Title

Management of compromised first permanent molars in children: Cross-Sectional analysis of attitudes of UK general dental practitioners and specialists in paediatric dentistry

Summary

Background
It is unclear on how children with compromised first permanent molars (cFPMs) are currently managed in the UK by either general dental practitioners (GDP) or specialists in Paediatric Dentistry (SPD).

Aim
Explore the current attitudes to the management of compromised first permanent molars amongst UK general dental practitioners and specialists in paediatric dentistry.

Design
Self-completed online questionnaire including three clinical vignettes of 7-year-old, 9-year-old and 15-year-old with cFPM. All registered SPDs (n=236), as of May 2017, 500 randomly selected GDPs from England, selected from a national performers list, and fifty-two Scottish GDPs, part of Scottish dental practice research network, were invited to complete the questionnaire.

Results
71.6% (n=53) of SPDs agreed that children with cFPM should be referred to a paediatric specialist for treatment planning, whereas the reverse for GDPs is true, as 86.8% (n=138) believe they have a responsibility to treat these teeth. Responses to clinical vignettes suggest a slight preference amongst GDPs to restore cFPM, including root canal treatment, whereas SPDs have a slight preference towards extraction.

Conclusion
Current pathways for cFPM, amongst UK general dental practitioners and specialists in paediatric dentistry, vary greatly between and within each professional group.

Keywords: Disturbances in dental development; Restorative dentistry/dental materials; Oral medicine/oral surgery; Growth and development

Introduction

Compromised first permanent molars (cFPM) are detrimental to the general health and social well-being of children in addition to having significant cost implications to health services.[1-3] cFPM can interfere with eating, sleeping, attending school and taking part in daily activities.[4] cFPM routinely causes children to experience pain and infection, as well as reducing their overall quality of life.[2, 5]

Caries and molar incisor hypomineralisation (MIH) are the main aetiological reasons for the compromised prognosis of first permanent molar teeth. Caries prevalence in first permanent molar teeth has been shown to increase with age as prevalence rises from 5% in 8 year olds to 25% by the time the child reaches age 15.[6] MIH has a reported global prevalence of (13.1% (11.8–14.5%)[7]with the mean number of molar teeth affected per child diagnosed with MIH reported as 1.6 to 3.16 (out of 4).[8]

There is a lack of clear guidance and direction on how best to manage cFPM in children. Several treatment options are available for cFPM; however, the evidence-base to support decision-making is limited and of low quality.[9-11] Alongside the option of no treatment, there are two pathways available:

- A restorative approach potentially involving endodontic and prosthetic rehabilitation
- Extraction of tooth, ideally when second permanent molar is bifurcating[9], to reduce the need for future orthodontic treatment or prosthetic replacement

Deciding which pathway to choose is complicated, and will depend on a number of modifying factors such as patient and parental attitudes, tooth restorability, level of patient compliance, general dental health (including ability to maintain any advanced restorative work), current malocclusion and future orthodontic need.[12, 13] Which ever approach is

followed, each have potential implications such as different occlusal outcomes, maintenance requirements and burden of care, which makes the decision to restore or extract difficult.

Restoring these teeth in early childhood enters the tooth into the 'restorative cycle' at an early stage. The length of this 'cycle' will vary drastically between individuals due to a multitude of tooth, patient and environmental factors. There are some specific problems, such as difficulty to anaesthetise and weaker bond strengths to materials, that are encountered when restoring cFPM conventionally,[14] however, minimally invasive techniques have altered the ways in which cFPM can be managed.[10]

UK clinical guidelines advocate the extraction of cFPM at the ideal developmental stage (assessed radiographically), to minimise dental and skeletal upset, which could lead to mesial migration of the unaffected and unerupted second permanent molar into the space left by the extracted first molar.[9] However, this recommendation is based on low-quality evidence with complete closure of the gaps not guaranteed as shown by a recent meta-analysis.[15] It was suggested that good to perfect gap closure is observed in 72% (95% CI: 63% - 82%) of maxillary molars when extracted at the ideal developmental stage, although this is only based on only thirty-eight teeth. In the mandible, pooled analysis of 489 mandibular first permanent molars showed that 48% (95% CI: 39% - 58%) have good to perfect gap closure when extracted at the ideal stage.[15] In addition, it is known that extracting cFPM too early or too late is likely to increase the chances of poor outcomes[16].

In addition, in the UK, there are no guidelines as to whether a specialist in paediatric dentistry (SPDs) or a general dental practitioner (GDPs) should manage these teeth.

It is therefore unclear how children with cFPMs are managed, hence the aim of this cross-sectional analysis is to explore the current clinical pathways for compromised first permanent

molars amongst UK general dental practitioners and specialists in paediatric dentistry and their attitudes to managing children with cFPMs.

Materials and methods

The study design is exploratory and observational and received a favourable outcome from Newcastle University Ethics Committee **(Ref:11609/2016).**

Context

In England and Scotland, GDPs' undertake routine dental care for children in general dental practice. Where necessary, a GDP can refer to community (non-specialist) or community/hospital based specialist services, for an opinion and/or for the provision of treatment. Any treatment provided by a GDP, community or hospital based specialist service is free for children under the age of eighteen.

Specialist services are usually run/led by people who have undergone a defined training programme, which allows them to register with the UK General Dental Council (GDC) as a specialist in paediatric dentistry. Specialists often work in community and/or hospital based services. A small number of GDPs across the UK will provide sedation. Those that do not offer will refer to either community or hospital based specialist services. General anaesthesia is only available in a hospital setting; however, this provision is not always part of a paediatric dental specialist service.

Questionnaire design

Questions that made up the questionnaire were developed based on previous literature on the management of dental conditions. These were adapted for the specific clinical problem. The research team discussed several iterations of the questionnaire before a consensus was agreed.

The questionnaire was piloted for content and face validity amongst specialists (non-paediatric) and non-specialists working in Newcastle Dental Hospital and Community Dental Service in County Durham and Darlington Foundation Trust. Dentists who concurrently work in general dental practice were not involved in the piloting process. Amendments were made to the layout and sequencing of the questions as a result of this process.

Questionnaire content

Demographics including gender, year and place of qualification, any postgraduate training in paediatric dentistry, type of practice (NHS, private, mixed NHS/private, community or hospital) and current position were collected.

Open and closed questions (on a 5-point Likert scale) were used in each questionnaire to elicit responses from both groups. Questions relating to importance of managing these teeth, whether a specialist in paediatric dentistry or orthodontics is needed for treatment planning or treatment, and how these teeth affect a child's general health and quality of life were used to explore the attitudes of both groups. Questions were also included to explore barriers to treating cFPM. Questions that were not relevant to a SPD, for example, "I would refer this patient to a specialist in paediatric dentistry for treatment planning" were omitted from their questionnaire. Free text comments were available for respondents to discuss reasons for referral of these teeth and any comment, overall, on the management of cFPM.

Three theoretical 'clinical vignettes' using clinical photographs and radiographs, were included (with patient's permission), which were designed to assess the pragmatic decision-making process general dental practitioners and specialists in paediatric dentistry make when managing this clinical scenario. Participants were invited to give all the options they felt

appropriate for each scenario. **(See Figures 1a, 1b & 1c).** Free text responses were available to discuss anything related to each vignette.

Sample

A sampling framework was developed by the research team to identify individual GDPs. Triangulation of three independent sources of information relating to NHS GDPs (NHS-BSA (NHS Business Services Authority), CQC (Care Quality Commission) individual practice reports and NHS choices website was carried out to identify these practitioners.

A national performers list identified individual NHS providers in each of the 27 commissioning regions. A purposive sample of providers were taken from each of the regions to account for variation in geographical location. A Care Quality Commission (CQC) report will be used to confirm these individual NHS practices. Practice postcodes were input into NHS Choices website to identify the staff working in each practice. An online random number generator was used to randomly select an individual practitioner working at that practice. Any NHS choices website entries that had not been updated since January 2016 were excluded. In total 500 English GDPs were invited to take part.

Fifty-two Scottish GDPs, who are part of the Scottish dental practice board research network (SDPBRN) were invited to take part in the questionnaire. This number was slightly larger than those randomly selected from each region in England. The total target sample size was 552 GDPs.

As of May 2017, there were 236 UK GDC registered specialists in paediatric dentistry and all were included in the target sample.

Questionnaire distribution

Questionnaires were uploaded to an online survey tool.[17] English GDPs were sent a postal invitation and a study specific business card which had a link to the online survey. These were sent to the practice address as an email address could not be obtained for each of the selected GDPs. Scottish GDPs, who were part of SDPBRN, had previously given consent to be contacted by email for research studies. These GDPs were sent an electronic link via email through the SDPBRN administrator.

Specialists were sent an email, with a link to the survey, inviting them to complete the online survey. The British Society of Paediatric Dentistry (BSPD) administrator and secretaries of the Specialists and Consultant branches of the society facilitated this.

Non-responders were identified using a pre-determined coding schedule, and secondary communication was undertaken six weeks later via the same initial methods for each group.[18] Subsequent communication was not carried out after the second attempt, as it is unlikely to yield a better response and if a response is obtained, there is a high chance of response bias.[18, 19]

Although it was our intention to limit our target sample to those noted above, the online link was disseminated onto a social media platform. This means the target sample size is likely to be somewhat larger than previously anticipated; however, an exact total target sample size figure is unknown.

Statistical Analysis

All questionnaires responses were validated and data transferred into *SPSS Statistics for Windows, Version 23.0.* Free text comments were assessed narratively. Due to the non-normal distribution of ordinal data obtained, Mann Whitney and Kruskal-Wallis tests and

Spearman's correlation were used. Thechi-square test was used for categorical variables. Multivariate factor analysis (with principal components extraction) was carried out to examine relationships between multiple ordinal variables. Each factor represents a different aspect (dimension) of the data. A factor is comprised of a weighted combination of the questions and questions having a high weight are used to label a factor. A factor score for each factor can be calculated for each respondent thus allowing construction of a multi-dimensional map where nearby point's depict respondents with similar views. The Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test were generated to ensure that the criteria for a satisfactory factor analysis were met.[20] Factors with eigenvalues greater than 1 were retained.[21] For interpretation purposes, Varimax rotation was employed which, when compared to the unrotated solution, better differentiated the factors. Factor loadings were interpreted with an absolute value greater than0.4.[22] The parametric two-sample t-test was utilised to test for significant differences between two groups when the data were on a continuous scale.

Results

A total number of 159 (28.8%) GDPs and 74 (31.3%) SPDs responded, of which female responses, 92 (57.9%) and 57 (77.0%) respectively, were the greatest. 147 (92.5%) GDPs and 68 (91.9%) SPDs qualified in the UK, with the median year since undergraduate qualification being 2002 (range: 1973-2017) and 1995 (range: 1975-2012) respectively. 1 (0.6%) GDP had postgraduate training in Paediatric Dentistry compared to all 74 (100.0%) SPDs who did. The type of practice and position within that practice of each respondent is shown in **Table 1**. These demographics indicate a wide variation of level of experience in both groups.

GDPs confirmed that 10.5% of all children seen by them had cFPM, whereas SPDs report a higher prevalence of 25.9%. Age of patient, stage of dental development, dental anxiety, orthodontic considerations and need for adjunctive therapies (mainly General Anaesthetic GA) were consistently observed in both GDPs' and SPDs' free text comments as reasons for prompting a referral and caveats to the management of each vignette . Questionnaire responses can be found in **Table 2.**

For Vignette 1, GDPs and Specialists agreed unanimously in their management approaches for this vignette. 95.6% (n=152) GDPs and 100% of specialists (n=74) felt either placement of a fissure sealant or prevention alone would be appropriate, however 50.9% (N=81) and 55.4% (n=41) respectively suggested they would combine approaches which meant it was more favourable than either in isolation. Responses to clinical vignettes of the nine-year-old and fifteen-year-old are shown in **Tables 3a & 3b**

There were significant differences between genders and position within the place of employment. Female GDPs were more likely to agree that cFPM affected quality of life (p=0.031) and that a child's cooperation will determine where they can be treated (p=0.005) whereas male specialists felt that active management of cFPM should only be carried out under general anaesthetic (p=0.006). A principal GDP, compared to a non-principal GDP, was more likely to say that a child's cooperation will determine where they can be treated (p=0.018).

For GDPs, there is evidence of association between the following questions:

- "GDPs in practice have a responsibility to treat first cFPM in children" and "it's important to manage children with cFPM" (p=0.007);
- "GDPs in practice have a responsibility to treat first cFPM in children" and "confidence in managing cFPM" (p=0.003).

- “cFPM will affect a child’s quality of life” and “cFPM can impact a child’s general health” (p=0.001)

For specialists, there is evidence of association between the following questions:

“GDPs in practice have a responsibility to treat cFPM in children” and “children with cFPM should be referred to a paediatric specialist for treatment” (p=0.001).
“cFPM will affect a child’s quality of life ” and “cFPM can impact a child’s general health ” (p=0.001)

After application of factor analysis, four factors cumulatively accounted for 57.5% of the total information in the data. Only the first (most important) two factors are discussed here, as these dimensions the most interpretable.

Scores for factor 1 will be tend to be high if the respondent:

- Agrees treatment planning of first permanent molars of poor prognosis in children must include a radiographic assessment of the full developing dentition
- Agrees it is important to manage children with first permanent molars of poor prognosis
- Agrees first permanent molars of poor prognosis will affect a child’s quality of life.
- Agress first permanent molars of poor prognosis can impact a child’s general health

Specialists had a significantly different score for factor 1 compared to GDPs ($p<0.005$) with specialists scoring higher than GDPs. Thus, compared to GDPs, specialists tend to more agree that radiographic assessment, management and a child's quality of life and general health are important when first permanent molars have poor prognosis.

Scores for factor 2 will tend to be high if the respondent:

- agrees that in the first instance, first permanent molars of poor prognosis in children should be referred to a paediatric specialist for treatment planning
- agrees first permanent molars of poor prognosis in children should be referred to a paediatric specialist for treatment
- disagrees that GDPs in practice have a responsibility to treat first permanent molars of poor prognosis in children

Specialists had a significantly different score for factor 2 compared to GDPs ($p<0.005$) with specialists, again, scoring higher than GDPs. Thus, compared to GDPs, specialists tend to more agree on paediatric specialist referral for treatment and treatment planning and less agree that GDPs have responsibility when first permanent molars have poor prognosis.

Figure 2 illustrates the difference in opinion between specialists and GDPs with specialists (blue circles) generally having high values of Factor 1 and Factor 2 compared to GDPs (red squares).

Discussion

It is apparent from our study that cFPM are not managed consistently, with distinct variation noted both within and between each professional group across the UK. In the UK, dental treatment is free for children under the age of eighteen. This is irrespective of treatment choice (e.g. filling or extraction), whether adjunctive therapies such as sedation or general anaesthesia are needed or who provides the treatment. There are similarities in responses for mild MIH at 7 years old (*vignette 1*). Whereas, for MIH with breakdown at 9 year old (*vignette 2*), and to a less extent significant caries in a 15 year old (*vignette 3*), there appears to be a slight preference amongst GDPs to restore cFPM, including undertaking root canal treatment where necessary, whereas SPDs have a slight preference towards extraction.

GDPs and specialists both agreed strongly that cFPM affect children's quality of life and general health, which is consistent with the literature that highlights the impact that compromised teeth[2], and first permanent molars have on children.[4] Differences in approach to pharmacological management by gender fit with previous findings that female healthcare professionals appear to be more empathetic than men as they appear to have a greater capacity for understanding others' thoughts and willing to take longer to work with anxious patients.[23] Principal GDPs are likely to have been practising for longer, and therefore have more experience in treating children. This is likely to account for the differences in the ability to assess a child's cooperation, however, time since qualification was not found to be statistically significant in any analyses of responses.

There appears to be strong correlation between GDPs feeling they have a responsibility to treat and being confident in managing these teeth in practice. Given this link between confidence and responsibility, if it is appropriate for GDPs to manage these teeth, then further training may be necessary for those lacking confidence. Over half of GDPs still relied on

specialist treatment planning advice from an orthodontist, which could account for those who may lack confidence in managing these teeth in practice.

There was a statistically significant correlation between specialists feeling that GDPs had a responsibility to treat children with cFPM in practice and referring them to a paediatric specialist for treatment. This does seem to be contradictory and could be explained that some specialists were unsure where these teeth were best managed. Alternatively, it could suggest that some SPDs felt children with mild cFPM can be treated in practice alone, but for the more severe cases, a shared-care approach should be taken.

Management of vignette 1

The placement of a fissure sealant, prevention alone or a combination of would be appropriate for managing the patient in vignette 1. Any of these approaches comply with the Department of Health's 'Delivering Better Oral Health Toolkit' guidelines for high risk children.[24] However, Chestnutt et al.[25] has shown, that twice-yearly application of fluoride varnish resulted in caries prevention that is not significantly different from that obtained by applying and maintaining fissure sealants after 36 months, with fluoride varnish being more cost-effective, although this was in a deprived population and in a community rather than dental clinic setting.[25]

Management of vignette 2

This vignette created the greatest diversity in opinion between and within the groups. It was apparent that GDPs favoured restoration of the affected teeth whereas SPDs were equivocal. Minimally invasive techniques can make restoring cFPM easier[10, 26] and it appears these approaches are being practised, as composite resin was the most common material chosen by

GDPs. Smaller number of respondents, in both groups, suggested the use of glass ionomer cement and preformed metal crowns. These are often temporary measures, with preformed metal crowns having the advantage of maintaining the structural integrity without causing any adverse symptoms.[27] The patient being asymptomatic and the need for future orthodontic input, and extractions, to correct their malocclusion, likely explains this temporisation approach. Although not first choice, removal of cFPM can assist in reduction of the overjet.[28] An alternative would be to extract these teeth, and not wait for an orthodontic assessment, as they are at the correct developmental stage to allow for mesial migration of the second permanent molar.[9] However, good to perfect gap closure is not guaranteed[15] and further extractions to relieve crowding may still be required[28].

Specialists and generalists were more likely to compensate non-affected upper first molars than lower first molars however, variation within groups still existed. Compensating a maxillary molar is done to avoid over-eruption of the lower molar, which can prevent desirable mesial movement; however, there is little data to support these claims.[29, 30]

It appears GDPs and specialists preferred local anaesthetic alone if the tooth was to be restored. Similarly, local anaesthesia alone was the preferred option for extraction amongst GDPs whereas specialists slightly favoured the general anaesthetic option compared to inhalation sedation and local anaesthetic alone. The method chosen will very much depend on the co-operation of the child, however, a number of specialists free text responses (n=21) highlighted that even those who are cooperative, given the age of the patient, a general anaesthetic would often be the preferred option if more than one molar was due to be extracted. Specialists routinely have direct access to general anaesthetic facilities and

potentially are more likely to assess and treat more anxious/less cooperative children. These reasons may explain why they are more likely to consider a general anaesthetic for this case.

Management of vignette 3

There appeared to be a good level of agreement amongst both groups for the most appropriate management strategies for this vignette. In general, both GDPs and specialists felt that extraction under local anaesthetic was the most appropriate action for this patient. Easier access to adjuncts to treatment (inhalation sedation, intravenous sedation and general anaesthetic) could explain why specialists significantly preferred these approaches when compared to GDPs. Interestingly, there was a higher proportion in both groups to use general anaesthetic when compared to vignette 2, which is surprising given the fact the patient is older in this scenario. A likely explanation is the fact that most agreed that all four molar teeth require to be extracted in this case, whereas, less respondents preferred to do this for the younger patient. Of note, a small number of specialists and significant number of GDPs felt that these teeth could be restored, including root canal treatment. This desire to retain teeth is likely to be driven by patient's wishes given the knowledge that the outcomes of extraction would certainly leave them with a space.

Multivariate Factor Analysis

Interpreting Factor 1 (the most important multivariate dimension of the data), suggests that SPDs assess children with cFPM more often, work with other specialities and routinely treat children under general anaesthesia, which likely explains why they perceive the need to assess the whole dentition rather than just the cFPM. Radiographs to assess the full

developing dentition may not be taken by GDPs with potential explanations being limited co-operation or not having access to appropriate equipment. Specialists are likely to see more severe presentations of cFPM on a more regular basis, which could explain why they feel it is more important to manage cFPM, when compared to GDPs, due to the effect on quality of life and general health. However, most GDPs agreed that the management of cFPM is of high importance but less strongly about the impact on quality of life and general health.

Interpreting Factor 2 (the second most important multivariate dimension of the data), suggests that SPDs tend to agree that, in the first instance, cFPM should be referred to a paediatric specialist for treatment planning and treatment, whilst disagreeing that GDPs in practice have a responsibility to treat cFPM, whereas the reverse is true for the GDPs. These diverse opinions to managing cFPM could be explained by the severity that specialists will often encounter, as we know that almost 70% of children attending a hospital-led service are having cFPM extracted due to their level of unrestorability.[31]

Implications of findings

These findings have implications for patients, dentists and policy makers both in the UK and internationally. The disparity in treatments being offered to patients within the UK is evident from this study; however, this confusion extends beyond the UK.[32, 33] Several studies have adopted a restorative approach to managing cPFM.[32] A Norwegian study showed that majority of non-specialist Norwegian dentists favoured restoration of affected first permanent molar teeth in a six-year and nine-year old, using either glass ionomer or composite resin, over extraction.[34] A similar restorative-based approach was observed in a Greek study, however, a greater variety of direct restorative materials (fissure sealants, amalgam, composite and preformed metal crowns) were used.[35] Although less common, managing

cFPM with indirect restorations, such as ceramic crowns in a German study[36] and cast gold copings in a Danish study[37], have been carried out. In comparison, only a handful of studies globally have reported their findings on managing cFPM by extraction alone[15] with one Swedish study reporting that subsequent spontaneous space closure occurs more often in the maxilla than the mandible.[38]

This confusion does appear to extend to professional groups in how they approach and manage these teeth. Although there were slight preferences by GDPs to restore and SPDs to extract compromised first permanent molars in 9- and 15-year-olds, there was a considerable amount of overlap of opinion between the groups as shown by the multivariate analysis. This disparity in treatment planning and treatment of these teeth amongst differing professional groups, in combination with the paucity of evidence to support either decision makes treatment planning challenging and difficult for this cohort of patients.

This finding does have significant impact on policy and commissioning of dental services. It could be that restoring these teeth is possibly more cost-effective than extraction; however, there is a paucity of economic evaluation data relevant to the context of the National Helath Service in the UK. In England, a commissioning guide for paediatric dentistry highlighted that managing cFPM can come under generalist, those with a special interest or qualified specialist service remits depending on the severity of the condition and need for services that only specialists are able to provide i.e. general anaesthesia. Although this is an attempt to help practitioners, specialists and commissioners, it adds to the confusion as all treatment options, other than general anaesthesia, can be provided in general dental practice irrespective of severity. This multivariate analysis highlights the confusion and disparity in treatment planning and treatment of these teeth amongst differing professional groups. This in combination with the paucity of evidence makes treatment planning challenging and difficult for this cohort of patients.[34]

Strengths and Limitations

To our knowledge, this is the first study in the UK that explores the attitudes and barriers to facilitating care for cFPM between two professional groups. These groups inherently will assess and treat different cohorts of children who have cFPM. Obtaining each groups opinion provides a clearer picture of what attitudes/barriers are likely to influence how these children with cFPM are currently cared for across primary and secondary care facilities. The addition of clinical vignettes attempts to determine the current management strategies related to these teeth in both primary and secondary care. These distinctions are important to consider to better understand how these teeth should be managed in future.

There were some limitations to our study. Participants were invited to provide all potential options they felt were appropriate for each vignette rather than being confined to only one choice for each vignette. Adopting this approach may have skewed our results and over-estimated how often certain treatments are carried out, however, this is more likely to reflect the reality of current pathways offered in the NHS, as any treatment plan (or decisions made) need to patient-centred and based on fully informed patients and/or parents. Due to difficulties in obtaining each GDP's email address (to invite them electronically) a postal invitation with a link was sent to these participants.

In contrast, almost all specialists in paediatric dentistry are affiliated to the BSPD, where a central database of email addresses is held, which allowed the link to be emailed to these participants. This approach may have affected response rate though and introduced selection bias, as it is unlikely that all 236 registered UK specialists in paediatric dentistry are members

of BPSD This provided a unique opportunity to compare the approaches to inviting participants to an online questionnaire. We found that the response rates for each group were almost identical (28.3% and 31.8%) suggesting neither approach was superior to the other. The response rate in both groups was slightly lower than anticipated, however, it is known that professional groups often have a low response rate to a questionnaire, unless the topic is of relevance to them.[18] It could be hypothesised that management of cFPM is of more relevance to specialists, as they encounter these teeth on a more regular basis, however the response rates contradict this theory. Non-responders were only invited one more time as multiple invitations and reminders are unlikely to yield a better response and, if a response is obtained, there is a high chance of response bias.[18]

The link to our survey was displayed on various social media platforms after one of the participants shared the link independently. It was our intention not to use social-media platforms to disseminate the survey, given the natural bias in participants who take part in social-media group forums. This is a limitation to our original study methodology as social media platforms provide an excellent opportunity to include the opinions of a large number of demographically diverse practicing dentists as well as disseminating research evidence[39].

In conclusion, current clinical pathways for compromised first permanent molars, amongst UK general dental practitioners and specialists in paediatric dentistry, vary greatly between and within each professional group. Contrasting opinions are observed between these groups regarding who should plan and manage these teeth. This highlights the need to further research what could be the most cost-effective pathway is and who should provide this care.

Why this paper is important to paediatric dentists

- It explores the variation in attitudes and beliefs, between general dental practitioners and specialists in paediatric dentistry in the UK, in managing compromised first permanent molars
- It highlights the diverse range of management strategies chosen for compromised first permanent molars in a 7-year, 9-year and 15-year old child
- It provides key information that will be useful to the planning and commissioning of children dental services within the UK

Conflict of Interest

The authors' declare no conflict of interest. GT & CRV's posts are funded by NIHR Academic Clinical Fellow and Clinician Scientist awards respectively. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

References

1. Gilchrist F, Marshman Z, Deery C, Rodd HD. The impact of dental caries on children and young people: what they have to say? International Journal of Paediatric Dentistry. 2015;25(5):327-38.
2. Sheiham A. Oral health, general health and quality of life. Bulletin of the World Health Organization 2005;83(9):641-720.
3. Grund K, Goddon I, Schueler IM, Lehmann T, Heinrich-Weltzien R. Clinical consequences of untreated dental caries in German 5-and 8-year-olds. Bmc Oral Health. 2015;15.
4. Taylor GD, Scott T, Vernazza CR. Research Prize Category: Impact of first permanent molars of poor prognosis: patient & parent perspectives. International Journal of Paediatric Dentistry. 2018;28(S1):2-3.
5. Shaikh S, Siddiqui A, Aljanakh M. School Absenteeism due to Toothache among Secondary School Students Aged 16-18 Years in the Ha'il Region of Saudi Arabia. Pain Research and Treatment. 2016.
6. Chadwick BL, Pitts NB. Children's Dental Health Survey 2013. Report 2: Dental Disease and Damage in Children: England, Wales and Northern Ireland. London: Health and Social Care Information Centre.; 2015.

7. Schwendicke F, Elhennawy K, Reda S*, et al.* Global burden of molar incisor hypomineralization. J Dent. 2018;68:10-8.
8. Willmott NS, Bryan RAE, Duggal MS. Molar-incisor-hypomineralisation: a literature review. European Archives of Paediatric Dentistry. 2008;9(4):172-9.
9. Cobourne MT, Williams A, Harrison M. National clinical guidelines for the extraction of first permanent molars in children. British Dental Journal. 2014;217(11):643-8.
10. Ricketts D, Lamont T, Innes NPT, Kidd E, Clarkson JE. Operative caries management in adults and children. Cochrane Database of Systematic Reviews. 2013(3).
11. Rasines Alcaraz MG, Veitz-Keenan A, Sahrmann P*, et al.* Direct composite resin fillings versus amalgam fillings for permanent or adult posterior teeth. Cochrane Database of Systematic Reviews. 2014(3).
12. Albadri S, Zaitoun H, McDonnell ST, Davidson LE. Extraction of first permanent molar teeth: results from three dental hospitals. Br Dent J. 2007;203(7).
13. Mackie I C, Blinkhorn A S, Davies H J. The extraction of permanent first molars during the mixed dentition period – a guide to treatment planning. J Paediatr Dent. 1989;5:85-92.
14. Lygidakis NA. Treatment modalities in children with teeth affected by molar-incisor enamel hypomineralisation (MIH): A systematic review. European Archives of Paediatric Dentistry. 2010;11(2):65-74.
15. Eichenberger M, Erb J, Zwahlen M, Schatzle M. The timing of extraction of non-restorable first permanent molars: a systematic review. European journal of paediatric dentistry : official journal of European Academy of Paediatric Dentistry. 2015;16(4):272-8.
16. Teo TKY, Ashley PF, Parekh S, Noar J. The evaluation of spontaneous space closure after the extraction of first permanent molars. European archives of paediatric dentistry : official journal of the European Academy of Paediatric Dentistry. 2013;14(4):207-12.
17. Jisc. Online Surveys 2018 [Available from: https://www.onlinesurveys.ac.uk/
18. McColl E. Design and use of questionnaires: a review of best practice applicable to surveys of health service staff and patients. Health Technology Assessment 2001;5(31).
19. Pit SW, Vo T, Pyakurel S. The effectiveness of recruitment strategies on general practitioner's survey response rates - a systematic review. BMC Med Res Methodol. 2014;14:14.
20. Field A. Discovering statistics using IBM SPSS Statistics: and sex and drugs and rock 'n' roll. 4th ed. London: Sage; 2013.
21. Kaiser HF. The Application of Electronic Computers to Factor Analysis. Educational and Psychological Measurement. 1960;20:141-51.
22. Stevens JP. Applied multivariate statistics for the social sciences. 4th ed. Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers; 2002.
23. Toussaint L, Webb JR. Gender differences in the relationship between empathy and forgiveness. The Journal of social psychology. 2005;145(6):673-85.
24. Delivering better oral health: an evidence-based toolkit for prevention. London, Health Do; 2017.
25. Chestnutt IG, Hutchings S, Playle R*, et al.* Seal or Varnish? A randomised controlled trial to determine the relative cost and effectiveness of pit and fissure sealant and fluoride varnish in preventing dental decay. Health Technol Assess. 2017;21(21):1-256.
26. William V, Messer LB, Burrow MF. Molar Incisor Hypomineralization: Review and Recommendations for Clinical Management. Pediatric Dentistry. 2006;28(3):224-32.
27. Lygidakis NA, Wong F, Jalevik B*, et al.* Best Clinical Practice Guidance for clinicians dealing with children presenting with Molar-Incisor-Hypomineralisation (MIH): An EAPD Policy Document. European archives of paediatric dentistry : official journal of the European Academy of Paediatric Dentistry. 2010;11(2):75-81.
28. Williams J, Gowans A. Hypomineralised first permanent molars and the orthodontist. European Journal of Paediatric Dentistry. 2003;4:129-32.

29. Jalevik B, Moller M. Evaluation of spontaneous space closure and development of permanent dentition after extraction of hypomineralized permanent first molars. Int J Paediatr Dent. 2007;17(5):328–35.
30. Innes N, Borrie F, Bearn D*, et al.* Should I eXtract Every Six dental trial (SIXES): study protocol for a randomized controlled trial. Trials 2013;14:59.
31. Albadri S, Zaitoun H, McDonnell ST, Davidson LE. Extraction of first permanent molar teeth: results from three dental hospitals. British Dental Journal. 2007;203(7).
32. Elhennawy K, Schwendicke F. Managing molar-incisor hypomineralization: A systematic review. J Dent. 2016;55:16-24.
33. Schwendicke F, Frencken JE, Bjørndal L*, et al.* Managing Carious Lesions: Consensus Recommendations on Carious Tissue Removal. Advances in Dental Research. 2016;28(2):58-67.
34. Kopperud SE, Pedersen CG, Espelid I. Treatment decisions on Molar-Incisor Hypomineralization (MIH) by Norwegian dentists - a questionnaire study. BMC Oral Health. 2016;17:7.
35. Kotsanos N, Kaklamanos EG, Arapostathis K. Treatment management of first permanent molars in children with Molar-Incisor Hypomineralisation. European Archives of Paediatric Dentistry. 2005;4:179-84.
36. Koch MJ, GarciéA-Godoy F. The Clinical Performance of Laboratory-Fabricated Crowns: Placed on First Permanent Molars with Developmental Defects. The Journal of the American Dental Association. 2000;131(9):1285-90.
37. Gaardmand E, Poulsen S, Haubek D. Pilot study of minimally invasive cast adhesive copings for early restoration of hypomineralised first permanent molars with post-eruptive breakdown. European Archives of Paediatric Dentistry. 2013;14(1):35-9.
38. Jalevik B, Moller M. Evaluation of spontaneous space closure and development of permanent dentition after extraction of hypomineralized permanent first molars. International Journal of Paediatric Dentistry. 2007;17(5):328-35.
39. Papakostopoulou M, Hurst D. Disseminating research evidence: what matters to general dental practitioners? British Dental Journal. 2018;225:413.

Professional Groups	**GDPs N=159** % (n)		**SPDs N=74** N (%)	
Type of Practice	NHS	**16.9%** *(n=27)*	Mixed Private/Hospital	**2.7%** *(n=2)*
	Mixed NHS/Private	**76.8%** *(n=122)*	Mixed CDS/Hospital	**12.2%** *(n=9)*
	Private	**1.9%** *(n=3)*	CDS only	**4.1%** *(n=3)*
	CDS only	**1.3%** *(n=2)*	HDS only	**79.7%** *(n=59)*
	Other	**3.1%** *(n=5)*	Other	**1.3** *(n=1)*
Current Position	Dental Foundation Trainee	**6.9%** *(n=11)*	Consultant	**62.2%** *(n=46)*
	GDP (Associate)	**46.5** *(n=74)*	Specialist	**37.8%** *(n=28)*
	GDP (Principal)	**27.7%** *(n=44)*		
	Community Dental Officer	**10.6%** *(n=17)*		
	Other	**8.3%** *(n=13)*		

Table 1: Type of Practice and position within practice of GDPs and SPDs

Professional Groups		GDPs (n=159)						Specialists (n=74)					
Question	**Question Number**	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree or Disagree (3)**	**Agree (4)**	**Strongly Agree (5)**	**Median Response**	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree or Disagree (3)**	**Agree (4)**	**Strongly Agree (5)**	**Median Response**
GDPs in practice have a responsibility to treat first cFPM in children	**1**	**2.5%** *(n=4)*	**1.3%** *(n=2)*	**9.4%** *(n=15)*	**45.9%** *(n=73)*	**40.9%** *(n=65)*	**4**	**0%** *(n=0)*)	**14.9%** *(n=11)*	**16.2%** *(n=12)*	**50.0%** *(n=37)*	**18.9%** *(n=14)*	**4**
In the first instance, cFPM in children should be referred to a paediatric specialist for treatment planning	**2**	**5.0%** *(n=8)*	**39.6%** *(n=63)*	**25.2%** *(n=40)*	**24.5%** *(n=39)*	**5.7%** *(n=9)*	**3**	**4.1%** *(n=3)*	**10.8%** *(n=8)*	**13.5%** *(n=10)*	**44.6%** *(n=33)*	**27.0%** *(n=20)*	**4**
In the first instance, cFPM in children should be referred to an orthodontic specialist for treatment planning	**3**	**4.5%** *(n=7)*	**22.6%** *(n=36)*	**22.0%** *(n=35)*	**41.6%** *(n=66)*	**9.4%** *(n=15)*	**4**	**4.1%** *(n=3)*	**45.9%** *(n=34)*	**24.3%** *(n=18)*	**20.1%** *(n=15)*	**5.4%** *(n=4)*	**2**
Active management (restoration/extraction) of cFPM in children should only be carried out under general anaesthetic	**4**	**43.4%** *(n=69)*	**39.6%** *(n=63)*	**13.2%** *(n=21)*	**3.8%** *(n=6)*	**0%** *(n=0)*	**2**	**41.9%** *(n=31)*	**42.9%** *(n=34)*	**10.8%** *(n=8)*	**0%** *(n=0)*	**1.4%** *(n=1)*	**2**
cFPM, in children, should always be restored to be maintained as a functional unit throughout life	**5**	**32.1%** *(n=51)*	**47.2%** *(n=75)*	**11.9%** *(n=19)*	**6.9%** *(n=11)*	**1.9%** *(n=3)*	**2**	**68.9%** *(n=51)*	**27.0%** *(n=20)*	**4.1%** *(n=3)*	**0%** *(n=0)*	**0%** *(n=0)*	**1**
cFPM in children should be referred to a paediatric specialist for treatment	**6**	**8.8%** *(n=14)*	**36.5%** *(n=58)*	**38.4%** *(n=61)*	**11.9%** *(n=19)*	**4.4%** *(n=7)*	**3**	**2.7%** *(n=2)*	**16.2%** *(n=12)*	**43.2%** *(n=32)*	**29.7%** *(n=22)*	**8.1%** *(n=6)*	**3**
Treatment planning of cFPM in children must include a radiographic assessment of the full developing dentition	**7**	**1.3%** *(n=2)*	**3.8%** *(n=6)*	**5.0%** *(n=8)*	**42.1%** *(n=67)*	**47.8%** *(n=76)*	**4**	**2.7%** *(n=2)*	**0%** *(n=0)*)	**0%** *(n=0)*	**14.9%** *(n=11)*	**82.4%** *(n=61)*	**5**
It is important to manage children with cFPM	**8**	**0.6%** *(n=1)*	**0%** *(n=0)*	**1.3%** *(n=2)*	**23.3%** (n=37)	**74.8%** (n=119)	**5**	**1.4%** *(n=1)*	**0%** *(n=0)*	**0%** *(n=0)*	**12.2%** *(n=9)*	**86.5%** *(n=64)*	**5**
cFPM will affect a child's quality of life.	**9**	**1.9%** *(n=3)*	**10.1%** *(n=16)*	**13.8%** *(n=22)*	**45.9%** *(n=73)*	**28.3%** *(n=45)*	**4**	**0%** *(n=0)*	**0%** *(n=0)*	**9.5%** *(n=7)*	**43.2%** *(n=32)*	**47.3%** *(n=35)*	**4**
cFPM can impact a child's general health	**10**	**0.6%** *(n=1)*	**11.9%** *(n=19)*	**15.1%** *(n=24)*	**55.3%** *(n=88)*	**22.0%** *(n=35)*	**4**	**0%** *(n=0)*	**1.4%** *(n=1)*	**9.5%** *(n=7)*	**56.8%** *(n=42)*	**32.4%** (n=24)	**4**

A child's cooperation level will determine whether they are treated in primary dental care services	**11**	**0%** *(n=0)*	**0.6%** *(n=1)*	**2.5%** *(n=4)*	**45.3%** *(n=72)*	**51.6%** *(n=83)*	**5**	**0%** *(n=0)*	**5.4%** *(n=4)*	**14.9%** *(n=11)*	**52.7%** *(n=39)*	**27.0%** *(n=20)*	**4**
I would feel confident in managing cFPM	**12**	**0.6%** *(n=1)*	**10.1%** *(n=16)*	**19.5%** *(n=31)*	**50.9%** *(n=81)*	**18.9%** *(n=30)*	**4**						
Managing cFPM in children is difficult	**13**	**1.9%** *(n=3)*	**6.3%** *(n=10)*	**15.7%** *(n=25)*	**53.5%** *(n=85)*	**22.6%** (n=36)	**4**						
cFPM in children should be referred to an orthodontic specialist for treatment	**14**	**12.8%** *(n=20)*	**35.7%** *(n=57)*	**33.3%** *(n=53)*	**14.5%** *(n=23)*	**3.7%** *(n=6)*	**3**						

Table 2: GDPs and SPDs questionnaire responses

Vignette 2	Yes	No
Professional Group	**GDPs (n=159)**	
Would you treat this case in practice?	83.6% (n=133)	16.4% (n=26)
If ticked YES to treat this case, would you refer this patient for an orthodontic opinion before commencing treatment?	73.7% (n=98)	26.3% (n=35)
If you ticked NO to treat this case, where would you refer to?	CDS 15.4% (n=4) District General Hospital 3.8% (n=1) Dental Hospital 80.8% (n=21)	
Professional Group	**Specialists (n=74)**	
Would you refer this patient for an orthodontic opinion?	83.8% (n= 62)	16.2% (N=12)
Treatment Options for UL6/LR6 (Affected teeth)		
Treatment Options	**GDPs (n=159)**	**Specialist (n=74)**
No treatment & best preventive practice only	17% (n=27)	5.4% (n=4)
Application of a fissure sealant to all first permanent molars	25.8% (n=41)	5.4% (n=4)
Restore all first permanent molars (including root canal therapy) under local anaesthetic	71.7% (n=114)	44.6% (n=33)
Restore all first permanent molars (including root canal therapy) under local anaesthetic and inhalation sedation	23.9% (n=38)	37.8% (n=28)
Restore all first permanent molars (including root canal therapy) under local anaesthetic and intravenous sedation	5% (n=8)	1.4% (n=1)
Restore all first permanent molars (including root canal therapy) under general anaesthetic	5% (n=8)	2.7% (n=2)
Extract all first permanent molars under local anaesthetic	30.8% (n=49)	48.6% (n=36)
Extract all first permanent molars under local anaesthetic and inhalation sedation	22% (n=35)	52.7% (n=39)
Extract all first permanent molars under local anaesthetic and intravenous sedation	8.8% (n=14)	8.1% (n=6)
Extract all first permanent molars under general anaesthetic	18.9% (n=30)	58.1% (n=43)
If you chose to restore UL6(26)" and LR6(46), what materials would you choose? Please tick your first choice restorative material	Composite 44% (n=70) Amalgam 12.6% (n=20) Glass Ionomer 17% (n=27)	Composite 23% (n=17) Amalgam 0% (n=0) Glass Ionomer 2.7& (n=2)

	Preformed Metal Crown 6.3% (n=10) Indirect Restoration 3.1% (n=5) Would not restore these teeth 17% (n=27)	Preformed Metal Crown 32.4% (n=24) Indirect Restoration 0% (n=0) Would not restore these teeth 41.9% (n=31)
Treatment Options for UR6/LL6 (Non-affected teeth)		
Treatment Options	**GDPs (n=159)**	**Specialist (n=74)**
No treatment & best preventive practice only	48.4% (n=77)	10.8% (n=8)
Application of a fissure sealant to LL6(36)	71.1% (n=113)	68.9% (n=51)
Extract UR6(16) alone as a compensating extraction	21.4% (n=34)	36.5% (n=27)
Extract LL6(36) alone as a compensating extraction	8.8% (n=14)	5.4% (n=4)
Extract both UR6(16) and LL6(36)	28.9% (n=46)	40.5% (n=30)

Table 3a: GDPs and SPDs response to vignette 2

Vignette 3	Yes	No
Professional Group	**GDPs (n=159)**	
Would you treat this case in practice?	82.4% (n=131)	17.6% (n=28)
If ticked YES to treat this case, would you refer this patient for an orthodontic opinion before commencing treatment?	60.3% (n=79)	39.7% (n=52)
If you ticked NO to treat this case, where would you refer to?	CDS 42.9% (n=12) District General Hospital 10.7% (n=3) Dental Hospital 46.4% (n=13)	
Professional Group	**Specialists (n=74)**	
Would you refer this patient for an orthodontic opinion?	16.2% (n= 12)	83.8% (N=62)
Treatment Options	**GDPs (n=159)**	**Specialist (n=74)**
No treatment & best preventive practice only	6.3% (n=10)	4.1% (n=3)
Restore all first permanent molars (including root canal therapy) under local anaesthetic	32.1% (n=51)	13.5% (n=10)
Restore all first permanent molars (including root canal therapy) under local anaesthetic and inhalation sedation	14.5% (n=23)	10.8% (n=8)
Restore all first permanent molars (including root canal therapy) under local anaesthetic and intravenous sedation	8.8% (n=14)	4.1% (n=3)
Restore all first permanent molars (including root canal therapy) under general anaesthetic	1.9% (n=3)	0% (n=0)
Extract all first permanent molars under local anaesthetic	75.5% (n=120)	77% (n=57)
Extract all first permanent molars under local anaesthetic and inhalation sedation	39% (n=62)	79.7% (n=59)
Extract all first permanent molars under local anaesthetic and intravenous sedation	29.6% (n=47)	64.9% (n=48)
Extract all first permanent molars under general anaesthetic	39% (n=62)	60.8% (n=45)

Table 3b: GDPs and SPDs response to vignette 3

Figures

Figures 1a: Vignette 1: Asymptomatic 7 Year-old with MIH with no post-eruptive breakdown; no clinical caries.

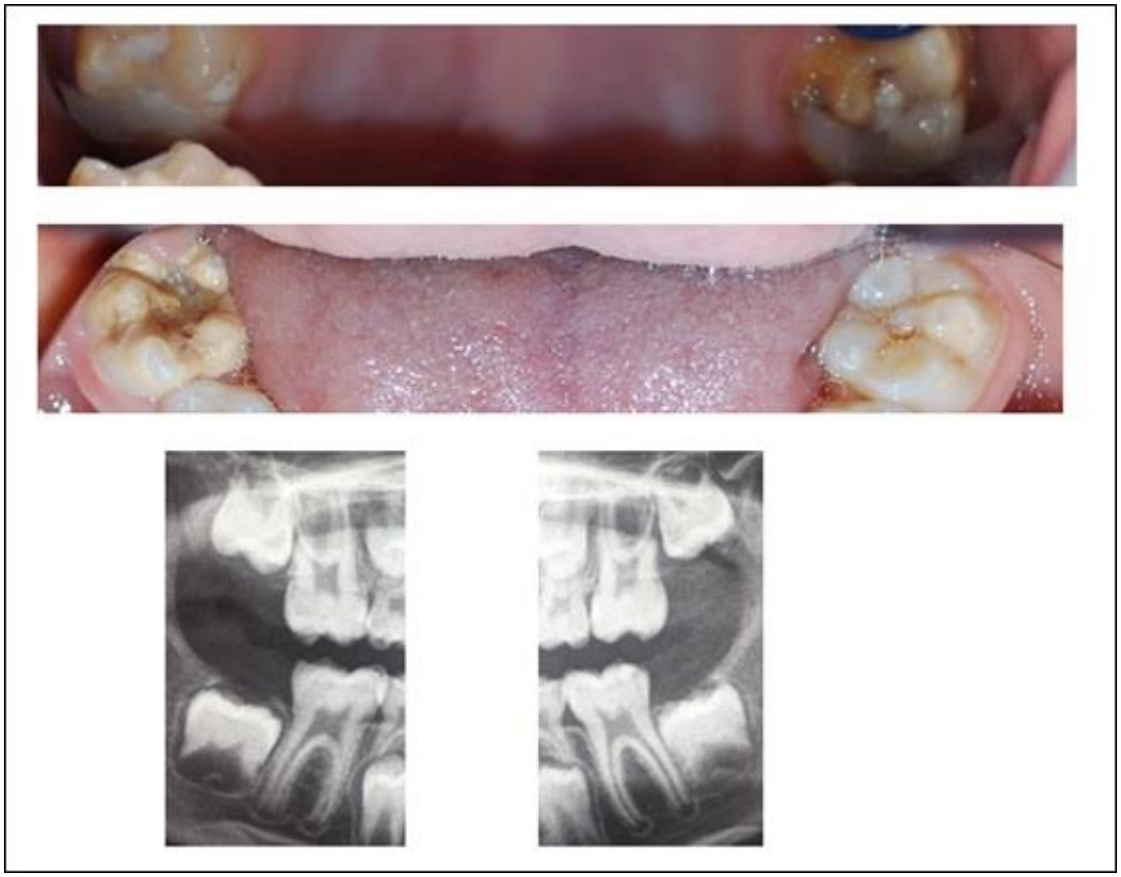

Figure 1b: Vignette 2: Asymptomatic 9 Year-old with MIH Hypomineralisation of the upper left (26) and lower right (46) first permanent molar teeth with post-eruptive breakdown noted; clinically sound upper right (16) (with intact fissure sealant) and lower left (36) first permanent molar teeth; No clinical caries is recorded; Class II Div I Incisors; Class II Molars; minimal crowding

Figure 1c: Vignette 3: Asymptomatic 15 year old patient has gross dental caries affecting all four first permanent molar teeth (16,26,36,46) which would render them of poor long term prognosis. Medically they are fit and well. They have excellent cooperation.

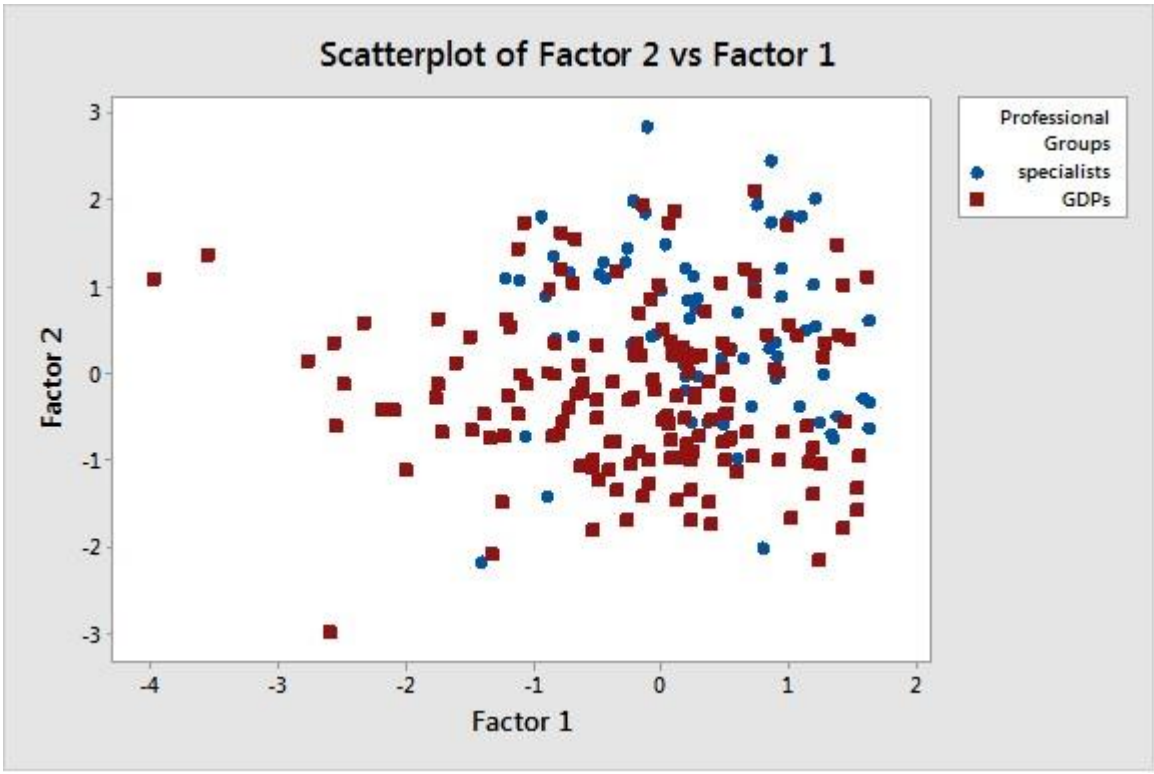

Figure 2: Scatterplot of Factor 2 vs Factor 1 (Specialists and GDPs)