

RESEARCH REPORT

# The Link Between Ventilator-Associated Pneumonia and the Mouth

**The intersection of VAP, COVID-19, oral health and equity**

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## Methods

The DentaQuest Partnership in September 2020 used the IBM Watson MarketScan Medicaid Database to examine inpatient administrative claims data for Medicaid enrollees. Data was obtained for all patients admitted to an ICU in 2016/2018 and received invasive mechanical ventilation for  $\geq 48$  hours. Within this cohort, cases of VAP were defined as patients with International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) diagnosis code J95.851 or patients with bacterial pneumonia diagnoses occurring  $\geq 48$  hours following intubation.<sup>18, 19</sup> Further, using dental claims data and Current Dental Terminology (CDT) codes, we identified patients who had any dental examination, prophylaxis or preventive visits within the three years prior to hospitalization.

Individual comorbidities were identified to create the Elixhauser comorbidity index based on ICD-10-CM diagnosis codes.<sup>20</sup> The primary independent variable was the number of dental examinations or preventive visits as a continuous variable. Other covariates include age in years as a continuous variable; sex coded as male vs. female; race categorized as white, Black, Hispanic and other; and Elixhauser comorbidity score categorized as zero, one, and two or more. We used multivariable logistic regression models to examine factors associated with incidence of VAP among patients who received mechanical ventilation for at least 48 hours.



## Key Findings

Roughly 14% of Medicaid patients on mechanical ventilation had a ventilator-associated pneumonia (VAP) diagnosis.



- Preventive dental visits decreased the likelihood of acquiring VAP.
- At least one preventive dental visit within three years reduced the likelihood of a VAP diagnosis by 22%.
- Black patients are more likely than white patients to be diagnosed with VAP.
- Patients with one or more comorbidities are at significantly greater risk for VAP.

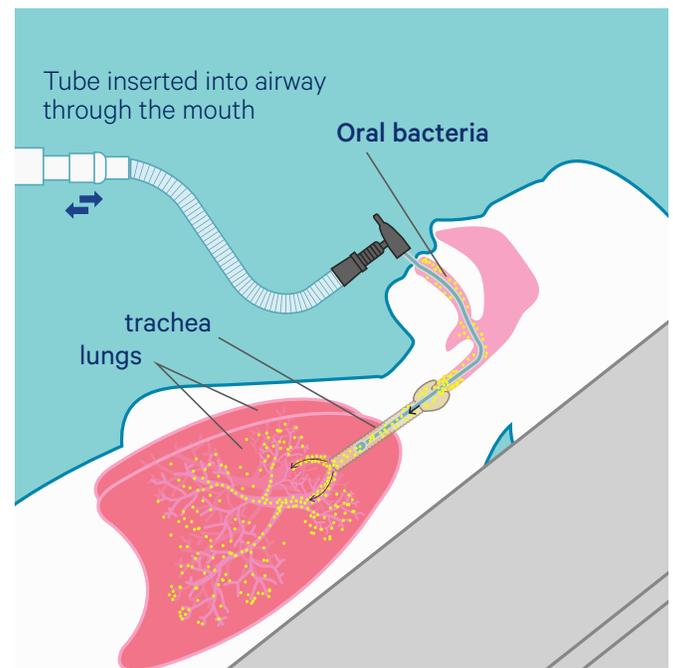
The COVID-19 pandemic made headlines in March 2020 in part because more patients than ever were relying on mechanical ventilation.<sup>1</sup> to survive and hospitals struggled with resource capacity. These ventilated patients already have depressed immune systems, making them more prone to secondary infections, including those caused by bacteria that grow in the oral cavity and actively travel to the lungs.<sup>2</sup> These patients are highly susceptible to ventilator-associated pneumonia (VAP), compounding the risk of adverse outcomes, including death.<sup>3</sup>

## What is Ventilator-Associated Pneumonia (VAP)?

VAP is the second most common hospital-acquired infection (HAI) and the leading cause of HAI deaths among critically ill patients.<sup>4</sup> VAP is likely to occur in 10-20% of patients who are mechanically ventilated for 48 hours or more.<sup>5</sup>

Both serious and deadly, VAP commonly occurs when a patient is connected to mechanical ventilation and bacteria travel from the oral cavity or breathing equipment into the lungs.<sup>6</sup> The airway tube disrupts natural defenses that help maintain a healthy oral microbiome, which refers to a healthy balance of organisms within the mouth and throat that protect against disease. This disruption creates an environment ripe for pathogens and thus increases risk of superinfections like VAP, particularly among already critically ill patients.

We conducted an analysis to understand the relationship between oral health and VAP, and the results indicate that improving oral health care and addressing existing disparities can help mitigate the number and frequency of VAP cases.



**Figure 1:** How oral bacteria enter the lungs

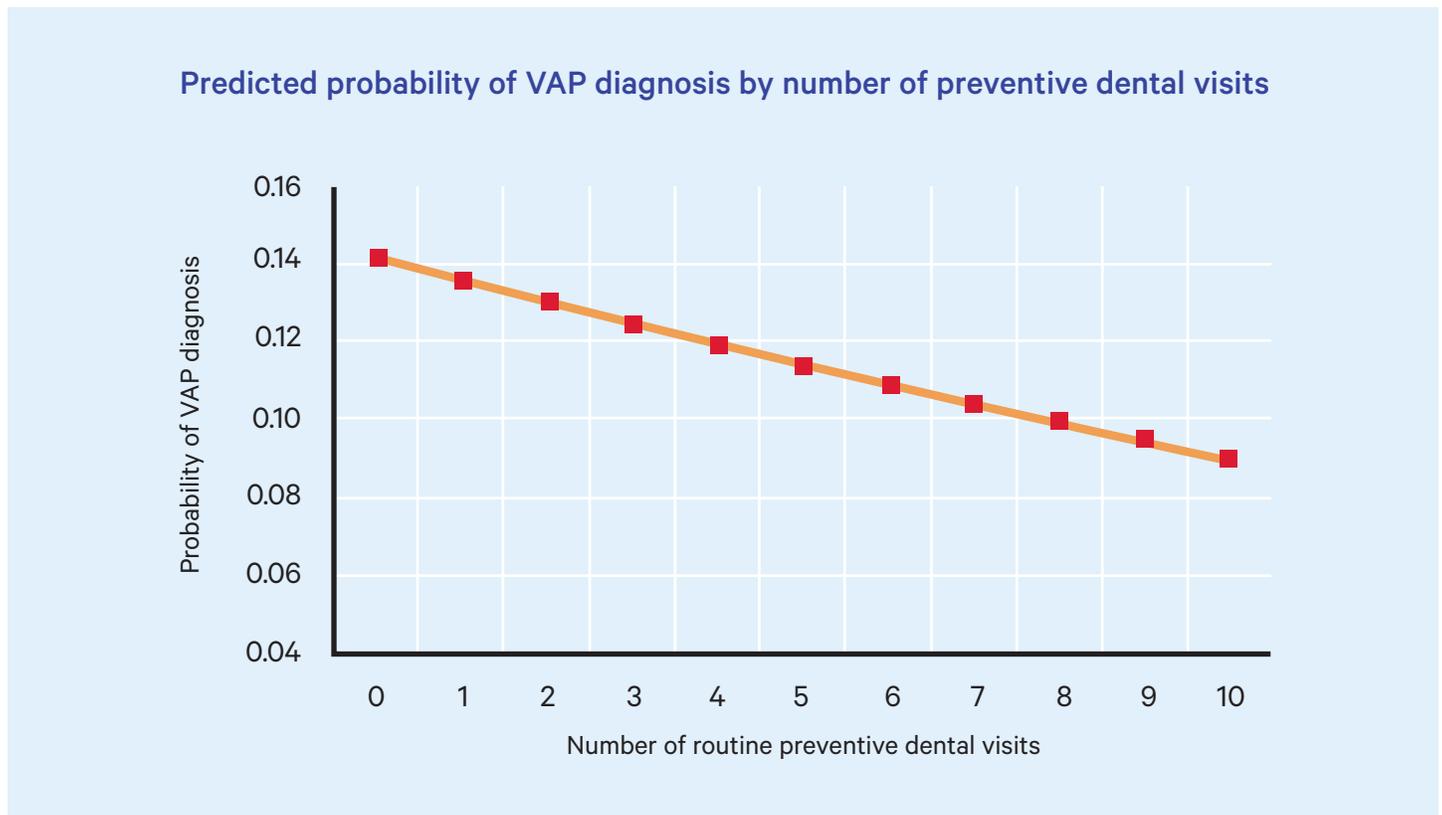
This study included 9,279 Medicaid patients who relied on mechanical ventilation for 48 hours or longer. Within this cohort, 14% (1,284 patients) were diagnosed with VAP.

## How are oral health and VAP related?

Given that VAP commonly stems from bacteria that travel from the mouth to the lungs, we examined VAP incidence data and past routine preventive dental visit data. We found that for each additional routine dental visit the patient had within the previous three years of being put on a ventilator, the predicted probability of VAP diagnosis decreased by 5%, after controlling for confounding factors including age, race, sex and comorbidities. Additionally, in a separate model using a dual variable for preventive dental visits, we found that those patients who had at least one preventive dental visit within the previous three years were 22% less likely to be diagnosed with VAP.

These findings reveal the importance of ongoing preventive oral care because neglected or ineffective oral care negatively impacts a patient's oral microbiome, making these patients more susceptible to bacteria-related hospital infections. The tooth surface, when not cleaned, may harbor pathogenic organisms. Routine dental visits prevent bacteria and plaque accumulation, so fewer pathogens exist in the mouth.<sup>7</sup>

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**Figure 2:** Adjusted predicted probability of VAP diagnosis by number of preventive dental visits

(We categorized number of preventive dental visits as none vs. at least one and ran a separate multivariable regression model)

Other studies share similar findings and point to how oral care delivered within the hospital can also positively impact outcomes. Some research, for instance, suggests interrupting the process of pathogen growth with daily oral care while ventilated significantly decreases time spent on the ventilator and may also reduce VAP risk and ICU length of stay.<sup>8,9,10,11</sup> Another study suggests promoting and maintaining oral health along with comprehensive inpatient oral care for mechanically ventilated patients can reduce the incidence of VAP.<sup>12</sup>

Given the demonstrated relationship between preventive dental care and VAP risk, as well as support from other literature, entering the hospital with a healthy mouth could lead to improved outcomes for patients reliant on ventilation.

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## Health Equity and Disparities

Mechanical ventilation is a common supportive treatment<sup>6</sup> response to COVID-19, a virus that limits immune strength to fight superinfections or HAIs. With reduced immunity, COVID-19 patients that acquire VAP are likely to see a decline in their clinical condition<sup>13</sup>

Among those patients on mechanical ventilators for 48 hours or longer, we found Black people were 39% more likely than white people to be diagnosed with VAP. And males were 20% more likely to be diagnosed than females.

In addition, the data shows comorbidities play a role: patients with 1 comorbidity were 73% more likely to have a VAP diagnosis compared to those with none, while patients with 2 or more were 98% more likely than those with none.

Studies have shown that coronavirus disproportionately impacts people of color and low-income communities and, specifically, counties with higher proportions of Black people.<sup>14</sup> In fact, those counties account for 52% of COVID-19 diagnoses and 58% of COVID-19 deaths nationally.<sup>14</sup>

Related, low-income communities and those that are predominantly Black are associated with higher rates of chronic disease comorbidities<sup>14</sup> and poor oral health — both of which are risk factors for COVID-19 and VAP. Other DentaQuest Partnership data from May 2020 data shows Black adults are 22% less likely to have had a routine dental visit in the past year and 68% more likely to have unmet dental needs, compared to their white counterparts.<sup>15</sup>

Together, the data demonstrates compounding disparities, meaning these communities not only are more likely to become infected with coronavirus, but also are more likely to acquire VAP from poor oral health if treatment includes mechanical ventilation, which is common among COVID-19 patients.

## Implications: COVID-19, Oral Health and the Overall Health System

During a pandemic such as COVID-19, long hospital lengths of stay incur a substantial health care burden because of a greater need for ventilators, personal protective equipment such as N95 masks, and more ICU beds. Several studies also

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show VAP adds roughly \$40K and seven days to a single hospital stay.<sup>16</sup> Thus, reducing the incidence of VAP is a critical step to ensuring enough available resources to care for critically ill patients, as well as the chance to improve outcomes among critically ill patients, given VAP remains a leading cause of hospital deaths among this group.<sup>4</sup>

The relationship between both incidence and risk factors for VAP, COVID-19 and oral disease are significant. As noted, disparities are particularly stark among Black communities. Given oral health is a common factor across these conditions, efforts to mitigate the trends should also share a common focus on oral health — both in and out of the hospital.<sup>17</sup> These findings underscore the need to address social conditions, structural racism, access to care, oral health education and other factors not only to improve oral health outcomes but also to reduce the risk for COVID-19, VAP and even death in Black communities.

Of course, there remains a need for additional research to establish any causal relationship between poor oral health and VAP. Medical and dental professionals also need to collaborate on standard in-hospital oral hygiene protocols for all patients, particularly those expected to require mechanical ventilation. Additional needs include standard dental evaluation and measures for accurate tracking.

Specifically, this evidence makes the case that the best way to prevent VAP is three-fold. First, promote effective oral health care and behaviors in the community; next, be attuned to historic disparities and thus heighten effective oral care for patients in anticipation of VAP; and third, effectively and fully implement oral care management protocols for all ventilated patients.

More generally, however, the findings reinforce the connection between oral health and overall health and underscore the breadth of health issues that ongoing oral health care can protect against. If we can increase the number of people getting preventive oral care, particularly within the highest risk communities, we can significantly reduce the incidence of oral disease and thus the burden on our health care system and patients' lives — regardless of coronavirus or any future pandemic.

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