

CBCT Use Among General Dentists in Nebraska

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Introduction

This analysis investigates the use and distribution of Cone Beam Computed Tomography (CBCT) in general dental practices in Nebraska. The goals include evaluating CBCT prevalence, its association with practice characteristics, and identifying referral patterns and factors influencing CBCT adoption.

Dataset Structure

This dataset contains responses from 51 general dental practices in Nebraska, collected via a survey. The primary focus is to assess the availability and usage of Cone Beam Computed Tomography (CBCT) technology in routine dental practice.

Key Variables

`cbct_abundance`: Indicates whether the practice owns a CBCT unit (Yes/No) — target variable.

`practice_location`: Urban, Suburban, or Rural classification of the dental office.

`practice_size`: Number of general dentists working in the practice.

`digital_radiograph_sensors`: Whether the practice uses digital radiograph sensors (Yes/No).

`cbct_interpretation`: How CBCT scans are interpreted (self-read, referred out, etc.) — applicable only to those with CBCT.

`scans_for_others`: Whether the practice performs scans for other dentists.

`limited_field_cbct`: If the CBCT machine allows limited field-of-view scans.

`refer_for_cbct`: For practices without CBCT, whether they refer patients for scans.

referral_location: Whom they refer patients to, if applicable.

Data Cleaning

The observed missingness in fields such as `cbct_interpretation` and `limited_fov_cbct` is structural. These fields are conditionally inapplicable for respondents who indicated not having a CBCT machine. Hence, they are not treated as missing for imputation or analysis. To address structural missingness in the dataset, blank responses in follow-up CBCT-related questions were recoded as “Not Applicable” only for clinics that reported not having a CBCT machine (`CBCT_abundance == “No”`). These blanks were identified as empty strings rather than true NA values. After cleaning, the timestamp column was removed for analysis.

Exploratory Data Analysis (EDA)

In this section we will show some Exploratory Analysis that will help us to understand data structure and relevant relationship among the variables

CBCT Ownership Prevalence

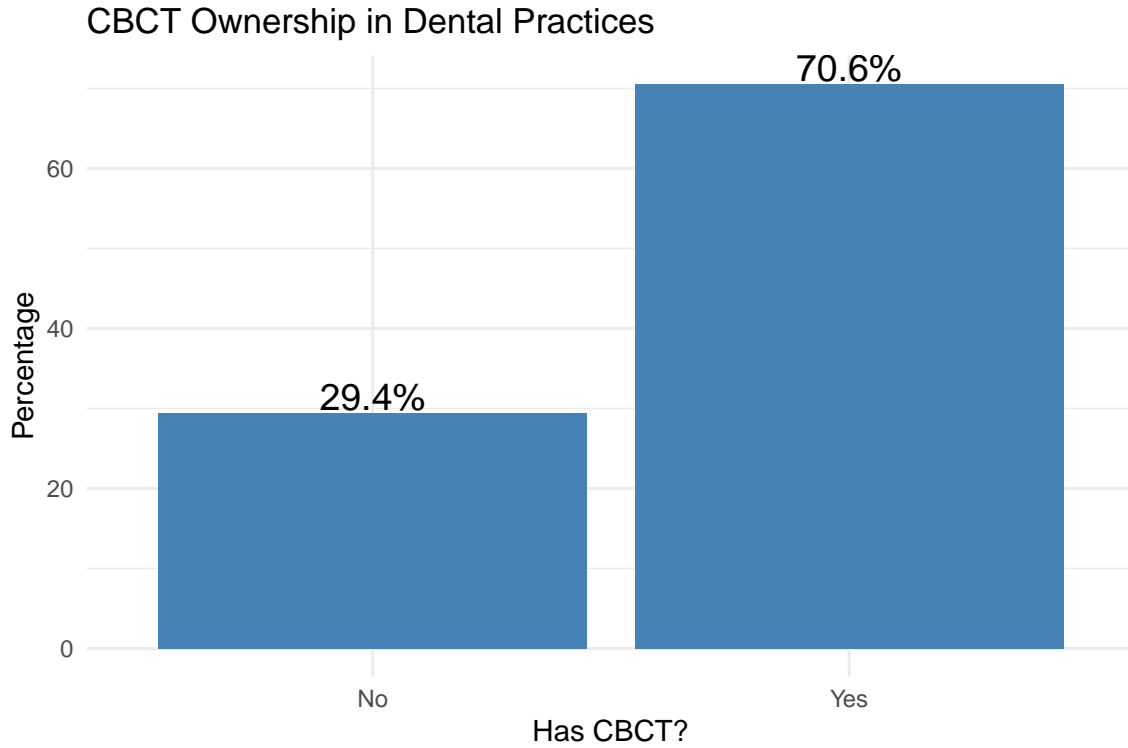
The bar chart displays the distribution of CBCT ownership among general dental practices in Nebraska — the primary outcome of interest in this study. A substantial 70.6% of surveyed practices reported owning a CBCT unit, while 29.4% do not.

This indicates that the majority of general practices in the sample have adopted CBCT technology, suggesting relatively widespread access. The remaining 29.4% represent a critical group for understanding barriers to adoption, such as practice size, location, or resource availability.

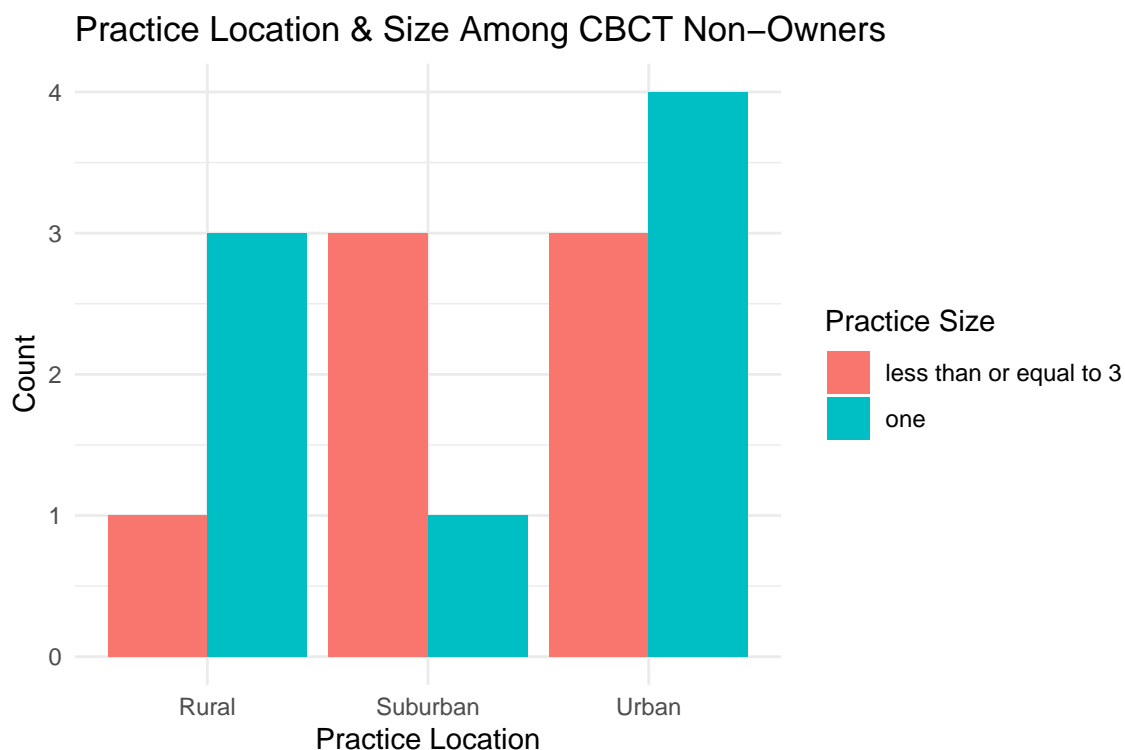
df\$cbct_abundance	n	percent
No	15	29.4%
Yes	36	70.6%

Table 1: Practice Location and Size Among CBCT Non-Owners

practice_location	practice_size	n
Urban	one	4
Rural	one	3
Suburban	less than or equal to 3	3
Urban	less than or equal to 3	3
Rural	less than or equal to 3	1
Suburban	one	1



Among the 29.4% of dental practices that do not own a CBCT unit, most are located in either urban or rural areas and are operated by a solo dentist or a small team (3 dentists). Urban solo practices make up the largest subgroup (4 out of 15 non-owners), while suburban practices without CBCT primarily consist of small teams. Across all locations, non-ownership of CBCT appears concentrated in smaller practices, regardless of geography. This pattern reinforces the idea that number of dentists and location may be barriers to CBCT adoption



Descriptive Summary Table

This summary table highlights three foundational characteristics of dental practices in the dataset. These factors — location, size, and use of digital radiographs — were chosen as key predictors of CBCT ownership based on theoretical relevance and data completeness. They reflect the structural and technological capacity of a practice and are thus ideal for inclusion in predictive modeling.

Practice Location: The majority of practices are in rural (47.1%) or urban (37.3%) areas, with fewer in suburban locations.

Practice Size: Over half of the practices are solo-operated, and about 39% have 2–3 dentists, suggesting mostly small to mid-size practices.

Digital Radiograph Sensors: A vast majority (96.1%) of practices use digital radiography, indicating a high level of digital tech readiness.

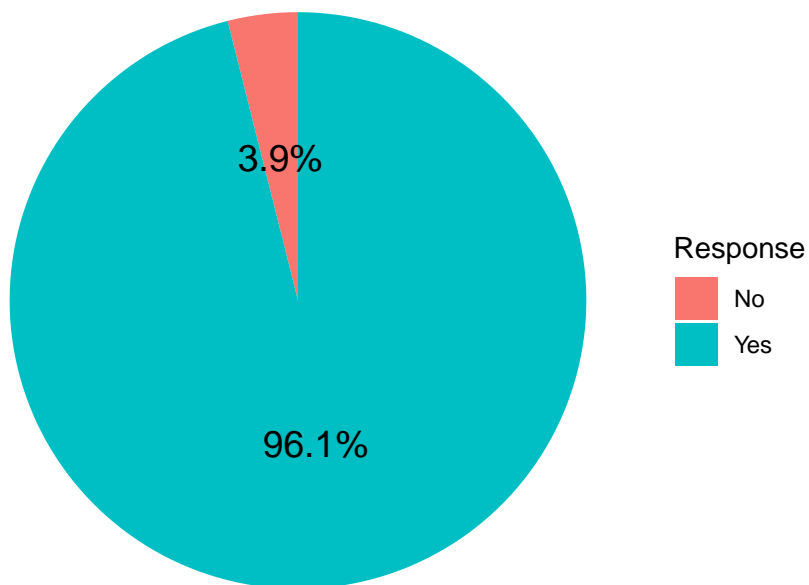
Table 2: Descriptive Summary Table

variable	level	n	percentage
Practice Location	Rural	24	47.1
	Suburban	8	15.7
	Urban	19	37.3
Practice Size	greater than 5	1	2.0
	less than or equal to 3	20	39.2
	less than or equal to 5	2	3.9
Digital Radiograph	one	28	54.9
	No	2	3.9
	Yes	49	96.1

Digital Radiograph Availability

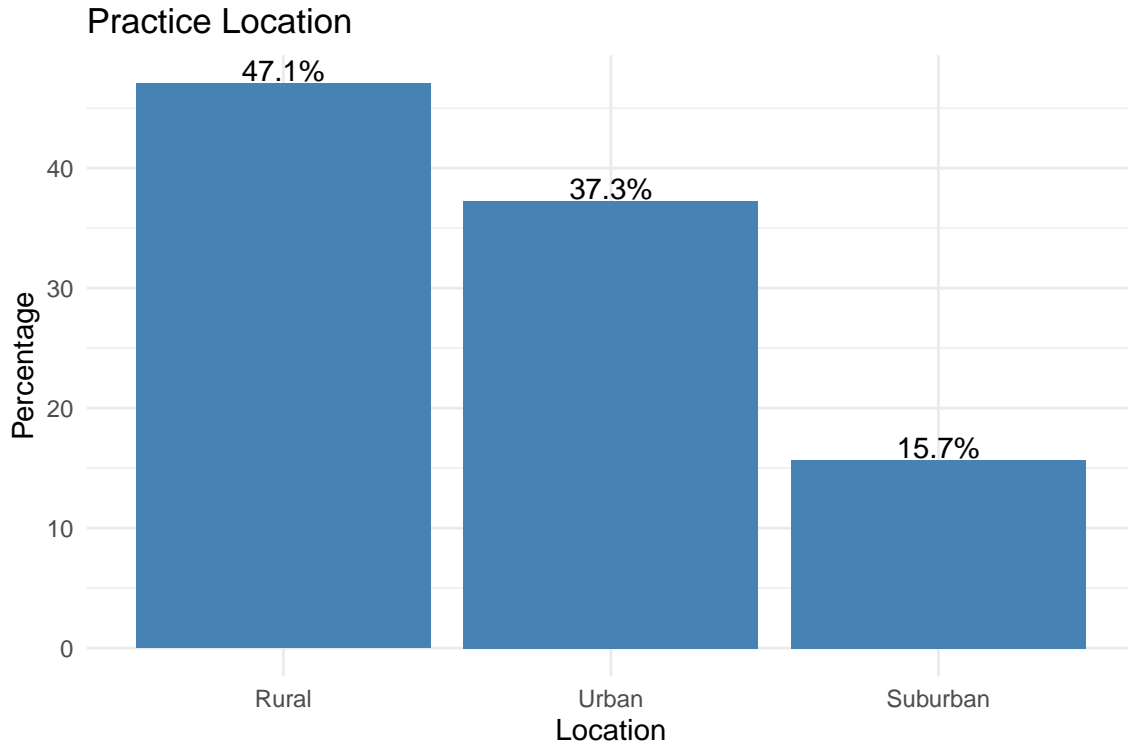
The pie chart reveals that 96.1% of the surveyed dental practices use digital radiograph sensors, with only 3.9% still relying on non-digital methods. This high prevalence of digital radiography suggests that most practices are already equipped with foundational digital imaging technologies, which may ease the transition toward adopting more advanced systems like CBCT.

Digital Radiograph Availability



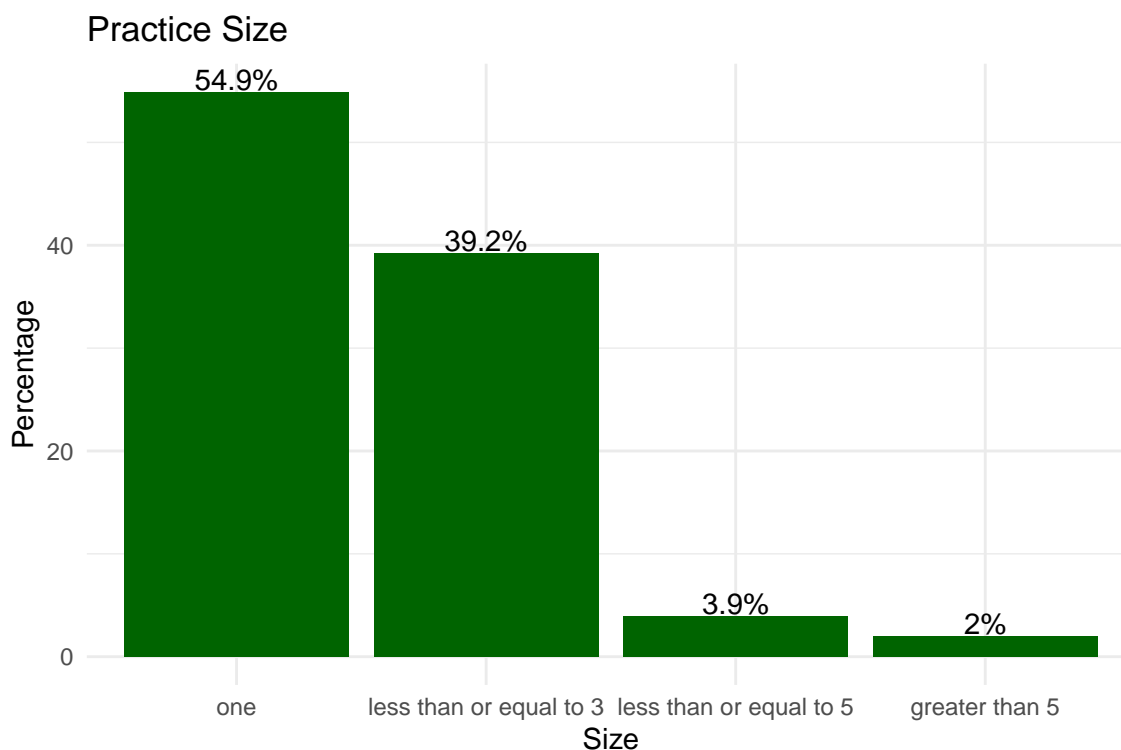
Practice Location Distribution

According to the bar chart, 47.1% of dental practices are located in rural areas, followed by 37.3% in urban areas, and 15.7% in suburban locations. This distribution highlights the prominence of rural and urban practices in the sample, and it provides important context when interpreting CBCT ownership trends and access to diagnostic technology across geographic settings.



Practice Size Breakdown

The majority of practices are relatively small, with 54.9% being solo-operated and another 39.2% having 2–3 general dentists. Only a small fraction of practices are larger, with 3.9% having up to five dentists and just 2% reporting more than five. This size distribution suggests that most practices may face resource limitations that could impact their ability to adopt high-cost imaging technologies like CBCT.



CBCT Ownership by Practice Characteristics

The following plots display the proportion of CBCT ownership across different levels of practice size and practice location. Each bar represents the distribution of practices with and without CBCT within that category.

The first plot shows the proportion of CBCT ownership by practice size. Practices with more than five dentists or those categorized as having “less than or equal to 5” show 100% ownership, while ownership drops for smaller practices. Among solo practices and those with three or fewer dentists, approximately 30–40% do not own CBCT units, indicating that smaller practices are less likely to adopt the technology—possibly due to cost, space, or workload constraints.

The second plot illustrates CBCT ownership by practice location. CBCT adoption appears highest in rural areas, where about 80% of practices own a CBCT unit. In contrast, suburban areas show only 50% ownership, and urban practices fall in between. This suggests that rural practices may rely more on in-house CBCT due to fewer referral options, while suburban and urban practices may have easier access to external imaging services, reducing the need for ownership.

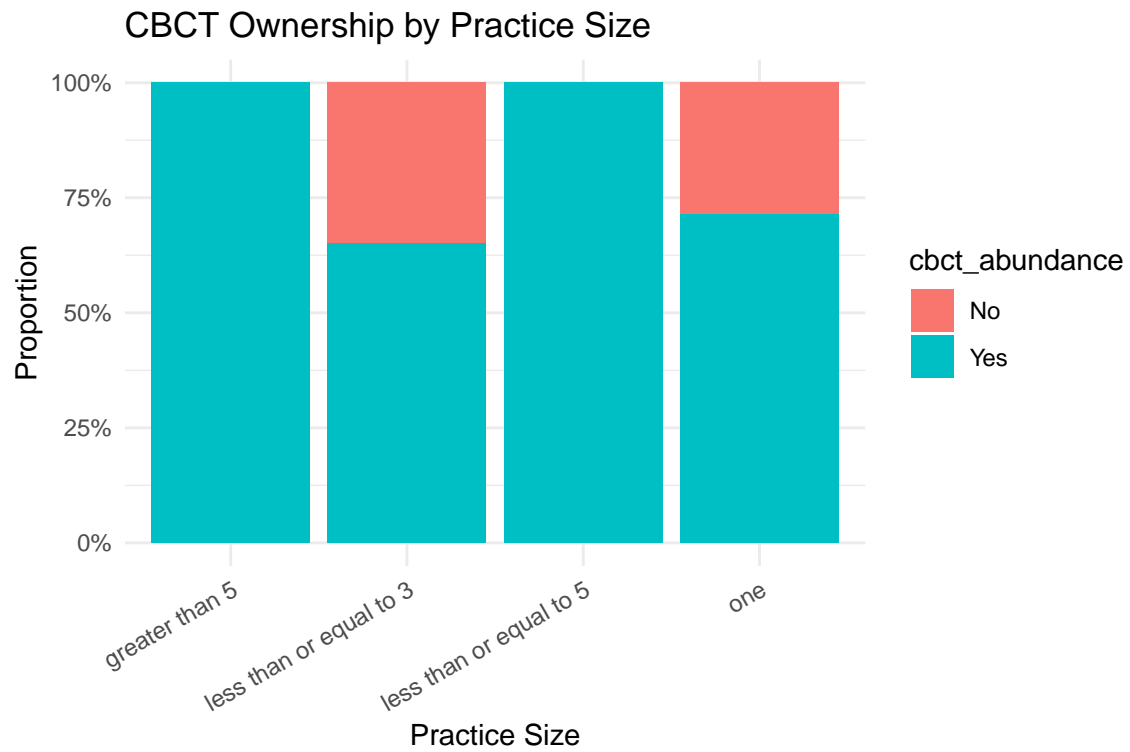


Figure 1: CBCT Ownership by Practice Size and Location

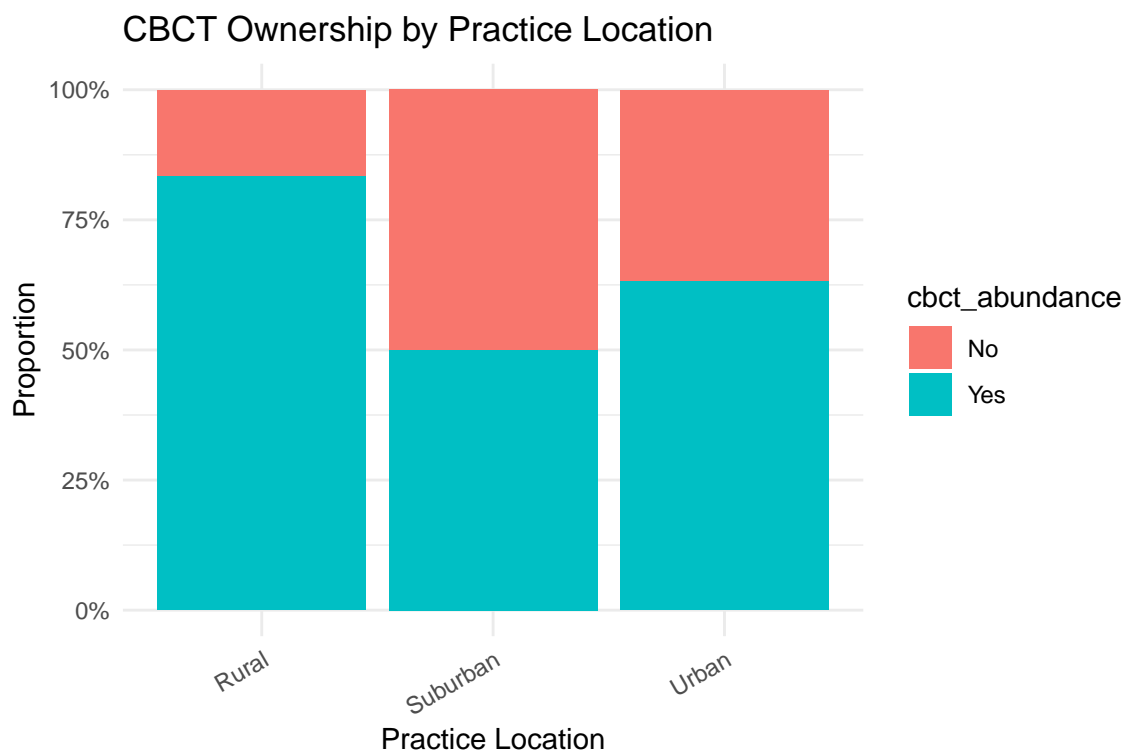


Figure 2: CBCT Ownership by Practice Size and Location

CBCT-Related Practice Patterns

Out of the 51 surveyed practices, 70.6% reported owning a CBCT unit. Among these CBCT users, the majority (77.8%) indicated they interpret their own CBCT scans, suggesting high confidence and integration of CBCT into their clinical workflows. A smaller proportion refer images to an oral radiologist (5.6%) or oral surgeon (2.8%), while 13.9% report other interpretation strategies.

When asked if they scan for other dentists, only 8.3% of CBCT owners provide scans for outside practices, while 91.7% use CBCT exclusively for their own patients. This suggests that most CBCT units are used in-house rather than as a shared resource.

Additionally, 97.2% of CBCT owners have machines with limited field-of-view capabilities, indicating preference or prioritization of compact, diagnostic imaging tailored to smaller anatomical regions.

Among the 29.4% of practices that do not own CBCT, a large majority (93.3%) reported referring patients to other facilities for scans. This shows that while non-ownership does not

Table 3: CBCT Flowchart Summary Table (Extended)

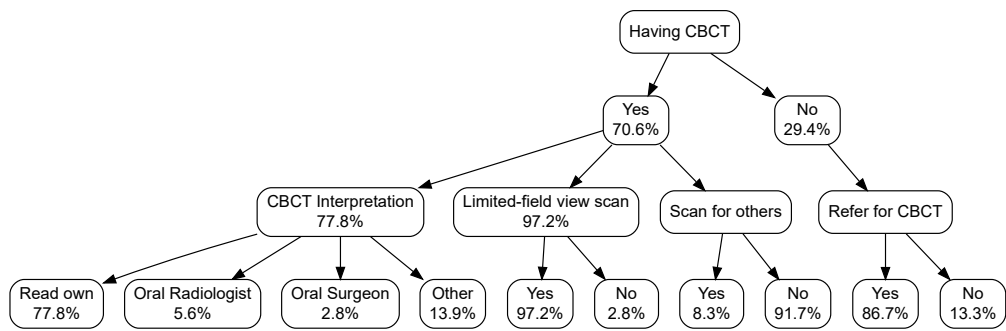
variable	level	n	percentage
Having CBCT	No	15	29.4
	Yes	36	70.6
CBCT Interpretation	I read my own CBCT scans	28	77.8
	Send them to an Oral Surgeon	1	2.8
	Send them to an Oral radiologist	2	5.6
	other	5	13.9
Scans for Others	No	33	91.7
	Yes	3	8.3
Limited Field View Scan	No	1	2.8
	Yes	35	97.2
Refer for CBCT (Among No CBCT)	No	1	6.7
	Yes	14	93.3

eliminate access to CBCT, it likely introduces external dependencies and potential workflow delays.

CBCT Ownership Flowchart

The flowchart illustrates the decision pathways and practice patterns associated with CBCT ownership among surveyed dental practices. It begins with 70.6% of practices reporting ownership of a CBCT unit, while 29.4% do not. Among those who own CBCT, 77.8% read their own scans, whereas others refer to an oral radiologist (5.6%), an oral surgeon (2.8%), or use other methods (13.9%). Regarding collaboration, 91.7% do not scan for other dentists, and only 8.3% do. Additionally, 97.2% of CBCT owners report having limited-field view capability, suggesting a preference for compact or focused imaging systems.

For the 29.4% without CBCT, the flowchart shows that 93.3% refer patients out for CBCT scans, while 6.7% do not, potentially indicating limited access or need. Overall, the flowchart provides a clear, visual summary of how practices integrate or navigate CBCT use in their clinical workflow.



Model

To better understand the factors associated with CBCT adoption in general dental practices, we developed predictive models using CBCT ownership (`cbct_abundance`) as the response variable. Based on the exploratory data analysis and theoretical relevance, three key practice-level predictors were selected: practice location, practice size, and digital radiograph availability. These variables reflect geographic context, clinical capacity, and technological readiness—factors that may influence a practice’s ability or decision to invest in CBCT technology.

To explore the factors associated with CBCT adoption among general dental practices, we began by conducting Pearson’s Chi-square tests of independence to assess the bivariate relationships between CBCT ownership (`cbct_abundance`) and selected practice characteristics. These initial tests provided insight into whether practice location, size, and digital radiograph availability were significantly associated with owning CBCT.

Building on these findings, we developed predictive models using logistic regression, decision tree, and random forest approaches. Each model used practice location, practice size, and digital radiograph sensors as predictors. These models allow us to evaluate both statistical associations and predictive strength in explaining CBCT ownership across practices.

Pearson’s Chisquare

The Pearson’s Chi-square tests were used to evaluate whether CBCT ownership is associated with practice characteristics. None of the variables tested showed a statistically significant association at the 0.05 level:

Practice Location had a p-value of 0.1599, suggesting a possible trend but not a strong association with CBCT ownership. *Practice Size* yielded a p-value of 0.7036, indicating no meaningful relationship. *Digital Radiograph Availability* showed a p-value of 1, meaning CBCT ownership is not associated with whether a practice has digital radiograph equipment.

[Note: All tests showed a warning that “Chi-squared approximation may be incorrect.” This is likely due to small cell counts in the contingency tables. In such cases, I tried with Fisher’s Exact Test and it also gave same result]

```
Pearson's Chi-squared test with simulated p-value (based on 2000
replicates)
```

```
data:  table(df$cbct_abundance, df$practice_location)
X-squared = 4.0164, df = NA, p-value = 0.1634
```

Pearson's Chi-squared test with simulated p-value (based on 2000 replicates)

```
data: table(df$cbct_abundance, df$practice_size)
X-squared = 1.5604, df = NA, p-value = 0.7291
```

Pearson's Chi-squared test with simulated p-value (based on 2000 replicates)

```
data: table(df$cbct_abundance, df$digital_radiograph_sensors)
X-squared = 0.425, df = NA, p-value = 1
```

Logistic Regression

A logistic regression model was used to explore whether a dental practice's location, size, or use of digital radiographs could predict whether they own a CBCT machine. Among these factors, the most notable finding was that practices located in suburban areas were significantly less likely to own a CBCT compared to those in rural areas. Practices in urban areas also showed a lower likelihood of owning CBCT, but this result wasn't strong enough to be considered statistically significant. This suggests that rural practices may rely more heavily on in-house CBCT technology, possibly due to limited access to referral imaging services.

For other factors like practice size and use of digital radiography, no clear associations were found. While practices using digital radiographs appeared slightly more likely to have CBCT, the evidence was not strong enough to rule out chance. Practice size had unstable results, likely because of very small numbers in certain size categories, making it hard to detect meaningful trends. Overall, the model suggests that location may play a role in CBCT ownership, but more data would be needed to draw stronger conclusions about size or digital readiness.

Call:

```
glm(formula = has_cbct ~ practice_location + practice_size +
    digital_radiograph_sensors, family = binomial, data = df)
```

Coefficients:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	15.8240	3956.1806	0.004	0.9968
practice_locationSuburban	-2.5647	1.1389	-2.252	0.0243 *
practice_locationUrban	-1.2674	0.7883	-1.608	0.1079
practice_sizeless than or equal to 3	-15.6694	3956.1804	-0.004	0.9968

practice_sizeless than or equal to 5	2.5647	4845.3117	0.001	0.9996
practice_sizeone	-15.8240	3956.1804	-0.004	0.9968
digital_radiograph_sensorsYes	1.7421	1.5628	1.115	0.2650

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 61.791 on 50 degrees of freedom
 Residual deviance: 52.601 on 44 degrees of freedom
 AIC: 66.601

Number of Fisher Scoring iterations: 16

Considering practice size in two groups

[Note: We noticed that some practice size categories had very few responses — in some cases, only one or none. This made it difficult for the model to estimate how practice size affects CBCT ownership. To solve this, we combined the size categories into just two groups: solo practices (with one dentist) and group practices (with two or more dentists). This simplification helped the model run properly and made the results more stable and easier to interpret]

The model suggests that practice location plays the most important role in predicting CBCT ownership. Suburban practices were much less likely to have CBCT compared to rural ones, and urban practices also showed lower ownership, though with more uncertainty. Practice size (solo vs. group) and use of digital radiographs did not show strong or statistically significant effects, though practices using digital radiography appeared somewhat more likely to have CBCT. Overall, the results point to location as the clearest influencing factor, while other characteristics may still be relevant but require more data to draw firm conclusions.

[Note: Using this model for your final report is better for interpretability and model stability]

Call:

```
glm(formula = cbct_abundance ~ practice_location + practice_size_simple +
     digital_radiograph_sensors, family = binomial, data = df)
```

Coefficients:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	0.2883	1.5955	0.181	0.8566
practice_locationSuburban	-2.0003	1.0293	-1.943	0.0520 .
practice_locationUrban	-1.3276	0.7862	-1.689	0.0913 .

```

practice_size_simple solo      -0.2883      0.7388  -0.390   0.6963
digital_radiograph_sensors Yes  1.7479      1.5625   1.119   0.2633
---

```

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

```

Null deviance: 61.791  on 50  degrees of freedom
Residual deviance: 56.242  on 46  degrees of freedom
AIC: 66.242

```

Number of Fisher Scoring iterations: 4

Interpretation of Odds Ratios

This table summarizes how different factors—such as practice location, practice size, and use of digital radiograph sensors—relate to the likelihood of owning a CBCT machine. The results suggest that suburban and urban practices may be less likely to own CBCT compared to rural ones, with the suburban effect being nearly statistically significant ($p = 0.052$). Digital radiograph users appear more likely to own CBCT, but the confidence interval is very wide, indicating uncertainty due to limited or unbalanced data. Practice size (solo vs. group) showed no significant association. Overall, while some trends are visible, none of the predictors are statistically significant at the conventional 0.05 level, and large confidence intervals indicate that the model results should be interpreted with caution—possibly due to the small sample size

\begin{table}

\caption{Odds Ratios and 95% Confidence Intervals for Predicting CBCT Ownership}

term	estimate	std.error	statistic	conf.low	conf.high	p.value
(Intercept)	1.334	1.596	0.181	0.041	43.612	0.857
practice_locationSuburban	0.135	1.029	-1.943	0.015	0.959	0.052
practice_locationUrban	0.265	0.786	-1.689	0.049	1.160	0.091
practice_size_simple solo	0.750	0.739	-0.390	0.162	3.112	0.696
digital_radiograph_sensors Yes	5.742	1.562	1.119	0.188	181.124	0.263

\end{table}

Odds Ratios

The following three charts help us understand how different practice characteristics are related to whether a dental office owns a CBCT machine. These charts show odds ratios, which tell us how likely a practice is to own CBCT depending on factors like location, digital tools, or number of dentists. The red vertical line at 1 means “no difference” — if a dot is far from this line, it may suggest a stronger relationship, but we also look at the lines (called confidence intervals) to judge how precise those estimates are.

Practice Location

This chart shows how location affects CBCT ownership, comparing Urban and Suburban clinics to Rural ones (the baseline group). Suburban practices appear less likely to have CBCT compared to rural offices, and this result is fairly consistent and statistically meaningful. Urban practices also tend to have lower CBCT ownership than rural ones, but the result is less certain. Overall, rural practices are most likely to have CBCT, which might reflect differences in patient volume, access to radiology referrals, or funding.

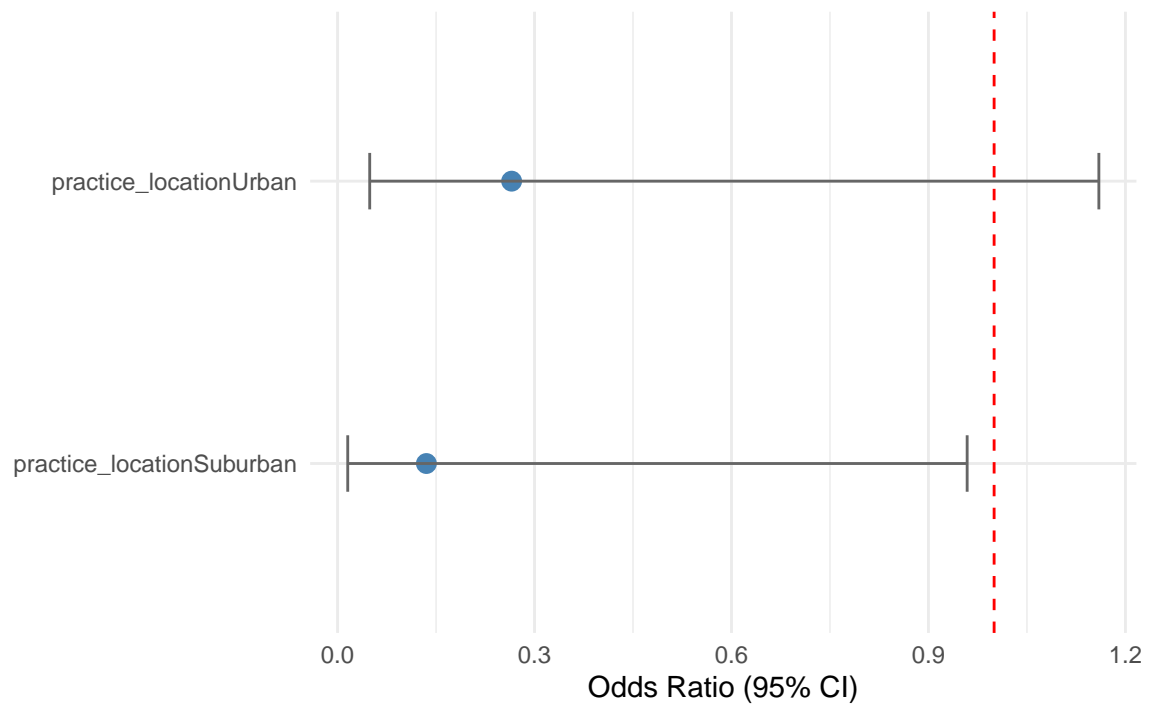
Digital Radiograph Use

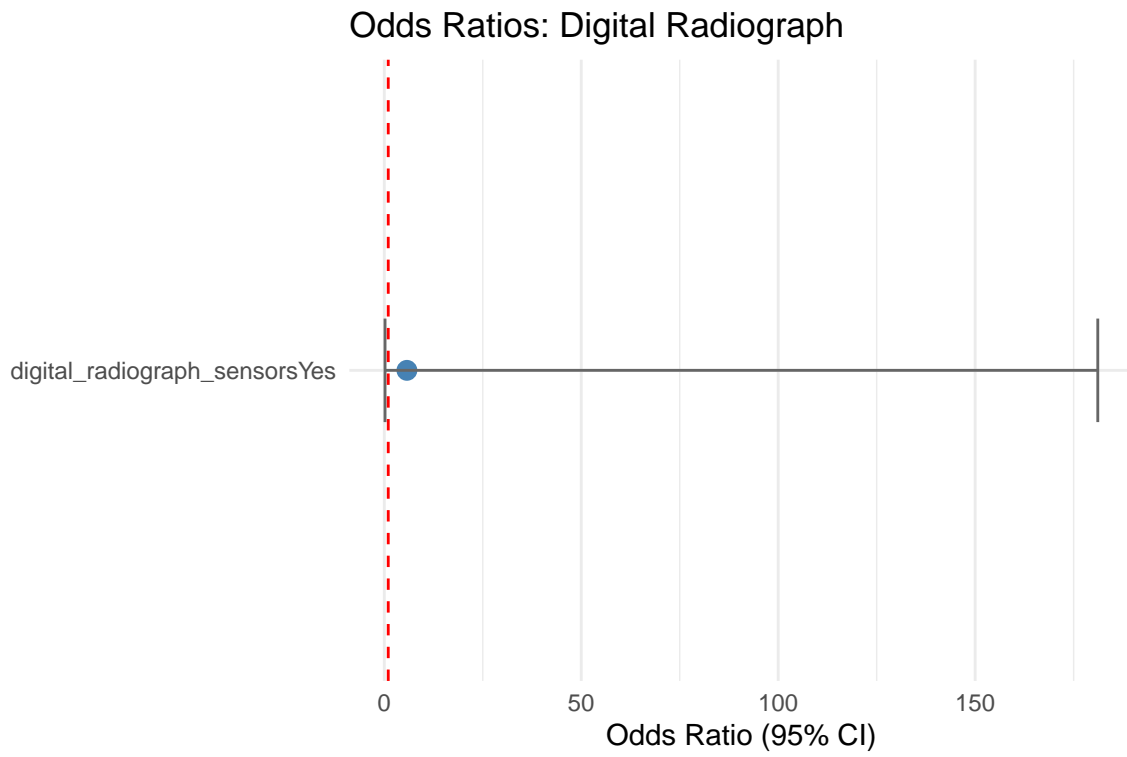
Here we compare clinics that use digital radiographs to those that don't. The chart suggests that clinics with digital radiography are more likely to own CBCT. However, there's a lot of uncertainty in the estimate — the line around the dot is very wide — so we can't be confident that the pattern is real. This means while digital-ready clinics seem more likely to invest in CBCT, we'd need more data to be sure.

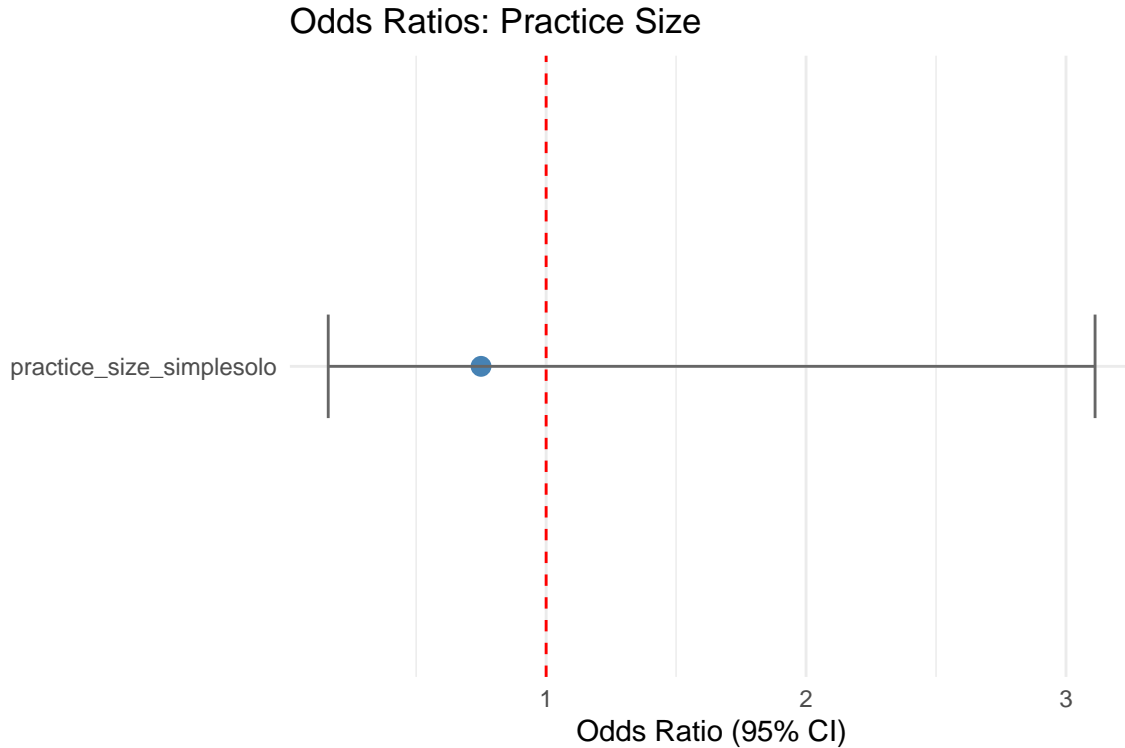
Practice Size

This chart compares solo practitioners to group practices. Solo clinics seem slightly less likely to have CBCT, but the difference is very small and uncertain. The confidence line is wide, which tells us the result could go either way. This suggests that practice size alone isn't a strong predictor in this sample, though solo dentists might face more resource barriers.

Odds Ratios: Practice Location







Conclusion

This study explored factors associated with the adoption of Cone Beam Computed Tomography (CBCT) among general dental practices in Nebraska. The majority of practices (70.6%) reported owning a CBCT machine, and digital radiograph usage was very high (96.1%), indicating overall technological readiness in the sample. However, practices located in **suburban areas** were significantly **less likely to own CBCT** than rural counterparts, even after accounting for size and digital readiness.

Other variables, including practice size and digital radiograph usage, showed suggestive but statistically inconclusive associations, likely due to small sample sizes or imbalanced category distributions. Logistic regression and Pierson's Chi tests consistently highlighted limitations in model stability, especially for practice size, which exhibited quasi-complete separation and unreliable estimates.

Recommendations

To improve the accuracy and usefulness of future studies, we recommend a few practical steps. First, some of the practice size groups had very few responses, which made it hard to compare results. Grouping similar practice sizes together would help make the findings more reliable. Second, increasing the number of dental offices surveyed would give a better overall picture and allow for stronger comparisons between different types of practices.

We also found that suburban practices were less likely to have CBCT machines, so it may be helpful to focus support or outreach efforts in those areas to encourage adoption. Finally, hearing directly from dentists—through interviews or open-ended questions—could provide valuable context about why they do or do not use CBCT in their practice. While this study offers helpful insights, a larger and more balanced dataset would allow for even stronger conclusions in the future.