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# Oral Health and Pneumonia in Adults With Intellectual and Developmental Disabilities: A Scoping Review

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## ABSTRACT

**Introduction:** Pneumonia is a leading cause of death for people with intellectual and developmental disabilities (IDD), who also have increased risk of oral disease. Given the known relationship between oral disease and pneumonia in similar populations, this review aims to explore what is known about the association between oral health and pneumonia among people with IDD.

**Methods:** This systematic scoping review was carried out in accordance with the Joanna Briggs Institute methods and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews checklist (PRISMA-ScR). A systematic search of Medline (Ovid), Embase, Cochrane Trials, Cochrane Review, CINAHL and PubMed was conducted, guided by a registered protocol. The PCC framework informed the search and inclusion criteria. Titles and abstracts were independently screened by two reviewers, with full texts assessed for relevance to oral health and pneumonia in adults with IDD.

**Results:** Following a protocol and defined criteria, (2544) articles were abstract screened; a further (31) reached full-text review, with (7) included in this review. Study designs included cross-sectional studies (2), retrospective cohorts (2), prospective cohorts (2) and one RCT pilot (1). Six studies reported oral carriage of respiratory pathogens such as *Streptococcus pneumoniae*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*. Two studies reported predictive relationships between oral pathogens and pneumonia, with increased odds of respiratory illness associated with positive PCR results for specific pathogens (OR 9.0, 95% confidence interval [CI] 2.3–38.8). Two studies identified poor oral health as a predictor of pneumonia, using validated tools such as the ROAG (OR 1.6, 95% CI 1.1–2.5). Mediating factors included enteral feeding, level of IDD, and history of oral disease.

**Conclusions:** Research consistently finds carriage of potential respiratory pathogens in the oral microbiome of people with IDD. Despite this, there is a significant lack of research into the relationship between the oral microbiome, poor oral health, and pneumonia in this population, though the latter two are both prevalent and consequential. There is an urgent need for further research exploring the role that oral health and the oral microbiome play in pneumonia among people with IDD.

## 1 | Introduction

Pneumonia is a significant disease that disproportionately affects people with intellectual and developmental disabilities (IDD), contributing to preventable suffering, early death, and diminished quality of life (Glover and Ayub 2010; Heslop et al. 2014; O'Leary et al. 2018). Death resulting from pneumonia has been found to be 10 times higher among people with IDD compared to the general population (Palmer 2001; Hosking et al. 2016; O'Leary et al. 2018). A recent Irish study found respiratory illness to be the leading cause of death among the IDD population in residential care (Mcmahon et al. 2023). This is in stark contrast to the general population, where respiratory disease is prevalent but results in a lower mortality rate. Pneumonia is a common acute respiratory infection affecting the alveoli and distal bronchial tree. There are two types of pneumonia that can be classified into two types: community-acquired pneumonia (CAP) and hospital-acquired pneumonia (HAP) (Almirall et al. 2021). Aspiration pneumonia (AP) which occurs when food, liquid, or vomit is inhaled into the lungs, accounts for 5%–15% of CAP cases (Lanspa et al. 2013; Lindenauer et al. 2018).

The development of pneumonia in both hospital and community settings is often associated with poor oral health (Mojon et al. 1997; Langmore et al. 1998; Terpenning et al. 2001; Awano et al. 2008; Bágyi et al. 2009). This is highly relevant to people with IDD, who often face significant challenges in maintaining oral health. This population group tends to have poorer oral health compared to the general population, with higher rates of untreated dental decay, gingivitis and periodontal disease (Anders and Davis 2010; Wilson et al. 2019). The bacterial species in the mouth can be altered significantly by poor oral hygiene and inadequate salivary flow (Palmer 2001; Wade 2021). Previous literature has suggested that the development of AP may be associated with dental plaque, gingivitis or dental caries (Scannapieco et al. 1992; Fourrier et al. 1998; Eisbruch et al. 2002; El-Solh et al. 2004; Scannapieco 2006; Acharya et al. 2018). Dental plaque is prone to colonisation by common respiratory pathogens, and there is a growing amount of evidence indicating the involvement of dental plaque as a reservoir for pathogenic organisms associated with pneumonia (Scannapieco et al. 2003; Janssens 2005; Scannapieco 2006; Bassim et al. 2008; Ameijeira et al. 2019; Yumoto et al. 2019). The presence of these pathogens in the oropharynx is particularly concerning if aspirated, especially among individuals with oral disease or multiple co-morbidities (Scannapieco et al. 2003; Pace and Mccullough 2010; Przybyłowska et al. 2016; Acharya et al. 2018).

The literature regarding older adults, oral health and lung health has long recognised the relationship between poor oral hygiene and an increased risk of pneumonia in the ageing population (Scannapieco et al. 2003; Azarpazhooh and Leake 2006). Indeed, both dysphagia and poor oral health were identified as independent risk factors for mortality in the frail ageing population (van der Maarel-Wierink et al. 2013), as well as in ageing individuals in residential care (Hägglund et al. 2019). A recent systematic review by (Khadka et al. 2021) highlighted a possible role for poor oral hygiene leading to the colonisation of potentially pathogenic microorganisms in the oral cavity. These microorganisms included *Staphylococcus aureus* (Terpenning et al. 2001; Sumi et al. 2006; Sumi et al. 2007) *Streptococcus pneumoniae*, *Candida* species (Awano et al. 2008), *Haemophilus influenzae* and *Klebsiella pneumoniae*(Sumi et al. 2006; Sumi et al. 2007) and *Pseudomonas aeruginosa* (Sumi et al. 2006). Their presence in the mouth is significantly associated with an increased risk of AP (Terpenning et al. 2001; Sumi et al. 2006; Sumi et al. 2007; Awano et al. 2008; Khadka et al. 2021).

Given this wealth of evidence linking oral health to pneumonia in older adults, it would appear to be equally important to understand this link for people with ID. Particularly, given their increased risk of, and from, both oral disease and AP. One recent review of nursing literature identified dysphagia, poor oral health and hygiene and tube feeding as top risk factors for AP in those with IDD (Lisiecka et al. 2024). However, the extent to which the literature explores the association between oral health and pneumonia among the IDD population is unknown. Therefore, this scoping review was undertaken to explore the literature reporting on relationships between oral health and pneumonia among adults with IDD and mediating factors in these relationships.

## 2 | Methods

### 2.1 | Design

This systematic scoping review was undertaken as per the Joanna Briggs Institute (JBI) manual (Peters et al. 2020); the protocol was preregistered following a registered protocol (see OSF: https://doi.org/10.17605/OSF.IO/K48AS for further methodological details). The PCC tool (population, concept and context) guided the search strategy (Methley et al. 2014). This review also complied with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) Checklist (Tricco et al. 2018) (Supporting Information S1).

### 2.2 | Search Strategy

In collaboration with an experienced librarian, an initial, preliminary search of MEDLINE and CINAHL led to the identification of key words in titles, abstracts, and index terms. These terms were used to develop the full search strategy (see Supporting Information S2). The search strategy was adapted for each database to account for differences in indexing and search functionality. Databases for full search included Medline (OVID), Embase, Cochrane Trials, Cochrane Review, CINAHL and PubMed. Forward citation searches were undertaken for all studies. There was no limitation to dates or languages.

### 2.3 | Selection Criteria

This review included studies involving adults (≥ 18 years) with a reported diagnosis of IDD or synonymous terms such as intellectual disabilities, developmental disabilities or learning disabilities. Studies focused on later-onset cognitive conditions (e.g., dementia) were excluded. There were no exclusions based on

ethnicity, gender, level of IDD or comorbidities. The concept of interest was the relationship between oral health and pneumonia for adults with an IDD. Only studies that made statements regarding objective measures of oral health in relation to pneumonia or respiratory health were considered for inclusion in this scoping review. Measures of oral health included plaque indices, periodontal and gingival indices, edentulism and the Decayed, Missing, Filled, Permanent Teeth (DMFT) index. Additionally, microbiological findings and salivary status were recorded. Pneumonia outcomes included confirmed or suspected cases (diagnosis, history, microbiological evidence, pneumonia-related death or hospitalisation). All types of pneumonia were considered (e.g., community-acquired, hospital-acquired, ventilator-associated, aspiration and nosocomial). In studies where pneumonia was reported as part of a broader category of respiratory infections, these were included if pneumonia was specifically mentioned. Studies were included regardless of setting, language or publication date. Eligible designs were descriptive and analytical observational studies (e.g., cross-sectional, cohort, case–control and case series) and experimental/quasi-experimental designs (e.g., RCTs, nonrandomised trials, before-and-after studies and interrupted time series). Excluded were qualitative studies, reviews, clinical guidelines and protocols, as outlined in Table 1.

### 2.4 | Study Selection

All citations were collated using EndNote X9, and duplicates were removed. RAYYAN (Ouzzani et al. 2016) was used to manage screening. Following training, titles and abstracts were screened independently by three reviewers (KB, DL and CMGP). Full texts were assessed by two independent reviewers (KB and CMGP), as per selection criteria, with discussion to resolve disagreement.

### 2.5 | Data Extraction

The extracted data were input into an adapted JBI extraction form by one reviewer (KB) with peer review by a second reviewer (CMGP); disagreements were resolved through discussion. All relevant data were entered into a data charting form adapted from the standardised JBI draft data extraction form. Extractable data included specific details about the population, concepts, context and key findings or recommendations relevant to the review objectives. After the data extraction, the data were checked by the authors, and any disagreements were resolved through discussion.

### 2.6 | Data Synthesis and Analysis

Data were collated narratively with tabulated study descriptions and brief summaries of data on oral microbiota, oral health and pneumonia. Studies were then aggregated into reports on potential respiratory pathogens in the oral cavity, the association between oral pathogens and pneumonia and the association between oral health and pneumonia. Identified potential mediating factors were then listed.

## 3 | Results

A total of 3654 studies were identified: Medline (OVID) ($n = 791$), Embase ($n = 1104$), Cochrane review ($n = 14$) and Cochrane trials ($n = 152$), CINHAL ($n = 216$) and PUBMED ($n = 1031$). Once duplicates ($n = 1651$) were removed, $n = 2003$ papers progressed to title and abstract screening; $n = 1972$ were then excluded at this stage. In total, $n = 31$ articles were included for full text review with ($n = 24$) studies excluded after review. The main reasons for exclusion were age or type of population. Following the selection process, $n = 7$ studies remained. See Figure 1 for PRISMA-ScR flow diagram (Tricco et al. 2018).

### 3.1 | Characteristics of People With IDD in Included Studies

The included studies involved a range of adults with IDD, primarily in institutional or care-dependent settings. Some studies explicitly described participants with moderate to severe IDD (e.g., Chiang et al. 2019; Binkley et al. 2009), while others used broader or less defined terms such as "developmental disabilities"

**TABLE 1** | Inclusion and exclusion criteria.

| Category | Inclusion criteria | Exclusion criteria |
|---|---|---|
| Population | Adults (≥ 18 years) with IDD or synonyms (e.g., intellectual disabilities, learning disabilities) | Individuals with later-onset cognitive disorders (e.g., dementia) |
| Concept | Studies reporting oral health measures in relation to pneumonia | Studies not linking oral health to pneumonia |
| Outcomes | Measured/suspected pneumonia: diagnosis, history, microbiological evidence, death | Studies without specific reference to pneumonia |
| Context | Any setting | — |
| Language | Any language | — |
| Time Frame | No restrictions | — |
| Study Design | Observational (cross-sectional, cohort, case–control, case series), experimental/quasi-experimental (RCTs, non-RCTs) | Qualitative studies, reviews, protocols, guidelines |

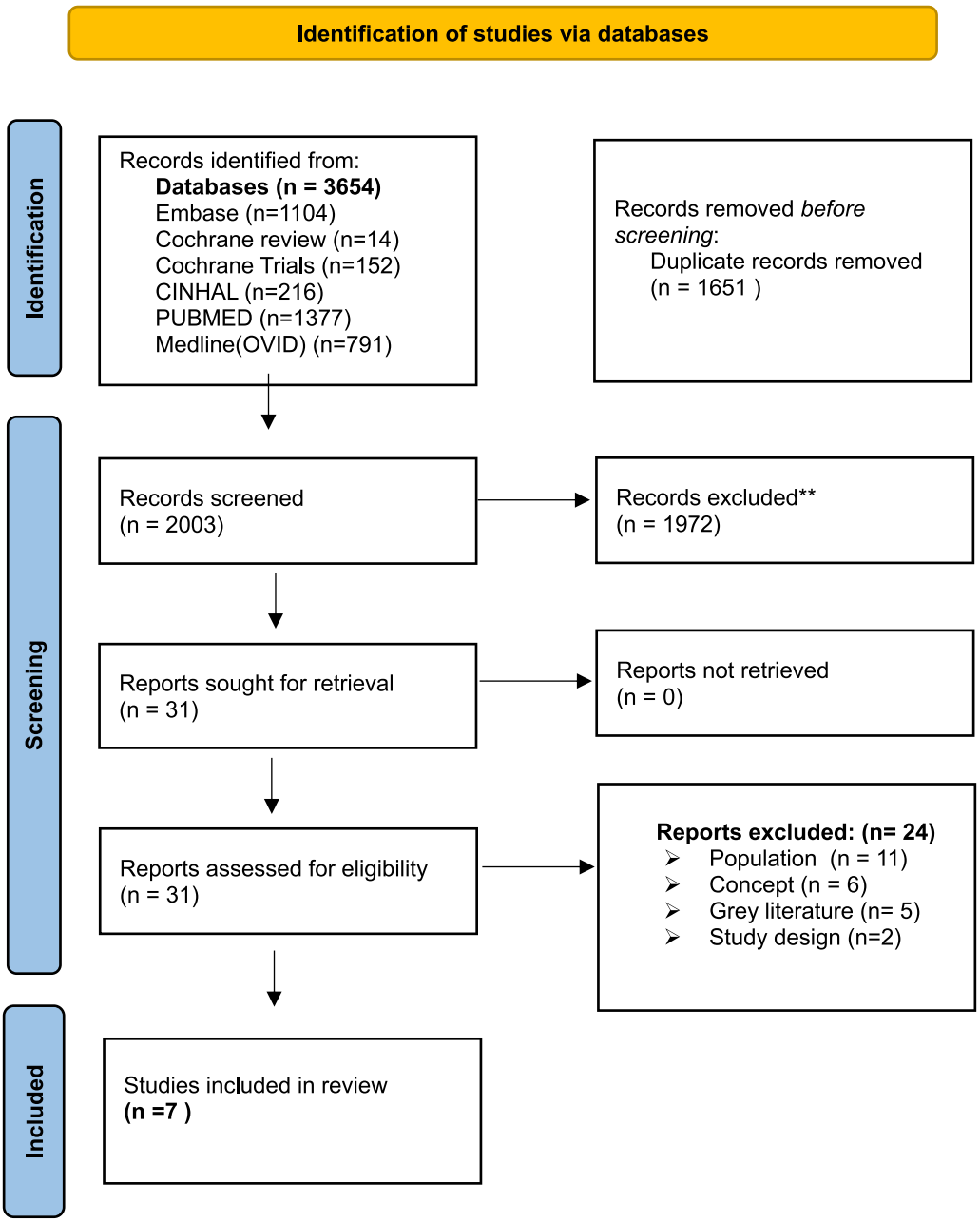


**FIGURE 1** | PRISMA-ScR flow diagram.

or "mental disabilities." Sample sizes ranged widely from small clinical groups ($n = 31$–$96$) to large-scale cohorts (e.g., Chiang et al. 2019, with over 117 000 individuals with IDD). The variation in how IDD was described and assessed limits the ability to make nuanced comparisons across studies and underscores the need for better disability-specific reporting in future research.

### 3.2 | Characteristics of Included Sources

The seven included studies ranged in year of publication from 2003 to 2019. Two studies adopted prospective cohort design (Binkley et al. 2009; Horie et al. 2014), two retrospective cohort designs (Zawadzki et al. 2016; Chiang et al. 2019), with two cross-sectional surveys (Ahanjan et al. 2013; Wang et al. 2023) and one pilot RCT (Ferozali et al. 2007). Two studies were from the United States (Ferozali et al. 2007; Binkley et al. 2009), two from Taiwan (Chiang et al. 2019; Wang et al. 2023) and one each from Iran (Ahanjan et al. 2013), Poland (Zawadzki et al. 2016) and Japan (Horie et al. 2014). All studies were published in English. A summary of included studies is presented in Table 2.

### 3.3 | Findings From the Literature

These findings are presented in the following sequence. Initially, the methods of data collection engaged within the studies are described. The focus then shifts to the oral pathogens identified, emphasising opportunistic pathogens associated with respiratory diseases. Next, the relationship between these pathogens and pneumonia is explored across the studies. This is followed by an outline of the findings related to oral health and its

**TABLE 2** | Summary of included studies.

| Authors/year/country | Aim | Sample | Method | Findings | Key findings and researcher comments |
|---|---|---|---|---|---|
| Ahanjan et al. (2013) Iran | To study oral and gingival microbial flora in institutionalised people with IDD of Sari and to estimate D% (percentage with untreated decayed teeth) and DMFT% (percentage of population affected with dental caries. | **Size:** $n = 138$<br>**Age: Mean** 28.3<br>**IDD:** not specified | **Design:** Descriptive cross-sectional survey<br>**Data collection:** Questionnaire complete by research team alongside dental visits and mouth/gum swabs.<br>**Variables:**<br>**Microbial:** Plaque samples and swabs were directly taken from the mouth (and gum) of the participants using a sterile swab.<br>**Oral health:** Questionnaire alongside dental visit.<br>**Pneumonia:** None<br>**Association between oral microbiome/health and pneumonia:** None | **Microbial**<br>The isolated microorganisms included *Streptococcus pneumoniae* (37.7%); *Streptococcus* sp. (18.8%); *E. coli* (16.7%); *Staphylococcus* sp. (1.4%); *Neisseria* sp. (45/6%); *Salmonella* sp. (8.7%); *Proteus* sp. (3.6%); *Diphteroid* (4.2%); *Pseudomonas* sp. (0.7%).<br>**Oral health:**<br>Limited relevant oral health data collected: 65.9% ($n = 135$ patients) had dental caries and 34.1% ($n = 3$ patients) did not.<br>**Pneumonia**: None<br>**Association between oral microbiome, oral health and pneumonia:**<br>Not studied<br>**Mediators/moderators:**<br>Significant bivariate association between frequency of isolated bacteria being present in the mouth and using a toothbrush ($p < 0.25$), dental caries being present($p < 0.03$) and history of tooth extraction ($p < 0.009$). | Higher prevalence of pneumococci was observed in people with IDD compared to people without. Authors therefore hypothesised that, as a result, the former were at increased risk of bacterial respiratory infections. |
| Binkley et al. (2009) USA | To determine the prevalence of potential pathogenic microorganisms in oral biofilms in persons with IDD & determine if there was an association between oral status, the presence of these microorganisms in the mouth, and respiratory infections | **Size:** $n = 63$<br>**Mean age:** 48 ± 11 years<br>**IDD:** Mild to profound IDD | **Design:** Observational cohort study (prospective)<br>**Data collection:** Data collection at baseline and each month for 6 months.<br>**Variables**<br>**Microbial:** Bacteriological data collection from six index teeth for PCR analysis.<br>**Oral health:** Oral health assessment using Revised Oral Assessment Guide (ROAG), with sub scores.<br>**Pneumonia:** Medical records were reviewed monthly to determine the incidence of respiratory infections diagnosed by the facility's physicians.<br>**Association between oral microbiome, oral health and pneumonia:** Logistic regression exploring factors associated with pneumonia, and respiratory infections. Factors with bivariate correlation of $p < 0.10$ with the dependent variable, were included in the model. | **Oral health:**<br>The mean Revised Oral Assessment Guide (ROAG) score was 14.9 ± 1.8, with a range of 11 to 19, indicating poor oral status for 73% ($n = 46$), with 27% ($n = 17$) with a very poor oral health status as per the ROAG score. Poor gingival health reported for 33% ($n = 21$) and poor oral hygiene for 41% ($n = 26$).<br>**Microbial:**<br>All participants carried anaerobic organism *P. melaninogenica. S. pneumoniae; S. aureus* (specifically MRSA), and *C. albicans* were detected by PCR analyses in 55% of participants.<br>**Pneumonia:**<br>19% ($n = 12$) were found to have pneumonia, and 34.9% ($n = 22$) had respiratory disease.<br>**Association between oral microbiome, oral health and pneumonia**<br>More participants diagnosed with pneumonia had potential respiratory pathogens in their baseline samples ($p < 0.03$) than those who were not diagnosed with pneumonia. Participants with a positive PCR result of potential respiratory pathogens at baseline had nine times the odds of developing any respiratory infection (95% confidence interval [CI] 2.3–38.8, $p < 0.002$). Participants diagnosed with pneumonia during the 6 months of the study, were more likely to score a low ROAG score ($p < 0.001$), and have microorganisms ($p < 0.05$) than those who were not diagnosed with pneumonia.<br>**Mediators/moderators**<br>Those who were enterally fed had almost four times the odds of developing respiratory infections (95% CI 1.1–13.8, ($p < 0.05$) than those not enterally fed. Those who were older ($p < 0.05$) were also more likely to develop respiratory infections. | Findings indicated an association between poor oral status, as measured by gingival sub-score of ROAG, and the presence of potentially pathogenic microorganisms in oral biofilms and the likelihood of developing respiratory infections in persons with IDD. |

(Continues)

**TABLE 2** | (Continued)

| Authors/year/country | Aim | Sample | Method | Findings | Key findings and researcher comments |
|---|---|---|---|---|---|
| Chiang et al. (2019) Taiwan | To compare respiratory infection status, and respiratory infection-related healthcare utilisation between individuals with and without IDD. | **Size**: $n = 117031$ (IDD group) and $n = 234062$ (Reference group)<br>**Age**: Range: 20–65<br>**IDD:** not specified | **Design**: Population-based, retrospective cohort design<br>**Data Collection**: Data was collected by Taiwan's Ministry of Health and Welfare Database. The data related to disabled individuals was from a 12-month period in 2014.<br>**Variables**<br>**Microbial data**: None<br>**Oral health data:** Presence of carious cavitation and periodontal disease were recorded based on a review of dental records.<br>**Pneumonia:** Pneumonia data were not disaggregated from respiratory disease data. Dependent variables were number of respiratory infection-related healthcare visits for 1 year.<br>**Association between oral microbiome, oral health and pneumonia**<br>Conditional logistic regression and generalised linear models were used to analyse related influential factors. | **Microbial:**<br>Not analysed<br>**Oral health:**<br>Chart review indicated 62.3% with record of carious cavitation and 63.6% with record of periodontal disease of those who had utilised health services for a respiratory illness<br>**Pneumonia:**<br>While disaggregated pneumonia data were not reported, pneumonia was recorded in combination with other respiratory health service use in 53.8% of cases over 1 year.<br>**Association between oral microbe, oral health and pneumonia:**<br>The probability of respiratory infection was 1.16 times (95% CI: 1.13–1.19) and 1.22 times (95% CI: 1.19–1.26) higher in those with a history of dental cavities and periodontal disease than those without such histories. ** pneumonia not specified<br>**Mediators/moderators:**<br>The probability of respiratory infection was 1.10 times (95% CI: 1.07–1.14) higher in those with profound IDD. | This study demonstrated a slight increase in the odds of respiratory infection-related healthcare utilisation among people with IDD who had recorded dental disease, than those with no such record. The probability of respiratory infection increased with increasing severity of disability. |

(Continues)

**TABLE 2** | (Continued)

| Authors/year/country | Aim | Sample | Method | Findings | Key findings and researcher comments |
|---|---|---|---|---|---|
| Ferozali et al. (2007) USA | To investigation if oral cleaning would decrease colonisation of bacteria and the infective capacity of the oral cavity. | **Size**: $n = 36$<br>**Age:** 31–79 years, mean age: 53.6 years<br>**IDD:** Profound IDD<br>**Three groups within the study:**<br>Group 1: Oral cleaning with suctioning toothbrush, sodium bicarbonate and a 1.5% hydrogen peroxide solution<br>Group 2: Toothbrushing with sodium bicarbonate and a 1.5% hydrogen peroxide solution<br>Group3: (Control) no new intervention | **Design:** Pilot RCT<br>**Data collection**<br>**Microbial:** Supra-gingival samples were obtained by swab in the space of the second molar prior intervention and on the last week<br>**Oral health:** Simplified Beck Oral Assessment Tool (gingival parameters and plaque as key indicators). Four elements of oral health were assessed; lips, oral mucosa, gingivae and plaque.<br>**Pneumonia:** Chart review/hospital discharge notes. * Not reported in the methods but noted in the results.<br>**Analysis:** 3x3 ANCOVA. Oral health data were analysed pre-, mid- and post-intervention; across three groups. | **Microbial:**<br>**Gram positive:** *S. aureus*, *Streptococcus* sp. **Gram negative** *Acinetobacter* sp., *Pseudomonas* sp., *Proteus* sp., *E. coli*.<br>**Oral health:**<br>All groups showed improvement in oral health over the study $F(2, 26) = 5.89$ ($p < 0.01$), with the study indicating without specific data that Group 1 had the greatest improvement over the course of the study<br>**Pneumonia:**<br>Authors report that all groups showed reductions in hospitalisation days for respiratory infections when compared to the same 90-day time period of the previous year, but, no data presented in the study to support this statement.<br>**Association between oral microbiome/oral health and pneumonia:**<br>Group 1, which had suctioning alongside their oral health had 90% reduction in pathogenic bacteria. Group 2 had an 81% reduction in bacteria. All three groups showed significant main effect for time assessment occurred ($p < 0.05$), reporting that all three groups had significant reductions in bacteria over the course of the study<br>**Mediators/moderators:**<br>Oral suctioning improves the oral hygiene and oral health status and decrease in bacterial load. | This study hypothesises from its findings that suctioning in collaboration with oral care is beneficial in reducing bacteria in the mouth, stating without data, that this reduces the risk of infection and upper respiratory illness. The mouths of the participants in the study showed the presence of the bacterial pathogens often associated with nosocomial pneumonia in studies of critically ill and mechanically ventilated patients in intensive care units (including Gram-negative bacilli), although further data on this statement not available in this study. Commentary in the discussion indicates oral care in collaboration with suction may reduce respiratory infections for individuals with multiple risk factors that place them at high risk for aspiration pneumonia. |
| Horie et al. (2014) Japan | To establish the presence of potential pathogenic microorganisms in oral biofilms in persons with severe motor impairment and IDD as a basis of prevention of aspiration pneumonia. | **Size**: $n = 31$<br>**Age:** range 6 to 68 years, mean = 40.5 years<br>**IDD:** People with intellectual disabilities living in residential care. | **Design**: Cross-sectional survey<br>**Data collection**<br>**Microbial:** Collection of oral samples from dorsum of tongue for culturing to determine presence of potential respiratory pathogens.<br>**Oral health data:** No oral health data<br>**Pneumonia:** not studied<br>**Association between oral microbiome/oral health and pneumonia**: No studied | **Microbial:**<br>MSSA (38.7%), *Candida* sp. (12.9%), four cases of *Klebsiella pneumoniae* (12.9%)<br>**Oral health:**<br>Not studied<br>**Pneumonia:**<br>Bacteria that can cause pneumonia found in the mouths of 12.9%.<br>**Association between oral microbiome/oral health and pneumonia:**<br>Not studied<br>**Mediators/moderators:**<br>Gender associated with OOP-positive and *Candida*-positive status. | Confirmation of oral carriage of potential respiratory pathogens. Despite no direct correlation tested, authors suggest that special oral care might be effective for the maintenance of oral health in patients with IDD. This is not supported by the evidence. Indirect evidence of link between oral health and respiratory health. |

(Continues)

**TABLE 2** | (Continued)

| Authors/year/country | Aim | Sample | Method | Findings | Key findings and researcher comments |
|---|---|---|---|---|---|
| Zawadzki et al. (2016) Poland | To analyse composition of oral microbiome as risk factors for complications in patients with masticatory system deteriorations, with a comparison between those with an IDD "" and those without "congenital diseases." | **Size**: $n = 96$<br>**Age range:** from 28 to 53 years; two age groups: 28–40 and 41–53 years<br>**Group I**—involving 48 persons with congenital diseases, associated with intellectual disability and masticatory system disorder **Group II**—involving 48 persons without congenital diseases with routine dental treatment. | **Design**: Retrospective chart review, between groups analyses.<br>**Data collection**<br>**Microbial:** Oral swabs from 10 sites including plaque, periodontium and gingival pockets<br>**Pneumonia** no respiratory history data collected<br>**Oral Health:** All participants were clinically reviewed for general health and oral cavity condition: the status of periodontal tissues, dentition, oral hygiene with no specific oral health assessment format detailed in the study.<br>**Association between oral microbiome/Oral health and pneumonia:** Not studied. | **Microbial:**<br>*Trichomonas tenax* trophozoites were isolated from different oral cavity sites and in saliva. These were more frequently present in older persons with congenital diseases- associated with mental retardation. Gram-positive (*S. aureus*) and Gram-negative (*E. coli*, *K. pneumoniae*, *P. aeruginosa*) respiratory pathogens were more frequently detected in the patients with somatic and mental retardations,<br>**Oral health data:**<br>In Group I involving persons with IDD: The poor oral hygiene status expressed by advanced dental caries, caries lesions as well as gingival bleeding, periodontitis and teeth loss was noted.<br>**Association between oral microbiome/Oral health and pneumonia:**<br>Oral health status was noted to have worse outcomes among the IDD population and with the) respiratory pathogens were more frequently detected in the patients with somatic and mental retardations but no data to support this finding<br>**Pneumonia**: None<br>**Mediators/moderators:**<br>Assumption only: Explanation of putative pathological process not based on study data | No data are presented but reportedly group with IDD had worse oral health and oral hygiene. No association demonstrated. Rather, implied, in discussion and based on the oral culture results and type of bacteria found associated with pneumonia. |
| Wang et al. (2023) Taiwan | To provide a global picture of the oral microbiome among NG-tube and oral-feeding patients in long term care. | **Size:** $n = 53$<br>**Age:**<br>**IDD:** Receiving long-term care due to moderate-to-severe disability<br>**Two groups**: $n = 26$ patients oral feeding; $n = 27$ fed with NG tubes. | **Design**: Observational cross sectional<br>**Data collection**<br>**Questionnaires:** on basic clinical and demographic data including history of pneumonia<br>**Oral health data:** full-mouth oral examination was then performed by the dentist, with a focus on gingival health. Severe gingivitis was defined by the presence of thick, visible calculus with bleeding gingiva, while mild gingivitis was assigned where there was only bleeding on probing.<br>**Microbial:** collection of tongue plaque samples with sterilised cotton swabs.<br>**Pneumonia:** Questionnaire on history of pneumonia<br>**Association between oral microbiome, oral health and pneumonia:** Logistic regression with NG-tube status as dependent variable and history of pneumonia, DM status, gingival status as independent variables. | **Microbial:**<br>Opportunistic pathogens like *Pseudomonas* and *Corynebacterium* were associated with NG-tube feeding, oral-feeding patients with commensal microbes (e.g., *Streptococcus* and *Veillonella*)<br>**Oral health:**<br>Patients fed with NG tubes presented higher caries index, residual root calculus and more severe gingivitis.<br>**Pneumonia:**<br>History of pneumonia was more frequently observed in the NG-tube (63%) than the oral-feeding (12%) group.<br>**Association between oral microbiome/oral health and pneumonia:**<br>None<br>**Mediators/Moderators:**<br>Association of NG tube with systemic and oral factors, among which, pneumonia showed the highest coefficient ($p < 0.001$) | *Corynebacterium* and *Pseudomonas* spp. were found in the mouths of NG tube feeding group. Tongue microbes in patients with NG tubes showed mostly Gram-negative bacteria with a mixture of aerobes and anaerobes, such as *Pseudomonas*, and also the Gram-positive *Corynebacterium* |

association with pneumonia in the studies. Finally, the mediating factors and established links between oral health and pneumonia are found in this review.

### 3.3.1 | Oral Microbiota, Oral Health and Pneumonia Data Collection Across Studies

**3.3.1.1 | Data Collection Methods.** Microbiological methods varied significantly across studies. Sample collection sites also varied and included: tongue scrapings (Horie et al. 2014), supragingival plaque or periodontal pockets of varying index teeth, or mandibular alveolar ridges in edentulous participants (Binkley et al. 2009; Ferozali et al. 2007; Zawadzki et al. 2016), or not specified (Ahanjan et al. 2013). Sample processing, where specified, included culturing (Ahanjan et al. 2013; Ferozali et al. 2007; Zawadzki et al. 2016), PCR analysis (Binkley et al. 2009) and next-generation sequencing of 16S fragments (Wang et al. 2023). These methodological differences introduce comparison limitations, as culturing detects only viable and cultivable bacteria, whereas sequencing identifies a broader spectrum, including nonculturable organisms. Ideally, a combination of methods would enhance validity and comparability of findings.

**3.3.1.2 | Oral Health Assessment.** Oral health measurement was inconsistent across studies. Some used structured assessment tools, including the Beck Oral Assessment Tool, Total Oral Assessment Score (TOAS) and the Revised Oral Assessment Guide (ROAG) (Binkley et al. 2009; Ferozali et al. 2007). In the three chart reviews, recordings of caries and periodontitis were used as measures of oral health (Chiang et al. 2019; Ahanjan et al. 2013; Zawadzki et al. 2016).). In the study by Wang et al. (2023), oral health data were gathered by a dentist doing a full mouth examination and not using any discernible assessment measure. Only two studies (Binkley et al. 2009; Ferozali et al. 2007) reported calibration procedures on diagnostic criteria, highlighting a broader issue within IDD research. These contextual challenges can reduce the feasibility of using validated tools reliably, potentially impacting both the accuracy and comparability of oral health data across studies involving adults with IDD.

**3.3.1.3 | Pneumonia Case Identification.** Four studies attempted to count cases of pneumonia incidence. One used self-reporting of a recent diagnosis of pneumonia (Wang et al. 2023). The other three studies counted cases where there was a positive history of pneumonia and related respiratory illness in health records or service records (Binkley et al. 2009; Chiang et al. 2019; Ferozali et al. 2007). The chart review element adopted a physician's diagnosis of a respiratory condition within the last 6 months, and Ferozali et al. (2007) similarly reviewed hospital discharge notes and patient records for respiratory diagnoses. Chiang et al. (2019) used health utilisation data from the NHI database (NHID) to record respiratory illness that included records of outpatient visits, hospital admissions and emergency department visits.

**3.3.1.4 | Pathogens in the Oral Cavity.** Six studies explored the oral cavity for the presence of potential respiratory pathogens (Ferozali et al. 2007; Binkley et al. 2009; Ahanjan et al. 2013; Horie et al. 2014; Zawadzki et al. 2016; Chiang et al. 2019; Wang et al. 2023). In total, there were 58 different types of pathogens found across these six studies. As the focus in this study was on pathogens related to pneumonia, the studies were further examined for results reporting pathogens related to respiratory illness.

**3.3.1.5 | Potential Respiratory Pathogens in the Oral Cavity.** Six studies explored the oral cavity for the presence of potential respiratory pathogens (Ferozali et al. 2007; Binkley et al. 2009; Ahanjan et al. 2013; Horie et al. 2014; Zawadzki et al. 2016; Wang et al. 2023). This included three studies that focused only on potential respiratory pathogens without attempting to include respiratory outcomes, rather basing their hypothesis on the concept that the mouth may function as a plausible reservoir for potential pathogens of pneumonia (Ahanjan et al. 2013; Horie et al. 2014; Zawadzki et al. 2016). The reported pathogens detected are outlined in Figure 2, which summarises the prevalence of specific species and taxa across studies. Pathogens of note included *Streptococcus pneumoniae* (Ahanjan et al. 2013; Binkley et al. 2009), *Corynebacterium* spp. and *Pseudomonas* spp. (Wang et al. 2023; Ferozali et al. 2007), including *P. aeruginosa* (Binkley et al. 2009) and members of the *Enterobacteriaceae* (*Klebsiella pneumonia* and *Escherichia coli*). The study by Wang et al. (2023) did not explore predictive relationships between oral pathogens and pneumonia. Rather, they found that taxa enriched in patients with nasogastric (NG) tubes were similar to those found in patients with pneumonia, including the genera *Corynebacterium*, *Pseudomonas*, *Actinotignum* and *Mycoplasma*.

**3.3.1.6 | The Association Between Oral Pathogens and Pneumonia.** Only two studies explored the predictive relationship between oral pathogens and pneumonia (Binkley et al. 2009; Ferozali et al. 2007) using PCR analysis and multivariate logistic regression. They reported that the presence of *S. pneumoniae*, *S. aureus* (specifically MRSA) and *C. albicans* was not an independent predictor of pneumonia diagnosis. Notably, these pathogens were associated with a nine-fold increase in odds of respiratory diagnosis, combining sinusitis, bronchitis, upper respiratory tract infection or pneumonia, as compared to participants with negative PCR results (95% confidence interval [CI] 2.3–38.8, $p = 0.002$). These wide-ranging confidence intervals indicate significant uncertainty in the finding. Ferozali et al. (2007) stated that carrying oral *P. aeruginosa* was

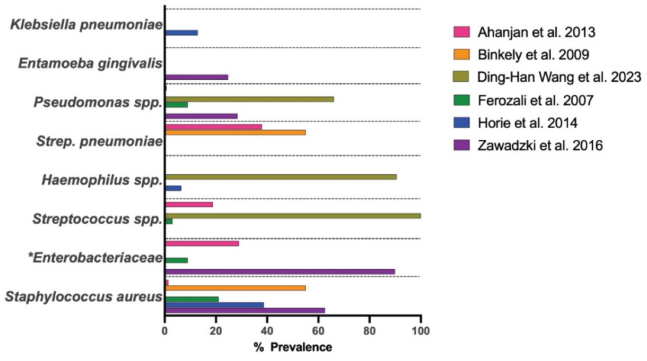


**FIGURE 2** | Prevalence of specific species and taxa across studies.

associated with participants being hospitalised with pneumonia; however, they did not share their analyses in their paper.

**3.3.1.7 | The Association Between Oral Health and Pneumonia.** Two studies using generalised linear models identified a relationship between oral health status and pneumonia/respiratory health using oral health measures as predictor variables and pneumonia and/or respiratory infections as outcome variables (Binkley et al. 2009; Chiang et al. 2019). Although both studies identified a relationship between oral health and respiratory outcomes, they differed substantially in design, population and measurement approach. Chiang et al. (2019) conducted a large-scale retrospective cohort study using national health insurance data, while Binkley et al. (2009) carried out a small clinical cohort study using the revised oral assessment guide (ROAG) to assess oral health and physician diagnoses to identify pneumonia. In the Chiang et al. (2019) study, with a population where 53.8% had a recorded health service utilisation due to respiratory infection over the study period, the authors found that the odds of respiratory infection were 1.16 times (95% CI: 1.13–1.19) and 1.22 times (95% CI: 1.19–1.26) higher in those with a history of cavitated dental carious lesions and periodontal disease compared to those without such histories. Binkley et al. (2009) studied a population of $n = 63$, where 12 participants were diagnosed with pneumonia and two with respiratory infections over the study period. Exploring the independent predictors of pneumonia, only the total (ROAG) score was found to be a significant predictor of pneumonia. The ROAG can range from 8 (considered as good oral status score) to 24 (considered a poor oral health status score). Within the Binkley et al. (2009) study, the range was found to be 11 to 9. The odds ratio for the ROAG score was 1.6 (95% CI 1.1–2.5, $p < 0.05$), indicating that a 1-unit increase in the ROAG score would correspond to a 1.6-factor increase in the odds of developing pneumonia. Other factors that were considered for this analysis but were not significant were poor ROAG score, several of the ROAG subscales (gingiva, tongue, swallow), enteral feeding and a positive baseline PCR result.

**3.3.1.8 | Potential Mediating Factors.** Included studies suggested potential mediating and moderating factors that may influence the relationship between oral health and pneumonia. Factors included enteral feeding, level of IDD and oral disease indicators.

**3.3.1.8.1 | Enteral Feeding as a Mediating Factor.** Two studies provided empirical evidence of a potential mediating role of enteral feeding in the relationship between oral health and pneumonia. Participants with a positive PCR result and who were enterally fed had almost 4 times the odds of developing respiratory infections (95% CI 1.1–13.8, $p < 0.041$) compared to those who were not (Binkley et al. 2009). However, enteral feeding was not seen as a significant covariate in the US study (Binkley et al. 2009), when modelling to predict pneumonia diagnosis. In the Wang et al. (2023), study statistical analysis using logistic regression showed an association between NG tube use and poor oral health outcomes and "more incidence of pneumonia", the latter showed the highest coefficient- statistical significance ($p < 0.00028$), when compared to the oral-feeding participant group. It is unclear whether enteral feeding itself or the underlying condition such as dysphagia or aspiration risk was the primary contributor to increased pneumonia risk, as this distinction was not consistently addressed across these studies.

**3.3.1.8.2 | IDD as a Mediating Factor.** The presence of oral bacterial carriage of potential pathogenic bacteria in the mouth had a higher prevalence in people with IDD compared to those without (Ahanjan et al. 2013; Horie et al. 2014; Zawadzki et al. 2016). Level of IDD was also a factor reported in Chiang et al. (2019), with the probability of respiratory infection 1.10 times higher in those with a severe to profound IDD.

**3.3.1.8.3 | Oral Disease Indicators as a Mediating Factor.** Having a diagnosis of periodontal disease or caries was found by (Chiang et al. 2019) to be a factor in increased healthcare utilisation rates for respiratory infections. The probability of respiratory infection was 1.29 times (95% CI: 1.17–1.42) and 1.26 times (95% CI: 1.19–1.33) higher in the IDD group who had a history of periodontal disease and caries, respectively, than for the reference group without such a history ($p < 0.001$). While in the US study (Binkley et al. 2009), mean ROAG scale scores were marginally higher ($p = 0.01$) in participants who were diagnosed with pneumonia ($n = 12$, $M = 16.0$, $\pm 1.7$) compared to those who did not have a diagnosis of pneumonia ($n = 51$, $M = 14.6$, $\pm 1.7$). No differences were found when subscales were analysed.

## 4 | Discussion

### 4.1 | Main Findings

This scoping review explored what is known of the association between oral health and pneumonia in the IDD population. The literature was found to study this association in two ways.

First, studies reporting the frequency of potential respiratory pathogens detected in the oral cavity found consistently high frequency of carriage of opportunistic pathogens in people with IDD. Over eight pathogens related to respiratory illness were detected across studies. Commonly identified respiratory pathogens included *Corynebacterium* spp., *Pseudomonas* sp., *Klebsiella pneumonia* and *Pseudomonas aeruginosa* and Pseudomonas spp. Carriage of opportunistic pathogens was found to be higher in people with IDD when compared to the general population (Ahanjan et al. 2013; Horie et al. 2014; Zawadzki et al. 2016). The association between oral pathogens and diagnosis of pneumonia was tested directly in only one study, finding no evidence of association, despite a weak correlation with respiratory illnesses more generally (Binkley et al. 2009).

Secondly, the relationship between oral health and pneumonia was directly assessed. From the two studies that did so, one found a correlation of significance between caries, periodontal disease and health service utilisation for respiratory illness (Chiang et al. 2019), and the other study found ROAG score to be associated with pneumonia (Binkley et al. 2009), although this association was likely to be clinically insignificant. The relationship between periodontal disease and a number of long-term conditions has been studied previously and the 'lack of a secure definition of periodontal disease 'is seen as a weakness (Needleman et al. 2017; Walter et al. 2019). The literature also

suggested a few potential mediating and moderating parameters including diagnosis or IDD and enteral feeding, both of which increased the likelihood of both carriage of opportunists and pneumonia. Moreover, the feasibility of applying calibrated and standardised oral health assessment tools in IDD populations may be limited by clinical realities such as communication barriers, behavioural challenges and sensory sensitivities. These factors are rarely acknowledged but likely affect both data quality and comparability across studies.

### 4.2 | Findings Relative to Existing Literature

There have been many studies exploring oral health and pneumonia for older people without IDD, especially in those living in residential care facilities, including numerous systematic reviews on this vast topic (Sjögren et al. 2008; Khadka et al. 2021; Liu et al. 2022; Marusiak et al. 2023; van der Maarel-Wierink et al. 2013). This research in gerontology has shown that the presence of poor oral hygiene for the ageing population is linked with pneumonia incidence (Yoneyama et al. 1999; Terpenning 2005) and mortality risk (Awano et al. 2008; Marín-Zuluaga et al. 2012; Liu et al. 2022). In this research, dental decay and inadequate oral hygiene were reported to increase the risk of pneumonia in elderly populations (Khadka et al. 2021). Based on the understanding garnered from such studies, numerous intervention studies were carried out involving preventative measures relating to regular professional oral hygiene care and oral health programmes in nursing homes, all of which heralded a reduction in the incidence of respiratory infections and pneumonia-related illness in older adults (Sjögren et al. 2008; Zimmerman et al. 2020; Khadka et al. 2021). The volume of research and the clear benefits arising from oral hygiene programmes in the older population lie in stark contrast with the two studies exploring this same relationship for people with IDD (Binkley et al. 2009; Chiang et al. 2019). Given the similarities between older adults and those with IDD in terms of vulnerability and care needs, lessons from gerontological research may offer useful directions for future IDD-focused studies.

### 4.3 | Strengths and Weaknesses of the Review

This study followed a systematic search strategy with broad selection criteria, identifying only a handful of studies specifically including people with IDD. Most studies had small sample sizes, raising concerns about power and generalizability. Larger datasets came from retrospective chart reviews, which have limitations, particularly around the validity of important variables. The inconsistent criteria used to rate oral health and pneumonia limited comparisons across studies. Standard indices of oral health were not adopted in studies, and proxy variables were often adopted for pneumonia diagnosis. While extensive research has established the link between poor oral hygiene and pneumonia in older adults, caution is warranted when interpreting findings related to oral disease. Lack of secure definitions of periodontal disease in some studies is a critical issue highlighted, and the need for standardised classifications is required going forward (Walter et al. 2019). Therefore, further research with robust, clinically meaningful and consistent criteria is essential to study the respiratory–periodontal relationship among the IDD population. While microbiological methods to estimate the prevalence of oral pathogens were a strength of included studies, future research must adopt prospective study designs, with adequate power, involving accurate application of validated and reliable measures of both oral health and pneumonia.

## 5 | Implications and Future Research

This scoping review found consistently prevalent potential respiratory pathogens in the mouths of people with IDD, a population at increased risk of and from pneumonia. This has clinical and research implications. There is a need for large, well-conducted studies exploring the relationship between oral bacteria, oral health and pneumonia in adults with IDD. These studies should be appropriately powered, using validated measures (particularly of oral hygiene on gingival health) and a suitably operationalised definition of pneumonia to test association. Such studies will also require secure case definitions of oral health status, specifically gingivitis and periodontal disease. Latterly, there will be a need for intervention studies to assess whether oral hygiene can reduce the incidence of pneumonia in this population.

## 6 | Conclusion

Potential respiratory pathogens are prevalent in the oral cavities of people with IDD, more so than in those without IDD. Their presence presents a plausible oro-respiratory pathway for the pathogenesis of pneumonia in this population. However, the literature reviewed here does not demonstrate that carriage of respiratory pathogens, or poor oral health for that matter, is associated with pneumonia in the IDD adult population. What little evidence exists is tenuous. Therefore, there is a critical need for more robust studies to determine whether poor oral health and hygiene are modifiable risk factors for pneumonia in individuals with IDD. Further translational research is essential to better understand and address these potential risks.

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#### Conflicts of Interest

The authors declare no conflicts of interest.

#### Data Availability Statement

Further data that support the findings of this scoping review are available from the corresponding author upon request.

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**Supporting Information**

Additional supporting information can be found online in the Supporting Information section.