

Long-Term Effectiveness of the Midwifery Initiated Oral Health-Dental Service Program on Maternal Oral Health Knowledge, Preventative Dental Behaviours and the Oral Health Status Of Children In Australia

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Abstract

Background: Early childhood caries remains a public health challenge and many interventions to manage this disease have focused on prevention during early infancy. Promoting oral health during pregnancy may also improve the oral health of children, however, there is limited evidence in Australia. The Midwifery Initiated Oral Health-Dental Service (MIOH-DS) was developed to train midwives to promote maternal oral health and a large trial showed the program substantially improved the oral health status, knowledge and behaviours of pregnant women. This study evaluated the long-term effectiveness of the program (post trial) on maternal oral health knowledge, preventative dental behaviours, and early childhood caries in offspring.

Methods: A prospective cohort study was conducted in three large metropolitan health services in Sydney, Australia. The study followed 204 women and their children three to four years after participating in the original MIOH-DS trial (intervention and control groups). The outcome measures included child dental decay (cariogenic bacteria), and a maternal oral health knowledge and behaviours questionnaire. Descriptive statistics were used to analyse the main outcomes and a regression model was constructed to explore predictors of dental decay among children.

Results: There were no significant differences across the outcome measures between the MIOH-DS participants (mother/child) and control groups except for a small difference in maternal oral health knowledge. Most mothers across both groups demonstrated high oral health knowledge and positive oral health practices, and the regression model found that these outcomes provided a protective effect (low levels of bacteria and dental caries) among children. Some aspects of oral health remained poorly understood by mothers across both groups—the oral health impact of sugary foods and drinks, at-risk feeding practices, and the recommended age for first dental visits.

Conclusions: The long-term impact of the program demonstrates the effectiveness of improving maternal oral health knowledge and preventative behaviours to reduce the risk of early childhood caries, although the specific effect of the MIOH-DS program was not found. Although oral health knowledge was high across participants the findings suggest the need for reinforced education around feeding, diet and dental visiting through postnatal early childhood services to show sustained improvements.

Background

The initiation of dental caries is a complex process where the presence of dental bacteria, specifically high levels of *Streptococcus mutans* and lactobacilli, have been associated with commencing and advancing dental decay [1, 2]. The presence of high sucrose levels accelerates this process as the dental biofilm and bacteria shift to metabolise sugars, increase acidity, and create an environment conducive to caries development [3]. Early childhood caries (ECC), defined as presence of at least one carious lesion in children under 6 years of age, is a common chronic disease that affects children globally. Many countries across the world report a prevalence of more than 50% of ECC among children, and up to 90% in some regions, by the age of five [4]. In Australia around 42% of preschool children experience decay in their primary teeth [5]. ECC can affect a child's quality of life in the short term, and impede speech, cognitive, psychological, and physical development over the long term [6]. The dental treatments for ECC can be costly [7] and delays in

treatment can exacerbate the child's poor oral health, potentially resulting in the need for more extensive dental treatment including hospitalisation [8]. ECC has also been found to be a predictor of future dental caries in permanent teeth [9].

Although ECC is a multifactorial disease, its onset and progression in children can be mitigated through cost-effective educational interventions for parents and children around oral hygiene practices as early as before birth and when feeding [10]. Many interventions that have been designed to manage ECC are focused on the early infancy period (around 0-2 years). The World Health Organization suggested that strategies should include a caries risk assessment by the child's first year and preventive measures such as behavioural management (oral hygiene, diet and the use of fluoridated toothpaste) [11].

Pregnancy is a period where mothers are more amenable to changes in health behaviours. Thus targeted oral health educational interventions during pregnancy, especially among mothers with fewer educational qualifications, could increase the effectiveness of existing interventions to reduce dental decay for children during early infancy [12]. One Cochrane review found that although giving feeding and dietary advice to pregnant women and mothers likely results in a small reduction in ECC, this review did not focus on the role of antenatal care providers [13]. Previous studies have demonstrated that antenatal care providers can effectively promote oral health through education, risk assessment and referrals among pregnant women [14-19]. To date, only one study conducted in the United States has followed up children from an oral health intervention during pregnancy involving non-dental professionals like nurses [20]. Larsen et al. [20] followed the cohort of children (n = 91) to assess the program's effectiveness in improving oral health outcomes. Children of the mothers who were part of the program, were found to have had fewer dental caries and extractions after three years.

In Australia, however, there are currently no studies evaluating the effectiveness of an antenatal intervention delivered during antenatal care in reducing the incidence of dental caries among children [21]. The Midwifery Initiated Oral Health-Dental Service (MIOH-DS) program was the first model of care in Australia where midwives were trained through an online platform to promote oral health among pregnant women [17]. This model involved training midwives in providing oral health education, performing an oral health screening assessment and following clear referral pathways to dentists. The model was designed so that antenatal care providers could raise awareness about the importance of oral health during an antenatal appointment with a woman, undertake a risk assessment, and connect them with a dental service [17]. A multi-centre randomised controlled trial (n=638) found that the model significantly improved the rate of pregnant women accessing a dentist, the mother's oral health and knowledge about appropriate oral health practices during pregnancy and in early childhood [22]. However, further research is needed to assess its effectiveness in maintaining the knowledge and practices in the long-term and reducing ECC among the children of mothers who received this intervention during pregnancy.

Methods

Recruitment and Demographics

Of the 638 mothers who were part of the MIOH-DS trial, 204 women were followed up and completed the questionnaire (31.9% response rate, 136 (66.7%) from MIOH/control groups, 68 (33.3%) from MIOH-DS group). Among the 435 mothers who did not participate, 162 (37.0%) were lost to follow up, 171 (39.3%) declined participation, 98 (22.5%) moved out of the study area and 4 (0.9%) experienced pregnancy loss. Most respondents who agreed to participate??($n=166$, 81.2%) agreed for their children ($n=169$) to receive an oral health assessment. Three of the mothers whose children received an oral health assessment had twins. Respondents were 33.56 ± 5.18 (SD) years old on average, most were born in Australia (62.7%) and spoke English only at home (71.1%). About half (47.8%) were not working at the time of the survey. A majority of respondents (78%) had either vocational or university education. (Table 1)

Oral health knowledge of mothers

Overall, participants ($n=176$) had high knowledge scores, with an average score of 21.77 ± 2.70 out of a total of 26 points. The higher proportions of incorrect responses were seen on items related to risk factors for tooth decay such as lack of calcium (89%) and sugary snacks at mealtimes (78%) as well as the recommended age for a child's first dental visit (69%) (Table 2). There was a small yet significant difference in total knowledge score between MIOH-DS and control groups (22.51 in MIOH-DS vs 21.39 in control, Mann-Whitney $U=2710.5$, $p=0.029$). Most significant differences were seen for knowledge regarding putting baby to bed with bottles of milk, performing regular 'lift the lip' checks, rinsing after meals, and sipping sweet beverages from bottles/cups throughout the day- see supplementary file 2.

Preventative dental behaviours

Dental visits

Of the mothers who had some concern with their child's teeth (25.0%), about half (49.0%) visited a dental professional for this problem. Less than half, reported regularly taking their child to a dentist each year (46.0%), and only about a third (36.3%) reported that their child saw a dentist in the last 12 months. Only 23.6% of mothers reported their children having their first dental visit at or before the age of one. Most children who had visited the dentist last saw a dentist in a private dental practice (65.0%) or a governmental dental clinic (18.8%). A small proportion of children (4%) were hospitalised for dental problems. See Table 3 for full dental visit data.

Although more than half of respondents received information about oral health care during early childhood (61.7%), few (1.6%) received the ECOH program at child health checks. A significant relationship was found between intervention and control groups whereby those who were in the MIOH intervention group were more likely to have received information about oral health care for their child by the time of this study ($p < 0.04$).

Oral hygiene

Most mothers reported that their child's teeth were brushed once or twice a day (92.1%). A majority of participants used children's toothpaste for their child's teeth (85.2%), followed by standard fluoride toothpaste (9.9%). Almost all (98.0%) mothers usually assisted their child to brush their teeth. Most respondents (83.3%) applied toothpaste and brushed their child's teeth. The majority (67.8%) of parents reported usually using a pea-sized amount of toothpaste on their child's toothbrush. There were no significant differences in these practices between groups.

Eating and feeding habits

Just over a quarter (27.6%) of mothers reported their child consuming juice at least once a day. A similar proportion (25.1%) reported their child consuming biscuits, cakes donuts or muesli bars, at least once per day. Fewer mothers reported at least daily consumption of confectionary (10.9%), or soft drink (3.0%).

A third of participants reported that their child currently uses a bottle (31.4%), and most reported that their child used a feeder cup (81.4%). More than two-thirds of participants identified that their child always drinks from a regular cup (68.1%). Just under half of mothers reported that their child (41.7%) regularly used a pacifier at some point in their lives. Most parents reported having practised, or currently practising, sharing utensils while feeding their child (60.3%). Some mothers reported giving their child a bottle when lying down to rest (40.2%), using their mouth to clean a pacifier for their child (12.7%), or coating a pacifier or bottle tea with honey or other sweet substance (3.4%), at some point. Cup usage was the only variable that varied significantly across groups, with 19.4% more mothers in the MIOH-DS group reporting their child always drank from a cup (Pearson's $\chi^2 = 11.734, p=0.019$)- see supplementary file 2

Dental decay among children

Less than half of mothers (43.6%) perceived their child's oral health to be "very good".

A quarter of mothers (25.0%) reported to have some concern with their child's teeth, gums, or mouth. (Table 4) No significant relationship was found between intervention and control groups. These women reported the following concerns: cavities (10.8%), toothache (1.5%), broken teeth (1.0%), bleeding gums (0.5%), loose teeth (0.5%) or other problems (12.7%).

The oral assessment found that overall, the 169 children who were assessed, had good oral health, with the mean dmfs and dmft being 0.66 and 0.56 respectively (Table 5). Of these children, only 15.5% tested positive for *Streptococcus mutans* and 15.9% tested positive for lactobacilli (See Table 4). This also did not vary significantly between intervention and control groups.

Relationships with dmft

Initial crosstabulations and a correlation matrix were conducted to inform a logistic regression model constructed to determine variables associated with dental decay among children (See supplementary file 3).

Variables were selected for this model on the basis of the research aims, potential to be confounding variables, as well as statistically significant associations at $p < 0.05$.

The final regression model found mothers' oral health knowledge scores at the end of the MIOH-DS trial, and coating pacifiers or teats with sweet substances to be significantly associated with their child's dmft at the time of assessment (Table 5). With each additional knowledge score point at the end of MIOH-DS trial, the odds of having a dmft of one or more were reduced by almost half (OR 0.581). Conversely, coating a pacifier or teat with sweet substances increased the odds of a dmft of one or more by over 15 times (OR 15.073). There was also a trend whereby children who consumed soft drink at least once per day had over ten times the odds of having a dmft greater than 1, however this was non-significant (OR 10.690). This model was shown to have good fit, with a Hosmer and Lemeshow goodness of fit test yielding a non-significant result (Table 5).

Results

Recruitment and Demographics

Of the 638 mothers who were part of the MIOH-DS trial, 204 women were followed up and completed the questionnaire (31.9% response rate, 136 (66.7%) from MIOH/control groups, 68 (33.3%) from MIOH-DS group). Among the 435 mothers who did not participate, 162 (37.0%) were lost to follow up, 171 (39.3%) declined participation, 98 (22.5%) moved out of the study area and 4 (0.9%) experienced pregnancy loss. Most respondents who agreed to participate?? ($n=166$, 81.2%) agreed for their children ($n=169$) to receive an oral health assessment. Three of the mothers whose children received an oral health assessment had twins. Respondents were 33.56 ± 5.18 (SD) years old on average, most were born in Australia (62.7%) and spoke English only at home (71.1%). About half (47.8%) were not working at the time of the survey. A majority of respondents (78%) had either vocational or university education. (Table 1)

Table 1: Demographic characteristics of respondents (n=204)

Variables	n (%)
MIOH group	
MIOH/control	136 (66.7)
MIOH-DS	68 (33.3)
Age in years , mean [median] (SD) (range, 22-50)	33.56 [32.96] (5.18)
Country of birth	
Australia	128 (62.7)
Overseas	76 (37.3)
Language spoken at home	
English only	145 (71.1)
English and another language	35 (17.2)
Language other than English	24 (11.8)
Parity	
Primipara	34 (16.7)
Multipara	170 (83.3)
Employment status (n=203)	
Working full-time	40 (19.7)
Working part-time	66 (32.5)
Not working	97 (47.8)
Highest educational qualification	
Secondary school	24 (11.8)
High school	21 (10.3)
Vocational education	105 (51.5)
University	54 (26.5)
Marital Status	
Single	39 (19.1)
Married/Partnered	159 (77.9)
Divorced	6 (2.9)
Average fortnightly household income	

< \$700	4 (2.0)
\$700 - \$1,200	32 (15.7)
\$1,200 - \$2,000	38 (18.6)
\$2,000 - \$3,000	35 (17.2)
> \$3,000	34 (16.7)
Don't know	43 (21.1)
Refused	18 (8.8)
Had private health insurance	68 (33.3)
Had concession/Health Care Card (<i>n</i>=199)	87 (42.6)
Child attending daycare/pre-school (<i>n</i>=203)	168 (82.8)

Oral health knowledge of mothers

Overall, participants (*n*=176) had high knowledge scores, with an average score of 21.77 ± 2.70 out of a total of 26 points. The higher proportions of incorrect responses were seen on items related to risk factors for tooth decay such as lack of calcium (89%) and sugary snacks at mealtimes (78%) as well as the recommended age for a child's first dental visit (69%) (Table 2). There was a small yet significant difference in total knowledge score between MIOH-DS and control groups (22.51 in MIOH-DS vs 21.39 in control, Mann-Whitney U=2710.5, *p*=0.029). Most significant differences were seen for knowledge regarding putting baby to bed with bottles of milk, performing regular 'lift the lip' checks, rinsing after meals, and sipping sweet beverages from bottles/cups throughout the day- see supplementary file 2.

Table 2: Oral health knowledge items and proportion of correct responses (CR)

Item	Correct responses n(%)
Having healthy baby teeth is not as important as having healthy permanent teeth because baby teeth will fall out (CR: False)	192 (94.1)
A good way to prevent cavities in children is to give sugary snacks only at meal times (CR: True)	44 (21.6)
It is ok to use the same spoon to taste baby's food (CR: False)	175(85.8)
Dental caries is a disease in which bacteria in your mouth use sugar to produce acid that breaks down your tooth enamel. (CR: True)	199(98.0)
Early tooth decay appears as yellow areas that later break down into brownish holes. (CR: True)	192(94.1)
Undetected tooth decay can cause a child to suffer considerable pain and even hospitalisation (CR: True)	202(99.0)
Children of mothers who have tooth decay are more likely to get tooth decay (CR: True)	147(72.1)
Cheese is a snack that is least likely to cause decay (CR: True)	143(70.1)
It is safe to put baby to bed with a bottle of milk (CR: False)	180(88.2)
A pea sized amount of toothpaste should be used when brushing children's teeth (CR: True)	202(99.0)
Children should be assisted in brushing till the age of 8 years (CR: True)	191(93.6)
Parents should regularly perform a 'lift the lip' check on their child (CR: True)	145(71.4)
Tooth decay in early childhood is: (CR: The single most common chronic childhood disease)	142(77.6)
Untreated tooth decay can lead to: (CR: All of the above)	189(92.6)
Which of the following drinks do not cause tooth decay? (CR: Water)	203(99.5)
What are factors that might increase the risk of tooth decay?	
Taking too much sugary food or drinks (CR: True)	203(99.5)
Not brushing teeth with fluoride toothpaste in the morning and at night (CR: True)	201(98.5)
Eating or drinking too frequently (CR: False)	77(37.7)
Not rinsing after meals (CR: True)	168(82.4)
Lack of calcium (CR: False)	22(10.8)
Breastfeeding beyond 12 months of age (CR: False)	155(76.0)
Discontinuing bottle feeding before 12 months (CR: False)	176(86.3)
Sipping from a bottle/cup throughout the day with something sweet in it (CR: True)	177(86.8)
None of the above (CR: False)	203(99.5)

When should you start brushing a child's teeth? (CR: When the first tooth appears)	156(76.5)
Before infant's teeth appear, parents should: (CR: Clean an infant's gums with a damp washcloth after meals and before bed)	116(56.9)
Tooth decay in early childhood is caused by a combination of many factors that include the following: (CR: All of the above)	201(98.5)
Which is not a risk factor for tooth decay in early childhood? (CR: Sleeping with a bottle filled with plain water)	204(100.0)
A child's first dental visit should be: (CR: At one year old)	63(30.9)

Preventative dental behaviours

Dental visits

Of the mothers who had some concern with their child's teeth (25.0%), about half (49.0%) visited a dental professional for this problem. Less than half, reported regularly taking their child to a dentist each year (46.0%), and only about a third (36.3%) reported that their child saw a dentist in the last 12 months. Only 23.6% of mothers reported their children having their first dental visit at or before the age of one. Most children who had visited the dentist last saw a dentist in a private dental practice (65.0%) or a governmental dental clinic (18.8%). A small proportion of children (4%) were hospitalised for dental problems. See Table 3 for full dental visit data.

Although more than half of respondents received information about oral health care during early childhood (61.7%), few (1.6%) received the ECOH program at child health checks. A significant relationship was found between intervention and control groups whereby those who were in the MIOH intervention group were more likely to have received information about oral health care for their child by the time of this study ($p < 0.04$).

Oral hygiene

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Eating and feeding habits

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day. Fewer mothers reported at least daily consumption of confectionary (10.9%), or soft drink (3.0%).

A third of participants reported that their child currently uses a bottle (31.4%), and most reported that their child used a feeder cup (81.4%). More than two-thirds of participants identified that their child always drinks from a regular cup (68.1%). Just under half of mothers reported that their child (41.7%) regularly used a pacifier at some point in their lives. Most parents reported having practised, or currently practising, sharing utensils while feeding their child (60.3%). Some mothers reported giving their child a bottle when lying down to rest (40.2%), using their mouth to clean a pacifier for their child (12.7%), or coating a pacifier or bottle tea with honey or other sweet substance (3.4%), at some point. Cup usage was the only variable that varied significantly across groups, with 19.4% more mothers in the MIOH-DS group reporting their child always drank from a cup (Pearson's $\chi^2 = 11.734, p=0.019$)- see supplementary file 2

Table 3: Child preventative dental behaviours as reported by mothers

Preventative dental behaviour	
	n (%)
Dental visits	
Sought dental professional for oral health problems/concerns	25(49.0)
Hospitalisation related to dental problems	4(2.0)
Child regularly visits dentist every year	92(46.0)
Last visit within past 12 months	73(36.3)
Age of first dental visit	
Under one year old	5(3.8)
One year	26(19.8)
Two years	38(29.0)
Three years	37(28.2)
Four years	5(3.8)
Never	20 (15.3)
Setting of child's last dental visit	
Private practice	76(65.0)
Government dental service	22(18.8)
School dental service	2(1.7)
Other	12(10.3)
Don't know	5(4.3)
Received information about child oral health	119(61.7)
Received ECOH program	3(1.6)
Oral hygiene	
Frequency of tooth brushing with toothpaste	
Less than once a day	14(6.9)
Once a day	97(47.8)
Twice a day	90(44.3)
More than twice a day	2(1.0)
Type of toothpaste used	
Standard fluoride toothpaste	20(9.9)

Children's toothpaste	173(85.2)
Non-fluoride toothpaste	6(3.0)
None	4(2.0)
Amount of toothpaste used	
Less than a pea sized amount	51(25.6)
A pea sized amount (recommended)	135(67.8)
More than a pea sized amount	13(6.5)
Assists child with tooth brushing	199(98.0)
Dietary and other habits	
Consumes juice at least once per day	56(27.6)
Consumes soft drink at least once per day	6(3.0)
Consumes biscuits, cakes donuts or muesli bars at least once per day	51(25.1)
Consumes confectionary at least once per day	22(10.9)
Drinks from bottle at least sometimes	35(17.2)
Always drinks from regular cup	139(68.1)
Child currently using bottle	64(31.4)
History of regular pacifier use	85(41.7)
Shares eating utensils with child	123(60.3)
Used mouth to clean pacifier for child	26(12.7)
Coated pacifier or teat with sweet substances	7(3.4)
Given a bottle when lying down to sleep	82(40.2)

Dental decay among children

Less than half of mothers (43.6%) perceived their child's oral health to be "very good".

A quarter of mothers (25.0%) reported to have some concern with their child's teeth, gums, or mouth. (Table 4) No significant relationship was found between intervention and control groups. These women reported the following concerns: cavities (10.8%), toothache (1.5%), broken teeth (1.0%), bleeding gums (0.5%), loose teeth (0.5%) or other problems (12.7%).

The oral assessment found that overall, the 169 children who were assessed, had good oral health, with the mean dmfs and dmft being 0.66 and 0.56 respectively (Table 5). Of these children, only 15.5% tested positive for *Streptococcus mutans* and 15.9% tested positive for lactobacilli (See Table 4). This also did not vary significantly between intervention and control groups.

Table 4: Child characteristics and oral assessment

Variable	n(%)
Age (mean ± SD [median])	4.07 ± 0.41 [3.92]
Parent reported concerns with child's oral health	51(25.0)
Parent perception of child oral health	
Very good	89 (43.6)
Good	85 (41.7)
Average	23 (11.3)
Poor	7 (3.4)
<i>Streptococcus mutans</i> positive	32 (15.5)
Lactobacilli positive	33 (15.9)
dmft (mean ± SD [median])	0.56 ± 1.31 [0]
dmfs (mean ± SD [median])	0.66 ± 1.87 [0]
dmft at least 1	37 (21.9)
<i>Dmft ≥ 1 indicates any child who had at least one decayed, missing or filled tooth.</i>	

Relationships with dmft

Initial crosstabulations and a correlation matrix were conducted to inform a logistic regression model constructed to determine variables associated with dental decay among children (See supplementary file 3). Variables were selected for this model on the basis of the research aims, potential to be confounding variables, as well as statistically significant associations at $p < 0.05$.

The final regression model found mothers' oral health knowledge scores at the end of the MIOH-DS trial, and coating pacifiers or teats with sweet substances to be significantly associated with their child's dmft at the time of assessment (Table 5). With each additional knowledge score point at the end of MIOH-DS trial, the odds of having a dmft of one or more were reduced by almost half (OR 0.581). Conversely, coating a pacifier or teat with sweet substances increased the odds of a dmft of one or more by over 15 times (OR 15.073). There was also a trend whereby children who consumed soft drink at least once per day had over ten times the odds of having a dmft greater than 1, however this was non-significant (OR 10.690). This model was

shown to have good fit, with a Hosmer and Lemeshow goodness of fit test yielding a non-significant result (Table 5).

Table 5: Regression model of determinants of having a dmft score of 1 or more (n=138)

Covariate	Odds Ratio (exp(B))	Standard Error	Wald	95% Confidence Interval for Odds Ratio		p value
				Lower	Upper	
Child consumes juice at least once a day	1.513	0.561	0.545	0.504	4.538	0.460
Child consumes soft drink at least once a day	10.690	1.331	3.170	0.788	145.085	0.075
Child consumes biscuits, cakes, donuts or muesli bars at least once a day	1.646	0.576	0.749	0.533	5.085	0.387
Child consumes confectionery at least once a day	0.941	0.905	0.005	0.160	5.547	0.946
Shares eating utensils with child	1.281	0.535	0.215	0.449	3.656	0.643
Used mouth to clean pacifier for child	0.663	0.782	0.277	0.143	3.070	0.599
Coated pacifier or teat with sweet substances	15.073	1.103	6.045	1.734	131.047	0.014
Given a bottle when lying down to sleep	0.686	0.543	0.482	0.237	1.988	0.487
Knowledge score post MIOH-DS	0.581	0.250	4.722	0.355	0.948	0.030
MIOH-DS vs MIOH/Control groups	0.579	0.547	0.998	0.198	1.692	0.318
Mother received information about child oral health	2.311	0.560	2.240	0.772	6.920	0.134
Constant	11.494	2.110	1.339			0.247
Nagelkerke R Square	0.233310					
Hosmer and Lemeshow test (p; df)	0.708; 8					

Discussion

This is the first study that has evaluated the long-term oral health outcomes in infants of mothers who received a comprehensive oral health program delivered by antenatal care providers during pregnancy. Results revealed that high maternal oral health knowledge provided a protective effect for dental decay in children. This protective effect supports guidelines that recommend the delivery of oral health education to mothers as early as during pregnancy [31, 32].

Overall, the participants demonstrated high levels of oral health knowledge and positive oral health practices. Almost all women could correctly identify items such as dental caries as a disease, the impact of undetected tooth decay and the appropriate amount of toothpaste required for children. Furthermore, the high rates of toothbrushing and appropriate usage of fluoridated products for children may be comparable to other studies conducted in high-income countries [33, 34]. There was a small but significant difference in maternal oral health knowledge in the intervention group which is an improvement from all previous studies that have found no change [14, 15]. Further, the intervention group did have better knowledge about key risk factors for early childhood caries such as putting the baby to bed with a bottle and sipping sweet beverages from bottles/cups as well preventative strategies like performing regular oral health checks (lift the lip). Given the control group in our study also received an educational oral health brochure during pregnancy which is unique, this result suggests that in the long-term, any form of early childhood oral health education antenatally is valuable and may contribute to higher maternal oral health knowledge post birth.

While knowledge scores were high overall, there were some aspects of oral health that were not very well understood by the mothers and which require further attention. For instance, items related to feeding practices and dental visits. This has also been identified as a gap in oral health knowledge by Blinkhorn et al. [35]. They found that although mothers had an understanding about good oral health practices, only 7% of mothers could identify the foods and drinks that contained the most sugar [35]. Understanding the oral health impact of sugar consumption is important as caregivers tend to have greater intention to limit sugary foods and drinks they offer to their child, when higher knowledge is evidenced [36]. Further, although it was not asked as a knowledge item, clearly the fact that some mothers reported coating their child's pacifier in a sugar sweetened substance, sharing utensils while feeding and giving a bottle to the baby while lying down, highlights a knowledge gap in these areas. Some studies have suggested that health advice from clinicians can assist to educate and remind parents about these feeding behaviours [37]. Reinforcement of oral health education postnatally could strengthen the impact seen with our intervention. One hypothesis for some gaps in knowledge/behaviour found in this study could be associated with the fact that the MIOH-DS program was delivered antenatally. In the ECOH program, delivered postnatally, certain feeding and dietary behaviours are typically reinforced through child health professionals; however, in this sample, very few mothers received the ECOH program for their child. Previous reported data on the MIOH-DS program also showed that oral health outcomes and knowledge among pregnant women were improved in the short term only [22]. In fact, changes in oral health knowledge appeared to diminish during the follow up period.

The need for postnatal education was recently noted by a review conducted by George et al. [21]. This work suggested that a combined intervention across both the antenatal and postnatal periods may deliver results in improved oral health outcomes among children. Other avenues of support such as general practitioners, maternal and early childhood services, pharmacies and childcare services may need to be considered to reinforce some of the key knowledge gaps identified in this study. Another avenue for education could be on packaging that surrounds pacifiers, infant bottles and baby spoons.

About 50% of children in our sample had seen a dentist by the age of two, but only a few had seen the dentist by the recommended age of one. This is a relatively better outcome than what is reported in the Australia's national dental telephone survey, which found that about 30% of children aged 2 to 4 years, had

seen the dentist [38]. While this is not a direct comparison, this statistic suggests that raising oral health awareness during pregnancy through programs like the MIOH-DS may positively affect some mothers' decision to access dentists for their children earlier. Strategies that have the potential to change intention to see the dentist and thus, improve dental visits are a very important step towards diminishing the ECC inequality. This has recently been suggested by Peres et al. [39]'s findings from the analysis of a National Child Oral Health Survey conducted in Australia. The need for timely messages about seeing the dentist is also supported by literature in other high-income countries, which have found that caregivers may not book dental appointments by the recommended age due to lack of awareness or misinformation [40-42]. Thus, reinforcing the need for educational interventions on dental visits during the postnatal and early childhood period.

The proportion of participants reporting access to public dental clinics in our study was similar to national reported data (19.4%) among children aged 2-4 years [38]. Reasons for accessing public oral health services were not explored in this study; however, various other Australian surveys have found that about 30% of parents were not aware that their child was eligible for free dental services [43, 44]. Only about half of parents in Queensland are aware of the Child Dental Benefits Schedule that subsidises the cost of preventative or general dental treatment for children in public or private practices [43]. In NSW, information about eligibility to free dental services could be reinforced postnatally during the established ECOH program.

The strengths of this study include prospectively collected data in a large cohort using validated measures. The limitations include the long latency period before the follow up. This may have contributed to the low response rate; many participants had moved away or changed contact details. Similarly, this loss to follow-up of women may have contributed to selection bias. Although the ECOH program is recommended state-wide, very few women in this study, received the program for their children. Consequently, it is difficult to ascertain the impact of the ECOH program on early childhood oral health when combined with an antenatal oral health intervention.

Conclusion

The long-term impact of the MIOH-DS program demonstrates the importance of improving maternal oral health knowledge during pregnancy to reduce the risk of children developing early dental decay. Our findings also further support the role of antenatal care providers in promoting oral health as a part of a healthy pregnancy. Although the oral health knowledge among the mothers was high generally, the study suggests that oral health education around feeding, diet, and dental visiting requires reinforcement during the postnatal period to bring about long-term behaviour change along with sustained improvements and innovative ways may need to be tested to find the best strategy. Future research should explore the long-term impact of an antenatal and postnatal oral health intervention on the oral health of children in children. Such strategies would align with the Australian governments focus on preventative initiatives across pregnancy and first 2000 days [45].

Abbreviations

decayed-missing filled surface (dmfs); decayed-missing-filled teeth (dmft); early childhood caries (ECC); early childhood oral health (ECOH) program; Greater Western Sydney (GWS); medical record numbers (MRNs); Midwifery Initiated Oral Health-Dental Service (MIOH-DS); New South Wales (NSW)

Declarations

Ethics approval and consent to participate.

This study has been approved by the South Western Sydney Local Health District Human Research Ethics Committee (HREC/16/LPOOL/418). Reciprocal approval was also granted from Western Sydney University (HE16/225). Participating in the study was voluntary and informed written and verbal consent was obtained from all participants.

Consent for publication

Not applicable.

Availability of data and materials

The dataset used during the current study are available from the corresponding author on reasonable request.

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Authors' contributions

AG and MJ were involved in the conceptualisation and design of the study. AG, AK, MS and MJ designed and wrote the first draft of the manuscript. Additionally, AG, AK and MS coordinated the data collection. AV and MJ assisted with data analysis and had the complete access to the data. AG, AK, MS, AV, SA, SB, HD, AY and MJ assisted with data interpretation. All the authors contributed to the subsequent versions of the manuscript and approved the final version for submission.

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