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A systems approach using the functional resonance analysis method to support fluoride varnish application for children attending general dental practice

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ABSTRACT

Background: All children attending General Dental Practice in Scotland are recommended to receive twice-yearly applications of sodium fluoride varnish to prevent childhood caries, yet application is variable. Development of complex interventions requires theorizing and modelling to understand context. This study applies the Functional Resonance Analysis Method (FRAM) to produce a sociotechnical systems model and identify opportunities for intervention to support application.
Methods: The FRAM was used to synthesise data which were: routine monitoring of fluoride varnish application in 2015/16; a longitudinal survey with practitioners (n = 1090); in-depth practitioner and key informant interviews (n = 43); and a 'world café' workshop (n = 56).
Results: We describe a detailed model of functions linked to application, and use this to make recommendations for system-wide intervention.
Conclusions: Rigorous research is required to produce accessible models of complex systems in healthcare. This novel paper shows how careful articulation of the functions associated with fluoride varnish application can support future improvement efforts.

1. Introduction

1.1. Childhood caries

Dental caries is a significant public health concern with a global cost burden (Kassebaum et al., 2015; Petersen, 2008). In Scotland, caries is the predominant reason for hospital admissions for elective surgery in children (Scottish Government, 2016c) and reducing this preventable harm is a key outcome for the Scottish Government's health and well-being strategy (Scottish Government, 2014). Upon entering school, 45% of children from the most deprived areas have experienced caries, and 18% from the most affluent (Scottish Government, 2016a), reflecting a known inequality in health outcomes (Scottish Government, 2000; Levin et al., 2009).

1.2. Prevention in practice in Scotland

Childsmile (Macpherson et al., 2010; Turner et al., 2010) is a population level oral health improvement programme for Scottish children with components in schools, nurseries, family homes and dental practices. This practice-based programme delivers parental advice on diet, fluoride and tooth brushing, and clinical prevention via the application of sodium fluoride varnish (FV) to children.

1.2.1. Sodium fluoride varnish application

There is high quality evidence for the caries-preventive efficacy of FV as a safe, topical treatment (Marinho et al., 2013; Weintraub et al., 2006). All children are deemed to be at risk of caries, and thus could benefit from application (SDCEP, 2010). Dental practices delivering NHS (National Health Service) care to children are thus expected to deliver FV at six-monthly intervals from the age of two, subject to satisfactory medical history. FV application (FVA) for 2–5yr old children

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is carried out either by a dentist, or under the prescription of a dentist by a dental therapist, hygienist or Extended Duty Dental Nurse; EDDN and is remunerated through the Statement of Dental Remuneration (SDR) via a varnish application fee (previously, application came under a general capitation fee for most dentists). Despite evidence for improved oral health through the wider *Childsmile* programme (Macpherson et al., 2013), delivery of this key preventive intervention is still variable. National monitoring data show that in 2015/16, just 18% of 2–5 year old children registered with an NHS dentist received the recommended two applications within a year (Childsmile Central Evaluation and Research Team, 2016).

1.3. Complex interventions

In this study we synthesised evidence from mixed data sources to model the likely effects of intervening in the FV system. There is now a wealth of literature (Campbell et al., 2007; Hoddinott et al., 2010) on the difficulty of intervening successfully in healthcare systems, which are complex (Pfadenhauer et al., 2017) and involve dynamic interacting components (May et al., 2016). Developing and evaluating interventions requires a) theorizing to inform design and b) modelling of mechanisms and contextual factors likely to come into play (Craig et al., 2008).

This study approached healthcare as a sociotechnical system whereby outcomes emerge from interactions between people, organisation, technology, internal and external environment, and tasks and processes (Holden et al., 2013). One notable challenge is to be able to define and describe this system context to provide evidence for intervention design and implementation (Datta and Petticrew, 2013). Interventions in health care can take various forms, such as behavioural, educational, financial, environmental, or technical (Michie et al., 2011). However, the key is that they are based on a model of how the system in question operates. The Functional Resonance Analysis Method (FRAM; see methodology) was employed in this paper because it can represent very many interacting elements in a way that is not too simplistic to be meaningful (Carayon et al., 2014).

We now describe how a FRAM model was synthesised from various data sources during the developmental stage of an intervention in General Dental Practice to prevent childhood dental caries.

2. Aims

This study aimed to identify and describe the system context for applying FV, by modelling related activities in practice. A specific objective was to identify opportunities for intervention to support dental teams in applying higher rates of varnish to their child patients.

3. Methods

3.1. The functional resonance analysis method

The Functional Resonance Analysis Method (FRAM) is a method for modelling complex organisational systems (Hollnagel, 2012) derived from Resilient Health Care theory (Braithwaite et al., 2015; Cook, 2006), which is concerned with how success is achieved through adaptation in complex environments (Anderson et al., 2016; Hollnagel et al., 2013). Recent papers have shown promise in using the FRAM to understand implementation of guidelines (Clay-Williams et al., 2015) and to guide safety management efforts (Pickup et al., 2017; Raben et al., 2017b). FRAM involves identifying functions (technological, human or organisational activities) in everyday work. The basic unit of analysis is a function hexagon (see Figs. 1 and 2).

Functions are specified according to six aspects:

- Inputs (I): Drivers; starting aspects which are transformed by the function
- Preconditions (P): Necessary conditions for the function to take place
- Resources (R): Consumables necessary for the execution of the activity
- Time (T): Temporal constraints
- Control (C): How the function is monitored e.g. through supervision
- Outputs (O): Resulting states or objects

The key to applying FRAM is to model: a) which functions are variable; and b) how they link to others. Some variability, from psychological or social factors such as individual differences, training/competency, or teamwork/communication, is inherent in the carrying out of functions. However, there is also variability from the complex ways in which activities relate to one another. Preconditions, time, control, or resources for a function may not be forthcoming from previous one (e.g. the function < obtain consent > may not give rise to the output 'consent' that is a precondition for a subsequent function < give treatment >). The idea of 'resonance' in FRAM is that the ways in which functions link is important, because compound variability may have amplified effect (positive or negative), thus giving information for improving system performance.

FRAM has no 'objective' system boundary, rather the analysts decide on the scope of the model according to utility and relevance to the research aims. To avoid infinite regress, FRAM allows for *background functions* (output only) and *stopping functions* (input only) which delineate system boundaries. The central purpose of FRAM is "to represent the dynamics of the system rather than to calculate failure probabilities" (Hollnagel, 2012)In this study we synthesised triangulated data from various sources to build the FRAM model. We now describe the work briefly by detailing data sources, and procedures for building and validating the synthesised model.

3.2. Data used for modelling

3.2.1. Routine monitoring data

The Scottish Dental Informatics Programme processes NHS primary care dental claim forms which, in addition to assisting payment for practitioners, provides data for the monitoring of FV activity. We accessed the last available full-year dataset (from April 2015 to March 2016). Claims data were managed in IBM SPSS v22.0 and SAS/STAT software.

3.2.2. Surveys

Data were gathered from a longitudinal survey (Gnich et al., 2015) of salaried and non-salaried General Dental Practitioners (GDPs) in Scotland, conducted before (time 1; n = 1090; response rate 54%; Aug–Oct 2011) and after (time 2; n = 709; new response rate 65%; Feb–May 2013) the introduction of the varnish application fee. Questionnaires were theory-based (Michie et al., 2005) and designed by a panel including clinicians, psychologists, and dental public health specialists. Dentists were asked to self-report application rates, then to rate barriers and facilitators to application.

3.2.3. Staff interviews

In- depth, semi-structured interviews were carried out with a criterion-based sample of practice staff (n = 36; Sep–Nov 2014) to identify functions associated with FV application.

We recruited using a sampling frame of practices where FV application rates were high (90^{th} percentile) or low (10th percentile) as a proportion of children attending a *Childsmile* appointment. Table 1 shows participating practices and staff and further stratification. Interview questions were designed to elicit: a detailed description of FV activity in the practice setting; factors facilitating or inhibiting application; and recommendations for improving application rates.

3.2.4. Key informant interviews

Targeted interviews (n = 7; May–Nov 2015) were then carried out to elicit expert opinions on important functions identified in practitioner