

Hydrogen Peroxide (H₂O₂) based oxidising products mainly used in practice and carbamide Peroxide (CH₆N₂O₃) based products (a hydrogen peroxide and urea adduct), may be prescribed by the dentist.

An oral bleaching product can be considered safe and free for sale when it contains no more than 0.1% hydrogen peroxide.⁽⁴⁾

In contrast, products with a concentration between 0.1 and 6% hydrogen peroxide are not available for consumers, but only for dentists. These products are restricted to patients over 18 years old after a clinical examination.⁽⁴⁾

The omnipresent publicity of the benefits and effectiveness of at-home tooth bleaching, as well as the easy accessibility and affordability of those products, have generated a real enthusiasm of the public. However, questions have been raised about the effectiveness and safety of these bleaching agents.⁽⁵⁾ In fact, the main adverse effects of tooth bleaching are hypersensitivity and gingival irritation which can persist for several days or even weeks.⁽⁶⁾

This dissertation will analyse the effectiveness and side effects of at-home tooth bleaching.

2. OBJECTIVES

The main objectives of this integrative systematic review are:

1. Compare and analyse the effectiveness of at-home bleaching
2. Compare and analyse the tooth sensitivity and adverse effects of at-home bleaching

3. METHODS

3.1) Protocol and register

The review protocol used was the one described according to PRISMA recommendations (PRISMA Statement) using the PRISMA 27-item checklist, available at <http://www.prismastatement.org/PRISMAStatement/Checklist>.

3.2) Eligibility Criteria

The studies included in this integrative systematic review were selected according to the following criteria, following the PICOS Strategy:

Population	Human patients undergoing at-home tooth bleaching treatment.
Intervention	At-home tooth bleaching treatment.
Comparison	Comparison of at-home tooth bleaching results.
Outcomes	To analyse the effectiveness and adverse effects of at-home tooth bleaching.
Study design	RCT, CT

Table 1 - PICOS Strategy

3.3) Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> • Accessible and complete articles 	<ul style="list-style-type: none"> • Articles not accessible or incomplete
<ul style="list-style-type: none"> • Studies with 10 additional participants 	<ul style="list-style-type: none"> • Case report, Thesis, Dissertation, In vitro study, Digital study, Systematic review
<ul style="list-style-type: none"> • Human studies 	<ul style="list-style-type: none"> • Animal studies
<ul style="list-style-type: none"> • Articles in English, Portuguese and French 	<ul style="list-style-type: none"> • Articles in languages other than English, Portuguese and French
<ul style="list-style-type: none"> • Articles published in the last decade 	<ul style="list-style-type: none"> • Articles published before 2012

Table 2 - Inclusion and Exclusion Criteria

3.4) Sources of information

Research strategy – A literature search was conducted in PubMed databases, with the keywords: "Tooth bleaching" "Home" "Effectiveness" "Tooth sensitivity"

Using the advanced search, the following keyword combinations were made

Articles published between April 2012 and April 2022 with the following languages were used: Portuguese, English and French. The search strategies were detailed in Table

Database	Research Strategy	Articles identified	Articles selected
Pubmed	<i>(Tooth bleaching AND Home AND Effectiveness AND Tooth sensitivity)</i>	49	9

Table 3 - Research Strategy

4. OUTCOMES

4.1) Studies selection

Step I - Database results

Searches were conducted in the Pubmed database and articles published between April 2012 and April 2022 were searched. Zotero software was used to help organise the articles and manage the bibliographic references.

The literature search identified a total of 49 articles. After reading the titles and abstracts/resumes, they were reduced to 18, of which 6 were excluded for not including the objectives of this integrative systematic review.

Step II - Articles reviewed

At this stage, 12 articles were reviewed to assess the quality and type of study.

Step III - Articles for inclusion

Of these 12 articles, 3 were excluded for not presenting sufficient relevant data, according to the objectives of this work.

Finally, 9 studies were included in this integrative systematic review.

Thus, the table was prepared based on the names of the authors of each study, the year of publication, the type of study, the main objective, the methods, the main results found and the conclusions.

The article selection process is illustrated in the flow chart (Figure 1)

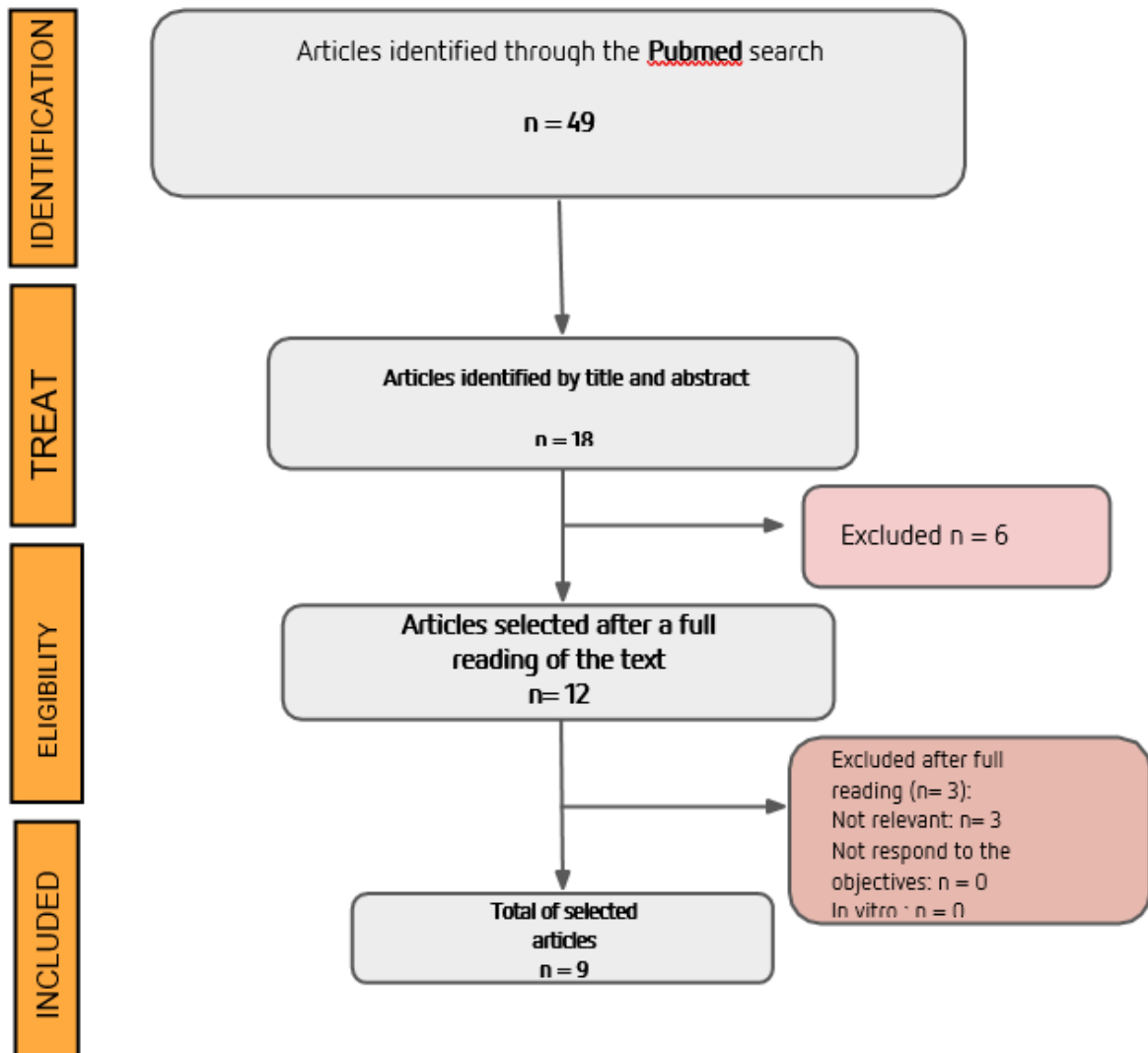


Figure 1 - PRISMA flow chart

4.2) Characteristics of the included studies

The following information was taken from the selected articles: authors' names, year of publication, study design, article title, objectives of the articles, sample, methods, outcomes obtained and conclusions.

The results are illustrated in the following table.

4.3) Data list

Authors	Title	Objectives	Sample	Methods	Outcomes	Conclusions
Da Costa et al. (2012) RCT	Comparison of Two At-home Whitening Products of Similar Peroxide Concentration and Different Delivery Methods	This study compared the bleaching efficacy, side effects, and patients' preferences/perceptions of two bleaching systems of similar peroxide concentration but different formulation and delivery methods	24 participants	<p>The tooth color change was measured using a shade guide (BSG) and a spectrophotometer (ES). Color difference was calculated: $\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$.</p> <p>One bleaching treatment was randomly applied to the right or left maxillary anterior teeth and the other was applied to the contralateral teeth, at-home with 35% carbamide peroxide in a tray or with 14% hydrogen peroxide in strips.</p> <p>The tooth color was evaluated at baseline, 15 and 30 days (15 days post bleaching). Participants rated their tooth and soft tissue sensitivity (1–10 scale) and completed a questionnaire on their preferences.</p> <p>Results were analysed by repeated measurement regression analysis/Tukey and Mann-Whitney ($p < 0.05$).</p>	<p>At 15 days, the teeth treated with a tray and strips presented $\Delta E^* = 7$ and 6, respectively ($\Delta BSG=3$ for both), and at 30 days, they presented $\Delta E^* = 7.5$ and 6.5, respectively ($\Delta BSG=3$ for both).</p> <p>There was no significant difference in tooth and soft tissue sensitivity between treatments.</p> <p>No participant reported tooth and gingival sensitivity at the post bleaching appointment.</p> <p>Of the participants, 83% preferred the tray over the strips.</p>	<p>Both ΔE^* and ΔBSG showed no significant difference in tooth color change between tray and strips at either time point.</p> <p>By the end of the study no participants reported tooth and gingival sensitivity.</p> <p>Participants preferred tray over strips</p>

<p>Alonso de la Peña et al (2014) RCT</p>	<p>Randomized Clinical Trial on the Efficacy and Safety of Four Professional At-home Tooth Whitening Gels</p>	<p>To evaluate the efficacy and safety of four gels of differing concentrations used for at-home vital bleaching.</p>	<p>96 volunteers participated in the study and were divided into four groups of 24 individuals</p> <p>Gr 1: 10% carbamide peroxide</p> <p>Gr 2: 15% carbamide peroxide</p> <p>Gr 3: 7.5% hydrogen peroxide</p> <p>Gr 4: 9.5% hydrogen peroxide</p> <p>The patients used the bleaching agent in a tray without reservoirs for 1h/day for two weeks</p>	<p>The measurement of the change in tooth color was made by two observers in the maxillary right central incisor and with a colorimeter in both upper central incisors and canines, using the CIE L*a*b* and CIE L*C*h* values.</p> <p>Sensitivity was evaluated by the participants on a scale with values as follows: 0 = absent, 1 = minor, 2 = moderate, 3 = considerable, 4 = severe.</p>	<p>At the baseline, the observers noted darker colors than the colorimeter ($p < 0.01$), and there were differences between incisors and canines in all the CIE L*a*b* and CIE L*C*h* values ($p < 0.001$).</p> <p>In all of the groups and for all of the CIE L*a*b* and CIE L*C*h* parameters, there were color changes in the assessments made in the four maxillary teeth after treatment ($p < 0.001$).</p> <p>There were no differences in ΔL^* and ΔE^* between the groups.</p> <p>The number of patients who experienced sensitivity and the intensity of the sensitivity were not significant.</p>	<p>There were no differences in the degree of bleaching among the different products. With all of the products there was an increase in luminosity intensity, a decrease in chromatic intensity, and an increase in the value or hue.</p>
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<p>López Darriba et al (2017) RCT</p>	<p>Efficacy of different protocols for at-home bleaching: Randomized clinical trial</p>	<p>To evaluate the efficacy of two products used for at-home bleaching with different application times.</p>	<p>80 participants were enrolled and divided into four groups</p> <p>Gr 1: 10% carbamide peroxide 1 hour a day</p> <p>Gr 2: 10% carbamide peroxide overnight</p> <p>Gr 3: 7.5% hydrogen peroxide 1 hour a day</p> <p>Gr 4: 7.5% hydrogen peroxide overnight.</p> <p>The duration of treatment was 14 days.</p>	<p>Color measurement was performed using a dental spectrophotometer on the right maxillary central incisor and the canine, at baseline and 2 weeks after.</p> <p>Participants recorded daily tooth sensitivity.</p> <p>To evaluate the influence of concentration and time on bleaching results (ΔE) the one-way ANOVA with Bonferroni post-hoc test and the student's t-test were used.</p>	<p>Group 2 showed the highest value of ΔE ($\Delta E = 10.59 \pm 2.68$), followed by Group 4 ($\Delta E = 8.95 \pm 2.32$), Group 1 ($\Delta E = 8.05 \pm 3.86$), and Group 3 ($\Delta E = 7.08 \pm 1.99$).</p> <p>There were differences between Groups 2 and 3 ($P = 0.001$) and between Groups 2 and 1 ($P = 0.032$).</p> <p>The same product applied overnight was more effective than applied 1 hour a day ($P < 0.05$).</p> <p>Different concentrations during the same application time achieved similar results.</p> <p>The reported tooth sensitivity was mild.</p>	<p>The most effective protocol was 10% carbamide peroxide applied overnight.</p> <p>The results of the present randomized clinical trial confirm that at-home bleaching is time but not concentration dependent and the incidence of side effects is influenced by the active agent concentration.</p> <p>Therefore, there is no need to use higher concentrations (7.5% hydrogen peroxide) for achieving satisfactory bleaching results.</p>
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<p>Chemin et al (2018) RCT</p>	<p>Effectiveness of and Dental Sensitivity to At-home Bleaching With 4% and 10% Hydrogen Peroxide: A Randomized, Triple-Blind Clinical Trial.</p>	<p>To evaluate the risk for and intensity of tooth sensitivity and color change of at-home dental bleaching with 4% and 10% hydrogen peroxide.</p>	<p>78 patients were selected and randomized into two groups: 4% hydrogen peroxide (White Class 4%, FGM) and 10% hydrogen peroxide (White Class 10%, FGM)</p> <p>In both groups, the at-home bleaching was performed for a period of 30 min twice a day for two weeks</p>	<p>The color was assessed by Vita Classical, Vita Bleachedguide 3D-MASTER and spectrophotometer Vita Easyshade (Vita Zahnfabrik) at baseline, during bleaching (first and second weeks) and after bleaching (one month).</p> <p>Patients recorded their tooth sensitivity using a numeric rating scale (0-4) and visual analog scale (0-10).</p> <p>Data from color change (DeltaE data) was submitted to two-way analysis of variance.</p> <p>The color change data in Delta SGU from the two shade guide units were compared with the Mann Whitney test.</p> <p>The risk of tooth sensitivity was evaluated by X² test and the intensity of tooth sensitivity from both scales was evaluated by a Mann-Whitney test (α=0.05).</p>	<p>The absolute risk and intensity of tooth sensitivity was higher in the group that used 10% hydrogen peroxide than the one that used 4% hydrogen peroxide.</p> <p>Data from change in the number of shade guide units and color variation after one month of bleaching for both groups showed significant bleaching, with no difference between groups.</p>	<p>At-home bleaching is effective with 4% and 10% hydrogen peroxide concentrations, but 10% hydrogen peroxide increased the absolute risk and intensity of tooth sensitivity during at-home bleaching.</p>
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<p>Chemin et al (2018) RCT</p>	<p>Clinical Evaluation of 10% Hydrogen Peroxide on Tooth Sensitivity and Effectiveness in at Home Dental Bleaching</p>	<p>To evaluate the dental effect and sensitivity of at-home dental bleaching with 10% hydrogen peroxide.</p>	<p>20 volunteers were selected for this study and was used 10% hydrogen peroxide for 30 min twice a day, for two weeks</p>	<p>Shade evaluation was assessed visually by the value-oriented shade guide Vita Classical shade guide, Vita Bleachedguide 3D-MASTER and by the Easyshade spectrophotometer at baseline, during bleaching (first and second weeks), and post-bleaching (one month).</p> <p>The perceptions of sensitivity were recorded by the patients through the numerical rating scale (0 to 4) and 0 to 10 visual analog scales daily.</p> <p>Data from the shade guide units was subjected to a one-way repeated measures analysis of variance test ($\alpha = 5\%$).</p> <p>The overall ΔE, absolute risk and intensity of tooth sensitivity were calculated as well as the 95% confidence interval.</p>	<p>The absolute risk of tooth sensitivity was 65% and the intensity was mild.</p> <p>Data from ΔSGU and ΔE after 1 month of bleaching for 10% hydrogen peroxide showed significant bleaching, 4 units for Vita Classical, 5 units for Vita Bleachedguide and 9.7 units for spectrophotometer.</p>	<p>At-home bleaching using 10% hydrogen peroxide is effective in 14 days of bleaching.</p> <p>The most common adverse events were mild tooth sensitivity, and no subjects discontinued use early because of a treatment-related adverse event.</p>
<p>Cordeiro et al. (2019) RCT</p>	<p>Clinical Evaluation of Different Delivery Methods of At-Home Bleaching Gels Composed of 10% Hydrogen Peroxide</p>	<p>To compare the tooth sensitivity, gingival irritation, and bleaching efficacy of at-home bleaching performed with 10% hydrogen peroxide using a conventional tray delivered system or two different bleaching systems (strips or prefilled disposable trays).</p>	<p>60 patients.</p> <p>Teeth were bleached during 14 days with a 30-minute gel contact with teeth per day. The 10% hydrogen peroxide was delivered in a bleaching tray (White Class, FGM) in strips (White Strips, Oral-B) or prefilled</p>	<p>The color changes were evaluated by subjective (Vita Classical and Vita Bleachedguide) and objective (Easyshade Spectrophotometer) methods at baseline and 30 days after the second bleaching session.</p> <p>Tooth sensitivity was recorded during 14 days with a five-point numeric rating scale and 0-10 visual analog scale.</p> <p>The risk of gingival irritation was also recorded during 14 days on a dichotomous scale.</p>	<p>No significant difference was observed in the risks of tooth sensitivity among groups (p.0.09). However, the conventional bleaching tray produced a higher intensity of tooth sensitivity when compared with the strips and prefilled disposable tray systems (p,0.04).</p> <p>Regarding gingival irritation, the prefilled disposable tray system showed a lower risk of gingival irritation when compared with</p>	<p>All 10% hydrogen peroxide bleaching systems showed similar bleaching after a 14-day use.</p> <p>However, the strips and prefilled disposable trays produced lower intensity of tooth sensitivity than the conventional bleaching tray system.</p> <p>The prefilled disposable tray produced lower risk of gingival irritation when compared to the conventional</p>

			disposable trays (Opalescence Go, Ultradent).	All data were submitted to appropriate statistical analysis ($\alpha=0.05$).	the conventional bleaching tray ($p=0.003$). Significant bleaching was observed in all groups after 30 days of clinical evaluation with no significant difference between them ($p=0.06$).	bleaching tray.
L. Darriba et al (2019) RCT	Influence of treatment duration on the efficacy of at-home bleaching with daytime application: a randomized clinical trial	To determine whether prolonging the daytime at-home bleaching treatment by 1 week increases the bleaching effect without causing more side effects.	50 participants were randomly divided into two groups Gr 1: A gel with 10% carbamide peroxide was applied for 2 h a day in custom trays during 14 days Gr 2: A gel with 10% carbamide peroxide was applied for 2 h a day in custom trays during 21 days	Color measurement was performed using a dental spectrophotometer on the right maxillary central incisor and the canine at baseline, at the end of treatment, and 1 and 6 months afterwards. Daily, participants recorded their tooth sensitivity and gingival irritation	At the end of the treatment, the ΔE_{00} of Gr 2 (5.77 ± 2.15) was significantly higher than the ΔE_{00} of group 1 (4.74 ± 1.94) ($p = 0.005$ (95% confidence interval: $- 2.13$ to $- 0.39$)). After 6 months, tooth color was more stable in group 2. The ΔS_{GU} values between the different appointment times were higher in the 3-week group. Participants from group 2 reported more side effects, but statistically, there were no differences compared with group 1 ($p = 0.225$ for tooth sensitivity and $p = 0.758$ for gingival irritation).	Daytime application of at-home bleaching for 3 weeks achieves greater bleaching results than for 2 weeks, immediately after treatment and 1 and 6 months afterwards. However, slightly more side effects could occur.
Mailart et al. (2021) RCT	One-year follow-up comparing at-home bleaching systems outcomes and the impact on patient's satisfaction: Randomized	To compare at-home systems with reduced daily time of use, with the conventional nightguard vital bleaching. Bleaching efficacy, adverse effects, and patient's satisfaction were evaluated	60 participants were randomly divided into the four treatments Gr1: Opalescence GO - 10% hydrogen	Color difference (visual and spectrophotometer), tooth sensitivity (visual analogue scale), gingival condition (Løe index), enamel mineralization (laser fluorescence), and patients' satisfaction (questionnaire) were assessed.	After 1 year, color difference was similar for the groups ($p > 0.05$). All groups showed similar sensitivity risk ($p > 0.05$). The intensity of sensitivity and gingival irritation was mild for all	All systems produced similar bleaching efficacy, which was maintained after 1 year. Patients were satisfied with bleaching outcomes. Tooth sensitivity occurred in

	clinical trial		<p>peroxide gel with prefilled - 30min/day</p> <p>Gr2: White Class-10% hydrogen peroxide gel with customized trays - 30 min/day</p> <p>Gr 3: Opalescence PF- 10% carbamide peroxide gel with customized trays- 2h/day</p> <p>Gr4: Opalescence PF- 10% carbamide peroxide with gel with customized trays- 8h/day</p>	Statistical tests were applied (5%).	<p>gels, but higher for Opalescence GO.</p> <p>All participants were satisfied with treatments.</p>	<p>all groups, but with overall mild intensity.</p> <p>No relevant gingival irritation and enamel demineralization was observed.</p>
Sutil et al. (2022) RCT	Effectiveness and adverse effects of at-home dental bleaching with 37% versus 10% carbamide peroxide: A randomized, blind clinical trial	To evaluate bleaching effectiveness, tooth sensitivity and gingival irritation of bleaching patients with 10% versus 37% carbamide peroxide.	<p>80 patients were selected randomly allocated into two groups (n = 40)</p> <p>Gr 1: 37% carbamide peroxide during 3 weeks 30min/day</p> <p>Gr 2: 10 % carbamide peroxide during 3</p>	<p>Color was evaluated with Vita Classical, Vita Bleachedguide 3D Master and Spectrophotometer Easyshade, at baseline, weekly and 30 days after treatment.</p> <p>Absolute risk and intensity of tooth sensitivity and gingival irritation were assessed with numeric rating scale and a visual analog scale.</p> <p>Color changes were compared with t-test for independent samples. tooth sensitivity and gingival</p>	<p>The 37% carbamide peroxide group showed faster bleaching than 10% group at 1–3 weeks.</p> <p>However, 1 month after conclusion, both groups showed equivalent bleaching (p = 0.06).</p> <p>Regarding sensitivity and gingival irritation, 10% and 37% groups met no significant differences (p > 0.05).</p>	<p>The use of 37% carbamide peroxide 30 min/day showed equivalent results to 10% 4 h/day</p> <p>The use of 37% carbamide peroxide 30 min/day may decrease the time of tray use in at-home protocol for bleaching because it presents equivalent results to 10% carbamide</p>

			weeks 4h/day	irritation were evaluated with Fisher's exact tests. Mann-Whitney test was used for numeric rating scale, and t-tests for visual analog scale ($\alpha = 0.05$).		peroxide 4 h/day
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Table 4 - Authors, Years, Study Design, Title, Objectives, Sample, Methods, Outcomes, Conclusions

5. DISCUSSION

5.1) At-home tooth bleaching effectiveness

Chemin et al. evaluated the effectiveness of the at-home bleaching protocol with 10% hydrogen peroxide. After two weeks of bleaching, a clinically visible color change of the teeth was verified, it produced a bleaching of 4 units with Vita Classical and 5 units of color change with Vita Bleachedguide and the color remained stable after 1 month of bleaching treatment. In *Darriba et al.*' study, the 10% carbamide peroxide bleaching gel used was effective in both groups (2 weeks treatments and 3 weeks treatments), since ΔE greater than 4 has been reached. These results are in agreement with those of *Da Costa et al.* that used a concentration close or equal to 10% hydrogen peroxide, with those of *Cordeiro et al.* (ΔE varied by approximately 7 to 10 units, meaning a clinically important bleaching), with those of *De la Peña et al.* (all the ΔE varied by approximately 3 to 10 units, meaning a clinically important bleaching).^(1,7-10)

Sutil et al. and *Chemin et al.* observed a better effectiveness and a faster bleaching when gels with higher concentration were applied. Indeed, the results showed a clear tendency for 37% carbamide peroxide (30 min/daily) to be more effective in the first 2 weeks of treatment than 10% carbamide peroxide was (4 h/daily). In *Chemin et al.*'s study 10% hydrogen peroxide showed a higher degree of bleaching than 4%, meaning that a higher hydrogen peroxide concentration may initially boost the bleaching outcome.^(11,12)

But it seems like, at the end of the treatment all the concentrations demonstrated the same effectiveness and the same bleaching effects. *Sutil et al.*, *Chemin et al.*, *De la Peña et al.*, *Da costa et al.* showed there were no differences between the groups at the end of the treatment. *Sutil et al.*, showed that at the end of 3 weeks of use, both concentrations of carbamide peroxide (10% and 37%) demonstrated the same bleaching effects. This results corroborate with *Chemin et al.* who showed that, this initial advantage is lost during the two-week treatment because all color measurement instruments

demonstrated the same degree of color change for the two bleaching products after the 2-week protocol.^(7,10–12)

Mailart et al. studied the effect of the time on the effectiveness of tooth bleaching, they concluded that there are no differences among the tested groups and they all presented an increase in the mean lightness values, which corroborates with *Sutil et al.*'s results, where 37% carbamide peroxide applied during 30 minutes daily achieved the same bleaching effectiveness as 10% carbamide peroxide applied during 4 hours daily. These results contradict *Darriba et al.*'s observations who support the claim that bleaching is time dependent, in fact the most effective combination was using low concentrations (10% carbamide peroxide) overnight compared to low concentrations with low time application, or high concentrations overnight, or high concentrations with low time application. On the other hand, *Darriba et al.* increased the treatment time in weeks (2 weeks treatment vs 3 weeks treatment) and they determined better results in term of bleaching effectiveness, the color change in the 3-week group was greater, being significant immediately after treatment, and after 1 month and 6 months post-treatment. The difference ΔE^{00} between groups in was ΔE between 0.5–1.0 units, which is clinically visible.^(8,11,13,14)

Da Costa et al. evaluated the influence of the delivery method (tray vs strip) on the tooth bleaching effectiveness. They showed that the methods of bleaching gel delivery, tray vs strip, did not influence the bleaching effect. *Cordeiro et al.* used a conventional tray-delivered system or two different bleaching systems (strips or prefilled disposable trays) and no significant differences were observed between the groups. All bleaching systems applied showed a significant bleaching effect. At the end of the bleaching protocol, a bleaching of approximately 3 to 8 shade guide units was detected for all groups, and the ΔE varied by approximately 7 to 10 units, meaning a clinically important bleaching.^(7,9)

5.2) At-home tooth bleaching adverse effects

Tooth sensitivity is the most common side effect of tooth bleaching. This effect is transient, occurring mainly in the first few days and disappearing by the end of treatment, and appears to be related to the composition of the gels and protocol of use.^(13,14)



In *Chemin et al.*'s study, 65% of the volunteers reported tooth sensitivity at some point during the protocol. Although most of the volunteers of *Chemin et al.*'s study reported tooth sensitivity, the level of sensitivity was mild. This may be related to the fact that the hydrogen peroxide used in this study has in its composition potassium nitrate and sodium fluoride as desensitizing agents. It also contains calcium in its formula, which has the purpose of minimizing the enamel demineralization process.⁽¹⁾

Chemin et al. evaluated the effect of the concentration on tooth sensitivity, they observed that the application of 10% hydrogen peroxide produced a higher risk of tooth sensitivity than did 4% hydrogen peroxide. The absolute risk of tooth sensitivity of the 10% hydrogen peroxide group was 64%, which is approximately double the one detected with the 4% hydrogen peroxide group, which corroborates with *Darriba et al.*'s results where patients from the groups of 7.5% hydrogen peroxide indicated higher intensity of tooth sensitivity than participants from the groups of 10% carbamide peroxide. Whereas in another study, there were no significant differences between these concentrations, like *De la Peña et al.* which registered 54% for a one-hour daily application for both concentrations of carbamide peroxide (15% and 10%), and 58% for a one-hour daily application for both concentrations of hydrogen peroxide (9.5% and 7.5%).^(10,12,14)

Mailart et al. studied the effect of the time on tooth sensitivity, in their study all groups presented similar risk of sensitivity, varying from 40 up to 60% throughout the treatment. In *Darriba et al.*'s study, both groups of 10% carbamide peroxide (1 hour a day and overnight) reported the same sensitivity (only 5% of participants). In *Sutil et al.*'s low tooth sensitivity levels have been shown after carbamide peroxide is applied for times as low as 30 min even if high concentration (37%) was used, these results are in agreement with those of *da Costa et al.* who showed effective bleaching when a high carbamide concentration (35%) was used for 30 min/day, without increase the levels of tooth sensitivity. According to *Darriba et al.* increasing the treatment by one week was related with higher incidence of side effects, but not statistically significant.^(7,8,11,13,14)

In *Da Costa et al.*'s study both bleaching systems yielded minimal side effects, with no differences between the methods. Of the participants, 21% reported mild tooth sensitivity when they used tray, and no symptoms were reported at the last appointment. Also, 25%



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of the participants reported mild gingival sensitivity during tray use, and 16% reported mild transient gingival sensitivity during strip use. None of the participants reported gingival or tissue sensitivity two weeks after treatment for both systems. In *Cordeiro et al.*'s no significant difference was seen in the absolute risk of tooth sensitivity but the results of the study showed a higher intensity of tooth sensitivity for the conventional bleaching tray compared with the strips and the prefilled disposable tray. Viscosity of the bleaching gel and the amount of gel in contact with the dental structure could be responsible for the different levels of tooth sensitivity.^(7,9)

6. CONCLUSION

After reviewing the studies on the effectiveness and adverse effects of home bleaching it can be concluded that:

1. At-home tooth bleaching is an effective treatment, but the effectiveness could be: time, concentration and delivery method dependent.

A higher concentration of bleaching gels applied for several shorter periods of time may retain color better at the beginning of treatment than low concentration gels applied for several longer periods of time (overnight application) or an extremely high concentration applied for a short period of time. But it seems like every treatments lead to the same effectiveness.

2. Tooth sensitivity is the main adverse effect of at-home tooth bleaching. Tooth sensitivity is mild and transitory but can vary with the concentration, time application or delivery methods of bleaching agents. In contrast, it can be reduced by the addition of desensitising agents.



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