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Interprofessional Collaboration among Family Physicians, Radiology Technologists, Pharmacists and Dental Assistants in Early Detection and Management of Osteoporosis through Dental Radiographic Screening

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Abstract

Interprofessional collaboration between family physicians, radiology technologists, pharmacists and dental teams offers a promising strategy for closing the osteoporosis detection and treatment gap. This systematic review synthesized evidence on (1) the diagnostic performance of dental panoramic radiographs for identifying individuals with low bone mineral density (BMD) and (2) models of collaborative care integrating primary care, pharmacy and oral health services for early detection and management of osteoporosis. Electronic databases were searched for studies published between 2010 and 2023. Ten original studies evaluating radiomorphometric indices or deep learning applied to dental panoramic radiographs against densitometric reference standards were included, alongside ten review/guideline papers on dental radiographic screening, interprofessional care and pharmacist-led osteoporosis management. Panoramic indices such as mandibular cortical width, mandibular cortical index and panoramic mandibular index consistently showed moderate to strong correlations with BMD and acceptable sensitivity and specificity for identifying osteopenia or osteoporosis, particularly in postmenopausal women. Recent deep-learning models further improved classification accuracy using panoramic images and clinical covariates. Reviews and guidelines highlighted the persistent treatment gap, the feasibility of opportunistic screening in dental settings and the positive impact of pharmacist- and team-based interventions on testing and treatment rates. An interprofessional pathway linking dental radiographic findings with family medicine and pharmacy services could enhance early detection and guideline-concordant management of osteoporosis.

Keywords: Osteoporosis; Dental panoramic radiography; Mandibular cortical index; Interprofessional collaboration; Family medicine; Pharmacist; Screening

1. Introduction

Osteoporosis is a major cause of fragility fractures and disability worldwide, yet under-diagnosis and under-treatment remain substantial despite clear international guidelines (LeBoff et al. 2022). Many high-risk adults, particularly postmenopausal women, never undergo bone mineral density (BMD) testing or receive anti-osteoporotic therapy, illustrating a persistent "osteoporosis care gap" (Dimai 2023; Laird et al. 2023).

Oral and maxillofacial structures are frequently affected by systemic bone loss. Reviews have described mandibular cortical thinning, increased porosity and reduced alveolar bone height as oral manifestations of osteoporosis,

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potentially visible on routine dental radiographs (Gulsahi 2015). Systematic reviews and meta-analyses have shown that mandibular radiomorphometric indices on dental panoramic radiographs, such as mandibular cortical width, mandibular cortical index and panoramic mandibular index, are moderately accurate predictors of low skeletal BMD when compared with dual-energy X-ray absorptiometry (DXA) (Calciolari et al. 2015; Munhoz et al. 2021). A narrative review emphasised that "innovative and sustainable use" of panoramic radiographs for osteoporosis detection could transform dental clinics into opportunistic screening sites, provided robust referral pathways to medical services exist (Yeung et al. 2020).

In parallel, endocrine and osteoporosis guidelines highlight the need for coordinated, multidisciplinary care, including primary care physicians, specialists and allied health professionals, to improve fracture risk assessment, initiation of therapy and long-term adherence (LeBoff et al. 2022; Dimai 2023). Systematic reviews of pharmacist interventions show that medication reviews, patient education and collaborative management increase rates of BMD testing and appropriate pharmacotherapy (Laird et al. 2023; "Pharmacists can play a key role…" 2010). Concept papers and empirical work on interprofessional collaboration in osteoporosis care further demonstrate that structured teamwork models in primary care and continuing-care settings improve implementation of guideline-recommended care (Toh et al. 2017; Masterson et al. 2016).

Despite these advances, the interface between dental radiographic screening and interprofessional medical management remains under-explored. Reviews of panoramic indices have mainly focused on diagnostic accuracy, with limited attention to how dentists, family physicians, radiology technologists, pharmacists and dental assistants can practically collaborate to implement opportunistic screening and follow-up pathways (Calciolari et al. 2015; Yeung et al. 2020).

The aim of this systematic review is therefore twofold: (1) to synthesize original research on the performance of dental panoramic radiographs in detecting low BMD or osteoporosis and (2) to integrate review and guideline evidence on interprofessional collaboration in osteoporosis care, with a focus on roles for family physicians, radiology technologists, pharmacists and dental assistants in implementing dental radiographic screening and subsequent management.

2. Methods

This review was conducted in accordance with the PRISMA 2020 statement (Page et al. 2021).

2.1. Eligibility criteria

We included original human studies that:

- Used dental radiographs (primarily panoramic radiographs) to derive radiomorphometric indices or image-based models for detecting low BMD or osteoporosis.
- Employed a densitometric reference standard (DXA or quantitative ultrasound) or established clinical criteria.
- Reported quantitative associations (correlations, odds ratios) or diagnostic performance measures (sensitivity, specificity, area under the curve).
- Were published in peer-reviewed journals between 1 January 2010 and 31 December 2023 in English.

These studies constituted the "A. ORIGINAL" set. Review articles, meta-analyses and major clinical guidelines addressing osteoporosis detection using dental radiography, interprofessional collaboration or pharmacist-led osteoporosis interventions during the same period formed the "B. REVIEW / META-ANALYSIS" set. We excluded case reports, editorials and studies without either a radiographic index or a reference standard.

2.2. Information sources and search strategy

Electronic searches were performed in MEDLINE, Embase, Scopus, Web of Science and the Cochrane Library, using combinations of controlled vocabulary and free-text terms related to osteoporosis, bone mineral density, dental panoramic radiography, mandibular indices, pharmacists, family medicine, primary care, interprofessional collaboration and screening. Reference lists of relevant articles and reviews were screened to identify additional publications (Calciolari et al. 2015; Yeung et al. 2020; Laird et al. 2023).

2.3. Study selection and data extraction

Two reviewers independently screened titles and abstracts, assessed full texts for eligibility and resolved disagreements by discussion. From each included original study we extracted country, setting, participant characteristics, study design,

radiographic modality and indices, reference standard, main diagnostic or correlation outcomes, and any descriptions of referral or interprofessional management pathways. For review and guideline articles, we summarized key conclusions related to diagnostic performance, opportunistic screening and collaborative care models.

2.4. Quality appraisal and synthesis

For diagnostic accuracy and cross-sectional studies, domains analogous to QUADAS-2 (patient selection, index test, reference standard, flow and timing) were considered when interpreting findings, although formal scoring was not undertaken due to heterogeneity. For reviews, we noted whether they were systematic, narrative or guideline-based. Given substantial clinical and methodological diversity (different indices, thresholds and reference sites), meta-analysis was not attempted. Instead, we conducted a structured narrative synthesis, grouping findings by conventional radiomorphometric indices, deep-learning approaches and implications for interprofessional collaboration.

3. Results

3.1. Overview of included studies

Ten original studies met the inclusion criteria (Table 1). These comprised cross-sectional, diagnostic accuracy and machine-learning designs from diverse settings, but all focused on adults, mostly postmenopausal women, undergoing both panoramic radiography and BMD assessment (Gaur et al. 2013; Bhatnagar et al. 2013; Bajoria et al. 2015; Marandi et al. 2010; Leite et al. 2010; Balto et al. 2018; Grocholewicz et al. 2018; Triantafyllopoulos et al. 2023; Jacob et al. 2022; Kim et al. 2022). Most studies were conducted in dental or oral medicine clinics, with DXA or quantitative ultrasound as reference standards. Mandibular cortical width, mandibular cortical index and panoramic mandibular index were the most frequently assessed indices.

Ten review or guideline articles were used to frame the broader context of panoramic screening and interprofessional osteoporosis care (Calciolari et al. 2015; Munhoz et al. 2021; Yeung et al. 2020; Gulsahi 2015; LeBoff et al. 2022; Dimai 2023; Laird et al. 2023; Toh et al. 2017; Masterson et al. 2016; “Pharmacists can play a key role…” 2010).

3.2. Characteristics of the included original studies

3.2.1. Conventional radiomorphometric indices

Several early-decade studies established foundational evidence for mandibular indices. In Brazilian and Iranian cohorts, Leite et al. and Marandi et al. examined seven panoramic radiomorphometric indices, showing that thinner mandibular cortices and lower panoramic mandibular index values were significantly associated with lower lumbar spine and femoral neck BMD in postmenopausal women (Leite et al. 2010; Marandi et al. 2010). These studies proposed preliminary threshold values but emphasised that indices were best suited for identifying women at risk rather than confirming osteoporosis.

Gaur et al. conducted a cross-sectional study of 40 Indian postmenopausal women, measuring mental index, panoramic mandibular index, gonial and antegonial indices and mandibular cortical index on panoramic radiographs, with DXA as the reference. They reported statistically significant correlations between several indices and BMD, and concluded that dentists using orthopantomographs “may play a vital role in screening patients with osteoporosis, mainly among post-menopausal women” (Gaur et al. 2013).

Bhatnagar et al. evaluated mandibular cortical width and cortical shape on panoramic radiographs in postmenopausal women, comparing them with ultrasound-based tibial BMD (Bhatnagar et al. 2013). Mandibular cortical erosion and reduced width were associated with low BMD; combined cortical findings yielded 96% specificity and 60% sensitivity, while cortical width alone achieved 73% sensitivity and 58% specificity, supporting panoramic radiographs as a reasonably specific screening tool.

Bajoria et al. analysed radiomorphometric indices in 23 Indian dental patients aged 18–70 years, demonstrating that indices such as mental index, panoramic mandibular index and mandibular cortical index decreased with age and showed lower values in women (Bajoria et al. 2015). They highlighted mandibular cortical index as a simple, visual parameter suitable for routine screening.

3.2.2. Population-specific and regional studies

Balto et al. investigated dental panoramic radiographic indices in postmenopausal Saudi women, comparing mandibular cortical width and cortical index with DXA-derived BMD (Balto et al. 2018). Logistic regression indicated that severely eroded cortices and cortical widths below proposed thresholds significantly increased the odds of osteoporosis. The authors recommended that dentists refer women with eroded mandibular cortices for densitometric evaluation.

Grocholewicz et al. combined panoramic radiography with quantitative ultrasound of the radius and proximal phalanx in Polish postmenopausal women, showing that higher categories of mandibular cortical index (reflecting greater cortical porosity) were associated with lower ultrasound T-scores and mandibular height (Grocholewicz et al. 2018). In women with osteopenia or osteoporosis, mandibular cortical width and mandibular ratio were significantly reduced, reinforcing the potential of mandibular cortical index as an adjunctive marker.

Triantafyllopoulos et al. introduced a novel aspect by combining dental panoramic indices with age at menarche in Greek women attending hospital clinics (Triantafyllopoulos et al. 2023). They found that earlier menarche, thinner mandibular cortex and higher cortical erosion grades were associated with lower BMD, suggesting that incorporating reproductive history into risk algorithms might refine referral decisions from dental settings to family physicians.

Jacob et al. studied postmenopausal women attending a family medicine outpatient department in India, assessing the "efficacy of digital panoramic radiograph as an adjunctive screening tool for osteoporosis" (Jacob et al. 2022). Mandibular cortical width measured on digital panoramics correlated with calcaneal quantitative ultrasound parameters; the authors concluded that digital panoramic radiographs taken for routine dental reasons in primary care–linked hospitals could be used to identify women requiring further osteoporosis assessment, explicitly highlighting the need for collaboration between family physicians, dental surgeons and radiology services.

3.2.3. Deep-learning approaches

Moving beyond manual indices, Kim et al. developed an ensemble deep-learning model using cropped mandibular regions from 778 panoramic radiographs of patients who also underwent hip or spine DXA (Kim et al. 2022). EfficientNet-B7 and ResNet-152-based convolutional neural networks were trained to classify osteoporosis versus non-osteoporosis; adding clinical covariates (age, sex and BMD-related variables) to the image-based model significantly improved accuracy. The ensemble models achieved high area under the curve values, suggesting that deep learning applied to routine dental images could provide automated risk stratification to support clinicians.

Collectively, the original studies demonstrate that both qualitative (mandibular cortical index categories) and quantitative (cortical width, panoramic mandibular index) radiomorphometric indices correlate with systemic BMD, and that performance can be enhanced through advanced image analysis. However, thresholds and measurement protocols varied considerably, limiting direct comparison.

3.2.4. Diagnostic performance and thresholds

Systematic reviews and meta-analyses provide a broader view of diagnostic performance. Calciolari et al. analysed panoramic measures for oral bone mass in detecting osteoporosis, reporting pooled sensitivity and specificity estimates for mandibular cortical width and cortical index that supported their use as preliminary risk indicators rather than definitive diagnostic tools (Calciolari et al. 2015). Munhoz et al. focused on the mandibular cortical index in postmenopausal women, concluding that an eroded or severely eroded cortex is associated with increased odds of low BMD, but highlighted substantial heterogeneity and methodological limitations across studies (Munhoz et al. 2021).

Yeung and Mozos summarised evidence that panoramic radiographs are widely available, low-dose and relatively inexpensive, making them attractive for opportunistic screening if combined with robust referral pathways (Yeung et al. 2020). Gulsahi emphasised that jawbone changes alone cannot replace densitometry, but they can trigger further evaluation in high-risk women (Gulsahi 2015). Deep-learning reviews similarly suggest that AI-based analysis of radiographs, including panoramic images, can reach diagnostic accuracies comparable to conventional DXA-based risk tools in selected settings (Dimai 2023).

Within this review's original studies, sensitivities typically ranged from moderate to high when broad thresholds were used (e.g. any cortical erosion), at the cost of specificity (Gaur et al. 2013; Bhatnagar et al. 2013; Balto et al. 2018). Specificity improved when combining multiple indices or applying stricter cut-offs for cortical width, but some low-BMD individuals were missed. AI-based models such as those of Kim et al. achieved higher overall accuracy, suggesting that automated analysis could help standardise interpretation and reduce observer variability (Kim et al. 2022).

3.3. Interprofessional implications: family physicians, radiology technologists, pharmacists and dental assistants

Although most original radiographic studies were conducted within dental settings, several explicitly proposed that dentists or oral radiologists should refer high-risk patients, identified via panoramic indices, to medical services for formal osteoporosis assessment (Gaur et al. 2013; Balto et al. 2018; Jacob et al. 2022). Reviews reinforce this concept, framing dentists as "front-line screeners" who can recognise mandibular signs of systemic bone loss and trigger further evaluation (Yeung et al. 2020; Gulsahi 2015).

The broader osteoporosis literature demonstrates that coordinated interprofessional models improve care. The NOF clinician's guide emphasises that optimal prevention and treatment require collaboration among primary care physicians, specialists, pharmacists and allied professionals, including structured communication about fracture risk and treatment plans (LeBoff et al. 2022). Dimai highlighted AI-supported decision tools as potential aids for multidisciplinary teams to prioritise high-risk patients (Dimai 2023).

Laird et al.'s systematic review showed that pharmacist-delivered interventions, such as medication reviews, patient counselling and reminder systems, significantly increased BMD testing and appropriate initiation of anti-resorptive therapy, especially when pharmacists worked closely with primary care physicians (Laird et al. 2023). A Canadian knowledge-translation paper concluded that community pharmacist screening programs "doubled the number of patients tested and treated for osteoporosis" compared with usual care ("Pharmacists can play a key role" 2010). Complementary evidence from interprofessional initiatives in primary and continuing-care settings further supports structured collaboration around osteoporosis management (Toh et al. 2017; Masterson et al. 2016).

In the context of dental panoramic screening, these findings imply that radiology technologists and dental assistants can help ensure high-quality, standardised panoramic images and apply validated measurement protocols, while dentists and oral radiologists interpret indices or AI outputs. Abnormal findings could be communicated to family physicians via structured reports, embedded alerts in shared electronic health records or direct referral letters. Family physicians would then confirm diagnosis with DXA, assess fracture risk, manage secondary causes and initiate pharmacologic therapy in collaboration with pharmacists, who could optimise medication selection, address adherence barriers and monitor for adverse effects (LeBoff et al. 2022; Laird et al. 2023).

Table 1 Characteristics of included original studies (A. ORIGINAL)

First author (year)	Country / setting	Population	Design	Radiographic modality & indices	Reference standard	Main findings relevant to osteoporosis screening
Leite (2010)	Brazil; dental school clinic	Postmenopausal women undergoing dental care	Cross-sectional	Panoramic radiographs; seven radiomorphometric indices (including mandibular cortical width, panoramic mandibular index, mandibular cortical index)	DXA at lumbar spine and femoral neck	Several indices, especially mandibular cortical width and cortical index, correlated significantly with BMD; proposed that panoramic indices can help identify women at risk of low bone mass.
Marandi (2010)	Iran; radiology unit	Women referred for BMD testing	Cross-sectional	Panoramic-based mandibular indices (mental index, panoramic mandibular index,	DXA of femoral neck and lumbar vertebrae	Lower radiomorphometric values were associated with reduced BMD; mandibular indices showed moderate ability

				mandibular cortical index)		to distinguish normal from osteopenic / osteoporotic women.
Gaur (2013)	India; oral medicine department	40 postmenopausal women (40–69 years)	Cross-sectional diagnostic	Panoramic radiographs; mental, panoramic mandibular, gonial, antegonial indices and mandibular cortical index	DXA BMD	Multiple indices showed significant correlations with BMD; eroded mandibular cortices and low indices were frequent in osteopenic / osteoporotic women; dentists using orthopantomographs can contribute to opportunistic screening.
Bhatnagar (2013)	India; dental college hospital	Postmenopausal women with variable BMD	Cross-sectional diagnostic	Panoramic radiographs; mandibular cortical width and cortical shape	Quantitative ultrasound at mid-shaft tibia	Combined cortical erosion and cortical width demonstrated 96% specificity and 60% sensitivity for low BMD; mandibular cortical shape alone had strong association with osteoporosis.
Bajoria (2015)	India; dental radiology clinic	23 adults (both sexes, 18–70 years)	Cross-sectional	Panoramic radiographs; mental index, panoramic mandibular index, mandibular cortical index, gonial and antegonial indices	No densitometric gold standard; age- and sex-related trends	Radiomorphometric indices declined with age and were lower in females; mandibular cortical index and cortical width considered simple, feasible screening parameters in routine panoramics.
Balto (2018)	Saudi Arabia; dental hospital	Postmenopausal Saudi women	Cross-sectional diagnostic	Panoramic radiographs; mandibular cortical width, cortical index and other indices	DXA BMD	Severely eroded cortices and reduced cortical width significantly increased odds of osteoporosis; authors proposed panoramic thresholds to

						trigger referral for DXA.
Grocholewicz (2018)	Poland; university clinic	Postmenopausal women	Cross-sectional	Panoramic radiographs; mandibular cortical index, cortical width, mandibular ratio	Quantitative ultrasound of radius and proximal phalanx	Higher mandibular cortical index categories (greater porosity) and reduced cortical width were associated with lower ultrasound T-scores; mandibular cortical index significantly correlated with skeletal status and mandibular height.
Jacob (2022)	India; family medicine outpatient setting	Postmenopausal women attending primary care–affiliated hospital	Cross-sectional diagnostic	Digital panoramic radiographs; mandibular cortical width and cortical index	Calcaneal quantitative ultrasound	Mandibular cortical measurements on digital panoramics correlated with ultrasound parameters; digital panoramics were considered effective adjunctive tools for opportunistic osteoporosis screening in collaboration with family physicians.
Triantafyllopoulos (2023)	Greece; medical and dental schools	Adult women	Cross-sectional diagnostic	Dental panoramic radiographs; mandibular cortical width and cortical index, combined with age at menarche	DXA BMD	Early menarche, thinner mandibular cortices and eroded cortical shapes were associated with lower BMD; combining reproductive history with panoramic indices improved risk stratification.
Kim (2022)	Japan; hospital radiology service	Adults undergoing DXA and panoramic imaging (778	Retrospective diagnostic with deep learning	Dental panoramic radiographs; convolutional neural networks (EfficientNet-B7,	DXA at hip or spine	Ensemble deep-learning models using mandibular regions plus clinical covariates achieved high

		usable images)		ResNet-152) with and without clinical covariates		accuracy for classifying osteoporosis vs non-osteoporosis, supporting automated screening based on routine panoramics.

4. Discussion

This systematic review confirms that dental panoramic radiographs can provide clinically useful indicators of low BMD and that integrating such findings into interprofessional care pathways has the potential to improve early detection and management of osteoporosis. Across diverse populations, mandibular cortical width, cortical index and related radiomorphometric measures consistently correlated with densitometric measures of bone status (Leite et al. 2010; Marandi et al. 2010; Gaur et al. 2013; Grocholewicz et al. 2018). Studies such as those by Bhatnagar and Balto further demonstrated acceptable sensitivity and specificity for identifying osteopenic or osteoporotic women, especially when cortical erosion and width thresholds were combined (Bhatnagar et al. 2013; Balto et al. 2018).

These findings align with systematic reviews showing that mandibular cortical index and cortical width have moderate diagnostic performance, suitable for preliminary triage rather than definitive diagnosis (Calciolari et al. 2015; Munhoz et al. 2021). Heterogeneity in index definitions, measurement techniques and thresholds, however, limits comparability and hinders development of universal cut-off values. Narrative reviews have therefore emphasised the role of panoramic radiographs as opportunistic screening tools that should prompt referral for DXA when abnormalities are present, rather than replacing established diagnostic standards (Yeung et al. 2020; Gulsahi 2015).

The inclusion of Jacob's family medicine–linked study and Triantafyllopoulos' work combining reproductive history with panoramic indices illustrates how radiographic screening can be embedded into broader clinical workflows (Jacob et al. 2022; Triantafyllopoulos et al. 2023). In these models, dentists and dental radiology teams perform risk stratification using panoramic images, while family physicians interpret these findings alongside other clinical risk factors and arrange confirmatory testing and treatment.

Emerging AI-based approaches represent an important evolution. Kim et al. demonstrated that convolutional neural networks trained on segmented mandibular regions, especially when combined with clinical covariates, can classify osteoporosis with high accuracy from panoramic images (Kim et al. 2022). Reviews of AI in osteoporosis similarly highlight that such tools could be integrated into radiology workflows to automatically flag high-risk patients for clinician review (Dimai 2023). For radiology technologists and dental assistants, this implies future roles in ensuring consistent image acquisition and quality control to support reliable AI outputs.

The broader osteoporosis care literature underscores the need for interprofessional collaboration. The clinician's guide stresses that fracture prevention requires coordinated efforts by primary care physicians, specialists and allied health professionals, including attention to risk factors, fall prevention and adherence to therapy (LeBoff et al. 2022). Pharmacist-led interventions have been shown to increase rates of BMD testing and appropriate treatment initiation, as well as to improve medication adherence (Laird et al. 2023; "Pharmacists can play a key role…" 2010). Interprofessional analyses and case examples using frameworks such as the D'Amour model demonstrate that clearly defined roles, shared goals and structured communication channels are essential for sustainable collaboration in osteoporosis programs (Toh et al. 2017; Masterson et al. 2016).

Bringing these strands together, an interprofessional pathway for dental radiographic screening might involve: (1) radiology technologists and dental assistants acquiring high-quality panoramic images during routine dental visits; (2) dentists or AI tools assessing mandibular cortical indices; (3) structured reporting of "at-risk" findings to family physicians; and (4) pharmacists collaborating with physicians to optimise pharmacologic management and adherence once osteoporosis or high fracture risk is confirmed. Such a model could reduce missed opportunities for early detection, particularly among postmenopausal women who regularly attend dental appointments but rarely receive BMD testing.

Nevertheless, several gaps remain. Most radiographic studies were single-centre and cross-sectional, with limited information on downstream clinical outcomes, such as actual referral rates, initiation of therapy or fracture reduction. Data specifically involving dental assistants, radiology technologists and pharmacists in integrated pathways were sparse. Future research should evaluate real-world interprofessional implementations of panoramic screening, include economic evaluations and explore patient perspectives on receiving osteoporosis risk information in dental settings.

5. Conclusion

Dental panoramic radiographs provide valuable information about mandibular cortical morphology and can serve as practical, low-cost tools for opportunistic osteoporosis risk screening. Radiomorphometric indices and deep-learning approaches demonstrate meaningful associations with systemic BMD and acceptable diagnostic performance. When combined with guideline-driven interprofessional care, linking dentists, radiology technologists, family physicians, pharmacists and dental assistants, panoramic findings can trigger timely DXA testing, risk assessment and initiation of therapy. To fully realise this potential, future work should standardise radiographic thresholds, integrate AI-supported decision tools and test collaborative care pathways that embed dental radiographic screening into routine primary and pharmacy-based osteoporosis services.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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