

<b>Institution: Teesside University</b>
<b>Unit of Assessment: 3; Allied Health Professions, Dentistry, Nursing and Pharmacy</b>
<b>Title of case study: Fluoride research: changes to national and international policy and practice in dental health</b>
<b>1. Summary of the impact</b>

According to the World Health Organization (WHO), 60% to 90% of school children are affected by tooth decay in industrialised countries <sup>1,2</sup>. At low levels, fluoride can reduce tooth decay, but high levels can damage developing tooth enamel in young children. **Our research has informed the revised WHO guidelines for monitoring community tooth decay prevention programmes and the UK National Fluoridated Milk Advisory Group’s recommendation to increase the amount of fluoride added to school milk.** The WHO guidelines are accepted and implemented internationally representing a substantial spread of influence. The recommendation to increase the amount of fluoride in school milk UK-wide is significant, as it will **further control and reduce dental caries**, especially in deprived areas with non-fluoridated water supply. In addition, we have established better measures of babies’ and children’s actual and ideal fluoride intake, including better techniques to determine the fluoride content of foods, a protocol for monitoring fluoride intake through urinary excretion, and experimentally-based models to monitor community preventive programmes.

1. Peterson PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risk to oral health. *Bulletin of the World Health Organization* 2005;83:661-669
2. Peterson PE. Priorities for research for oral health in the 21<sup>st</sup> century – the approach of the WHO global oral health programme. *Community Dental Health* 2005; 22:71-74.

<b>2. Underpinning research</b>
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We, in collaboration with Newcastle University, have undertaken studies focusing on the current important issues in fluoride research including fluoride measurement and total exposure for maximum dental benefit while minimising the risk of dental fluorosis. Our work is consistent with the WHO’s current Priority Action Area - Oral Health and Fluorides.

From 2003 to 2010, we collaborated with nine fluoride research centres to develop and evaluate key standardised direct and indirect techniques for determining the fluoride content of biological and non-biological samples [1] and hence, accurately, the fluoride exposure of individuals. We and other fluoride laboratories have successfully used these techniques to measure fluoride contents of different samples at our laboratories. **Zohoori** has been employed at Teesside University since May 2007; therefore all work conducted after this date took place in the submitting unit. **In 2008, Dr Zohoori** led a project in which fluoride contents of more than 180 commercially available foods and drinks used by babies and young children in the UK were measured [2,3]. **In 2009, Dr Vida Zohoori in collaboration with Newcastle University developed a specific Standard Operating Procedure (SOP) to measure fluoride content of milk.** This SOP has been used by one of the three dairies in the UK that produce fluoridated milk to measure fluoride concentration as a routine check.

Mouthwashes are increasingly used as an adjunct to toothpastes in oral hygiene regimes. **In 2008, Dr Vida Zohoori led a project to test the potential benefit of the combined use of a fluoridated toothpaste and a fluoridated mouthwash.** Our study [4] formed part of a position paper in the *British Dental Journal* (Pitts et al., 2012:

<http://www.nature.com/bdj/journal/v212/n7/pdf/sj.bdj.2012.260.pdf>), which contained key recommendations for the use of such products, and has also been cited by the British Dental Association: Available at: <http://www.bda.org/students/help-advice/clinical/ortholist.aspx>

<http://dentalhygienetherapy.co.uk/oral-health-news/dental-patients-ignore-oral-health-advice/>

In 2009, Dr Vida Zohoori collaborated with the Institute of Nutrition and Food Technology, University of Chile; Antioquia University, Colombia; and Newcastle University, UK **to develop experimentally-based models in order to estimate total daily fluoride intake and retention from urinary fluoride excretion data** [5]. The data have been used to revise WHO guidelines for urinary fluoride excretion to monitor community preventive programmes.

For many years and in many countries, fluoride has been added to milk as a primary preventive and public health measure for caries control. In the UK, milk fluoridation is used in a school-based programme for children at high risk of caries, residing in low fluoridated water areas. These schemes provide fluoride milk (containing 0.5 mg fluoride in a 189-ml carton) on school days. However, it has been suggested that this amount of fluoride might not achieve the best balance of dental protection and risk of side-effects. **In 2008 at Teesside, Dr Vida Zohoori was the co-applicant of a study, commissioned by the UK National Fluoridated Milk Advisory Group**, which aimed to determine whether children receiving fluoridated milks are sub-optimally exposed to fluoride based on WHO guidelines for urinary fluoride excretion; and to provide a robust evidence base to determine whether the amount of fluoride added to school milk should be reviewed. This study concluded that both the existing fluoride concentrations of 0.5 mg fluoride and the intervention project dose of 0.9 mg fluoride in 189 ml milk may be too low to achieve WHO recommended urinary fluoride excretions concomitant with optimal fluoride exposure for children > 6y [6]. Based on this study, the National Fluoridated Milk Advisory Group decided, in May 2011, to recommend an increase in the amount of fluoride added to a 189 ml carton of school milk in the UK from 0.5 mg to 0.8 mg fluoride.

### 3. References to the research (Citations from Scopus database)

[1] Martínez-Mier EA, Cury JA, Heilman JR, Katz BP, Levy SM, Li Y, Maguire A, Margineda J, O'Mullane D, Phantumvanit P, Soto-Rojas AE, Stookey GK, Villa A, Wefel JS, Whelton H, Whitford GM, Zero DT, Zhang W, **Zohoori V**: Development of Gold Standard Ion-Selective Electrode-Based Methods for Fluoride Analysis. *Caries Research* 2011; 45: 3-12.

**Cited 10 times. Available in REF 2.**

[2] Maguire A, Omid N, Abuhaloob L, Moynihan PJ, **Zohoori FV**. Fluoride content of Ready-to-Feed (RTF) infant food and drinks in the UK. *Community Dentistry and Oral Epidemiology*. 2012, 40(1):26-36.

**Cited 2 times** as well as in the following book chapter:

*Nutrition in Infants: Risks and Management, R Sharma - Nutrition in Infancy, 2013 – Springer*  
[http://link.springer.com/chapter/10.1007/978-1-62703-224-7\\_2#](http://link.springer.com/chapter/10.1007/978-1-62703-224-7_2#)

[3] **Zohoori FV**, Moynihan PJ, Omid N, Abuhaloob L, Maguire A. Impact of water fluoride concentration on the fluoride content of infant foods and drinks requiring preparation with liquids before feeding. *Community Dentistry and Oral Epidemiology*. 2012, 40:432-440.

**Cited 3 times.**

[4] Duckworth RM, Maguire A, Omid N, Steen IN, McCracken GI, **Zohoori FV**. Effect of rinsing with mouthwashes after brushing with a fluoridated toothpaste on salivary fluoride clearance. *Caries Research*. 2009, 43:391-396. **Cited 10 times. Available in REF 2.**

[5] Villa A; Anabalon M; **Zohoori V.**; Maguire A; Franco AM; Rugg-Gunn A. Relationships between Fluoride Intake, Urinary Fluoride Excretion and Fluoride Retention in Children and Adults: An Analysis of Available Data. *Caries Research*. 2010, 44:60-68. **Cited 10 times. Available in REF 2.**

[6] Maguire A, Walls R, Steen N, Teasdale L, Landes D, Omid N, Moynihan P, Zohoori FV. Urinary fluoride excretion in 6- to 7-year olds ingesting milk containing 0.5 or 0.9 mg fluoride. *Caries Research*. 2013, 47: 291-298. **Available in REF 2.**

**4. Details of the impact**

The stated goal of WHO community-based public health programmes is to implement the most appropriate means of maintaining a constant low level of fluoride in as many mouths as possible. **We have collaborated with nine laboratories in five different countries on an international project** that aimed to develop a much needed gold standard method for measuring fluoride in biological and non-biological samples (Martinez-Mier et al., 2011). This was the basis for development of a Standard Operating Procedure, in collaboration with Newcastle University, **which has been used** by Fresh Pastures Dairy, Ossett <sup>(a)</sup>.

Mouthwashes are increasingly used as an adjunct to toothpastes in oral hygiene regimes. **In 2009, we led a project, funded by Johnson & Johnson, to test the potential benefit of the combined use of a fluoridated toothpaste and a fluoridated mouthwash.** The original concern expressed by some was that 100 ppm fluoride in mouthwash would be too low, but our study was the first one to show that it is sufficient to maintain salivary fluoride levels, where this is a main concern for dental professionals and the consumers. Our study (Duckworth et al., 2009) formed part of a position paper in the British Dental Journal <sup>(b)</sup>, which contained key recommendations for the use of such products. Our study has also been cited by the British Dental Association: “The value of mouthwash to orthodontic patients” <sup>(c, d)</sup>.

From a public health perspective, it is very important to observe if a population receives optimal exposure to fluoride. WHO recommends that any fluoride supplementation programmes should be monitored prior to and after implementation to ensure that ingestion of fluoride from all sources by the children involved is at the appropriate level. However, it is very difficult to estimate total daily fluoride intake in children. We developed experimentally-based models allowing the estimation of total daily fluoride intake and retention from urinary fluoride excretion data (Villa et al., 2010). WHO published a monitoring document in 1999 (Monitoring of Renal Fluoride Excretion in Community Preventive Programmes on Oral Health), which has been a valuable key source to the WHO Global Oral Health Programme. A formal review of the guidance was undertaken in December 2011 at the **WHO technical working group meeting to which Dr. Vida Zohoori of the Health and Social Care Institute, as an international expert in the use of fluoride for public health, was invited** <sup>(e)</sup>. Our publication (Villa et al., 2010) has been accepted as **one of the bases for the revised WHO guidelines for urinary fluoride excretion to monitor community preventive programmes.**

Since only 10% of the UK population receive fluoridated water, a school milk fluoridation scheme was introduced in 1993 as a public health measure for caries control in non-fluoridated socially-deprived areas. Fluoride milk schemes are offered by 510 education establishments in the UK including more than 40,000 children aged between 3 and 11 years. Currently a 189 ml carton of semi-skimmed milk containing 0.5 mg fluoride is the standard daily dose in the UK. However, it is not clear that this delivers the optimal amount of fluoride to balance dental protection against side effects.

**Dr Vida Zohoori**, (alongside Dr Anne Maguire, a Professor of Preventive Dentistry at the School of Dental Sciences, Newcastle University) was **commissioned by the UK National Fluoridated Milk Advisory Group to investigate the urinary excretion of fluoride associated with milk fluoridation.** We designed and carried out a study to provide a robust evidence base for dental public health consultants and other health professionals to review the amount of fluoride added to school milk. Our study did not show any statistically significant differences in urinary fluoride excretion between the children who received fluoridated milk containing 0.5 mg fluoride and those who received fluoridated milk containing 0.9 mg fluoride. Our study also suggested that the moderate effectiveness of 0.5 mg fluoride milk used in the school milk programme could be due to the low fluoride dose in milk and/or sub-optimal compliance with milk consumption in the children participating in the scheme. Our study, therefore, concluded that actual fluoride milk consumption should be assessed when the efficacy of UK school milk schemes is being investigated or evaluated, particularly if the fluoride dose is under review.

**Impact case study (REF3b)**

**As a result of our study, the National Fluoridated Milk Advisory Group decided in May 2011 that the amount of fluoride added to school milk in the UK should be increased from 0.5 to 0.8 mg fluoride** <sup>(f,g)</sup>. Approval for this increase has been obtained from all ten participating local authorities and the change has taken effect since September 2013 <sup>(h)</sup>. (We appreciate that the date of the implementation falls outside the REF impact census period, but it is included here to show the evidence translation process in the round. The implementation could not have occurred earlier, due to the school summer holiday period.)

Our study also showed that UK schemes should review their current monitoring programme. As a result, in 2012 we (Dr Vida Zohoori, as the co-author, alongside Dr Anne Maguire, a Professor of Preventive Dentistry at the School of Dental Sciences, Newcastle University) developed a protocol for baseline and ongoing monitoring of total fluoride intake and urinary fluoride excretion in children participating in milk fluoridation programmes in the UK. The **National Fluoridated Milk Advisory Group's monitoring group has now prepared a Standard Operating Procedure based on the protocol we have developed.**

**5. Sources to corroborate the impact**

- (a) Director, Fresh Pastures CIC.
- (b) <http://www.nature.com/BJJ/journal/v212/n7/pdf/sj.bdj.2012.260.pdf>
- (c) <http://www.bda.org/students/help-advice/clinical/ortholist.aspx>
- (d) <http://dentalhygienetherapy.co.uk/oral-health-news/dental-patients-ignore-oral-health-advice/>
- (e) Responsible Officer, Oral Health Chronic Disease and Health Promotion. World Health Organization, Geneva.
- (f) Specialist in Dental Public Health, Public Health England, Manchester.
- (g) Assistant Public Health Programme Manager. Knowsley Council, Merseyside.
- (h) <http://www.knowsley.gov.uk/pdf/public-health-annual-report-2012-2013.pdf>

**Written factual statements supporting the impact claims have been received from (e), (f), and (g), and are available on request.**