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PAR
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PRESCRIPTION D'EXAMENS PAR IMAGERIE DIAGNOSTIQUE : IMPACT D'UNE STRATÉGIE D'INTERVENTION ÉDUCATIVE

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AVANT PROPOS

Dépôt initial du travail de recherche (Mémoire)

Conformément aux articles 136.2 et 138.1 des règlements des études de cycles supérieurs (rédaction du mémoire sous forme d'articles scientifiques et article scientifique avec plusieurs auteurs) et au règlement interne définissant les modalités de la présentation du mémoire, le lecteur trouvera ci-joint : un exposé substantiel rédigé en français, dans lequel sont présentés les objectifs, la méthodologie et les résultats obtenus; une discussion sur l'ensemble de l'article rédigé pour publication et des informations permettant au jury d'évaluation du mémoire d'apprécier la contribution spécifique de l'étudiant au travail collectif sont aussi présentés dans le travail, de même que la version (en anglais) de l'article, soumis pour publication à la revue *Implementation Sciences.*

RÉSUMÉ

Introduction

Malgré une réduction significative de la fréquence d'utilisation de la radiographie conventionnelle observée en Amérique et en Europe, au cours des dernières décennies, l'utilisation de routine de la radiographie demeure une pratique répandue en chiropratique. Afin d'encourager une pratique mieux structurée et plus uniforme, des lignes directrices en imagerie diagnostique ont récemment été publiées sur les affections du rachis et des extrémités chez l'adulte à l'intention des chiropraticiens et d'autres intervenants de la santé. Le transfert de connaissances à partir des lignes directrices et, incidemment, la capacité à modifier la pratique des professionnels de la santé suite à la formation continue apparaissent mitigés en raison du manque apparent d'efficacité des stratégies étudiées à ce jour.

Objectif

L'objectif de l'étude était de vérifier l'efficacité d'une intervention éducative appliquant une stratégie mixte sur le taux de prescriptions appropriées en imagerie diagnostique chez deux groupes de chiropraticiens.

Méthodologie

Éligibilité: Deux cent sept (207) chiropraticiens, membres de l'Association Chiropratique Suisse, assistant à une formation continue à Davos en septembre 2007 pouvaient participer à l'étude. Les participants avaient tous reçu une formation adéquate en imagerie diagnostique telle qu'exigée par les standards du Conseil

International en Éducation Chiropratique, de même qu'un entraînement particulier en milieu hospitalier qui inclut la prescription d'imageries spécialisées.

Devis de recherche et randomisation: Un essai randomisé contrôlé avec suivi par la poste chez un groupe de chiropraticiens suisses assistant à une formation continue a été réalisé. Parmi les 207 praticiens assistant à la formation continue, 160 ont été assignés au hasard à l'un des quatre groupes de 40 individus. Pour des raisons de logistique, un groupe a dû être exclu, n'étant pas disponible au moment d'administrer le pré-test. L'horaire des conférences n'a pas permis de reprendre le pré-test ultérieurement. Les 120 sujets restants ont été assignés de manière aléatoire à une condition expérimentale (N = 80) et à une condition de contrôle (N = 40).

Intervention : Les participants du groupe expérimental et du groupe de contrôle assistaient d'abord à une présentation visant à expliquer comment les lignes directrices avaient été développées. De plus, celle-ci visait à permettre aux praticiens de mieux comprendre les facteurs impliqués dans la prise de décision clinique reliée à la prescription d'imagerie diagnostique et les risques inhérents à l'exposition aux radiations ionisantes. Le groupe expérimental a par la suite participé à un séminaire éducatif sur le sujet de la radiologie, révisant les indications pour la prescription d'imagerie diagnostique chez les patients adultes avec affections rachidiennes, alors que le groupe de contrôle a participé à un séminaire sur une thématique qui n'avait pas de lien avec la radiologie. Le séminaire de radiologie (intervention éducative en partie interactive et appuyée par une dizaine de cas cliniques) visait à revoir les indications appropriées pour les imageries diagnostiques sur les affections vertébrales. À l'insu des participants, le groupe expérimental était subdivisé en trois groupes égaux de

participants (IG1, IG2 et IG3), afin de mesurer l'efficacité de l'ajout d'une intervention à la mi-période. Au mi-temps de l'expérimentation, seul un sous-groupe (IG2) a été invité à revoir la présentation PowerPoint présentée lors du séminaire de radiologie, 6-8 semaines après la conférence, agissant ainsi comme rappel (intervention additionnelle).

Groupe de contrôle : Afin de vérifier si l'intervention éducative était efficace, le groupe contrôle n'a pas assisté au séminaire de radiologie, mais a plutôt participé à un séminaire sur un sujet non relié, soit des techniques novatrices en neuro-mobilisation pour le traitement des affections vertébrales.

Mesures : L'information démographique recueillie lors du pré-test incluait les sept éléments suivants: année de graduation, diplôme supérieur, temps en pratique, type de pratique, présence d'un appareil de radiographies sur le lieu habituel du travail, nombre moyen de séries radiographique du rachis prescrites par semaine et nombre de références en imagerie spécialisée prescrites par mois. Les mesures primaires visant à estimer le niveau de réponses appropriées quant à la prescription d'imagerie diagnostique étaient une série de 10 situations cliniques, incluses dans trois versions équivalentes du questionnaire (A, B et C). Pour chaque version (versions évaluées par quatre radiologistes chiropraticiens spécialistes non participants à l'étude afin de déterminer leur validité et leur niveau de difficulté), environ un tiers des cas cliniques ne requérait aucune imagerie avant d'administrer des soins conservateurs, la radiographie conventionnelle était jugée nécessaire pour environ un tiers des cas, alors que les autres scénarios cliniques suggéraient fortement le besoin d'imageries spécialisées. Chaque participant devait indiquer s'il jugeait nécessaire de prescrire des imageries

diagnostiques et préciser lesquelles, lorsque approprié, pour chacun des 10 scénarios cliniques. Les lignes directrices, non publiées au moment de l'expérimentation, représentaient le standard étalon pour les réponses recueillies auprès des participants de la présente étude pour les trois mesures (pré-test, post-test et test final). Le pré-test et le test final ont été administrés à tous les participants de l'étude. Afin d'évaluer la pertinence du rappel (accès à la présentation PowerPoint du séminaire de radiologie à la mi-période), seuls les groupes IG1 et IG2 ont complété le post-test à 6-8 semaines.

De plus, les versions B et C du questionnaire ont été interchangées dans les sous-groupes assignés au post-test et au test final (IG1 et IG2), de manière à ce que la moitié des participants complète la version B du questionnaire et l'autre la version C lors du post-test, et l'inverse au test final. Similairement, la moitié des participants qui n'était pas soumis au post-test à la mi-temps (sous-groupe IG3 et groupe de contrôle) était assignée soit à la version B ou C du questionnaire lors du test final. Cette stratégie visait à déterminer si un rappel en cours d'expérimentation permettait aux participants d'obtenir un meilleur résultat aux tests de compétence, signifiant qu'une formation seule est moins efficace qu'une formation avec rappel. Enfin, ceci permettait également d'équilibrer les niveaux de difficulté des tests B et C en contrebalançant les versions à travers des sous-groupes de répondants.

Plan d'analyse : L'analyse principale obéissait à un plan factoriel mixte à deux dimensions ($A \times B_R$). Un Khi-deux a été utilisé afin de comparer les données démographiques entre les sujets du groupe expérimental et du groupe de contrôle. Les différences de moyennes des scores obtenus aux questionnaires ont été traitées par analyse de variance. Une différence était considérée significative au seuil de 0,05.

Certaines interactions ont été décomposées a posteriori en utilisant le critère de Dunnett. Deux mesures d'adhésion aux lignes directrices ont été calculées, la première, en estimant (à partir d'une table de contingence 2×2) la proportion des cas non recommandés pour des radiographies parmi tous les cas ne présentant aucun indice de pathologie potentiellement grave (IPPG). La seconde visait à estimer la proportion des participants ayant signalé la pertinence d'imagerie diagnostique telle que proposée par les lignes directrices, parmi tous les cas avec IPPG. Ces deux mesures d'adhésion aux lignes directrices ont été estimées en calculant des intervalles de confiance à 95%.

Résultats:

Description de la population à l'étude : Les caractéristiques cliniques de base des participants étaient les mêmes d'un groupe à l'autre ; fait exception l'accès à un appareil de radiographie sur place ($\chi 2 = 5.80$; $dl = 1$, $p < 0.05$), accès plus fréquent dans le groupe expérimental (82.4%) que dans le groupe de contrôle (58.6%) et le type de pratique ($\chi 2 = 5.03$; $dl = 1$, $p < 0.05$) dans lequel le groupe expérimental était plus sujet à être en pratique de groupe ou multidisciplinaire (63.5%) que le groupe de contrôle (37.0%). Les différences observées n'ont cependant pas eu d'impact observable sur les répondants lors du pré-test ($t = 0.640$; $dl = 102$, $p > 0,05$) ou entre le pré-test et le test final ($t = 0.933$; $df = 71$, $p > 0.05$). Enfin, les interactions de chaque sous-groupe expérimental avec le groupe de contrôle n'étaient pas significatives ($t =$ 0,398 pour IG1; $t = 1,126$ pour IG2; $t = -0,213$ pour IG3) au critère de Dunnett (t crit. = 2.097; $dl = 73$, $k = 4$). En ce qui concerne le type de pratique, le test t de Student n'était

pas significatif (t = 0.375; dl = 99, p> 0.05), suggérant qu'être en pratique seul, en groupe ou en équipe multidisciplinaire n'a pas influencé l'attitude générale quant à l'intention de prescrire des imageries diagnostiques à partir de cas cliniques. Enfin, cette caractéristique ne semble pas avoir influencé les résultats obtenus au pré-test et au test final pour les groupes d'intervention et de contrôle (t = 1.197; dl = 73, p> 0.05),

Soixante-dix sujets (87.5%) du groupe expérimental et 29 (72.5%) du groupe témoin ont complété le pré-test, 31 participants (62.9% et 51.8% des sous-groupes IG1 et IG2 respectivement) ont complété le post-test à la mi-période et 53 sujets (66.3%) du groupe expérimental et 26 (65%) du groupe de contrôle ont retourné le test final à 14-16 semaines. Une proportion similaire de participants a complété la version B et la version C du questionnaire à la mi-période et à la dernière mesure.

Analyses primaires : Six participants ont été exclus des analyses en raison de questionnaires incomplets ou pour avoir dépassé la date butoir suggérée pour la remise du questionnaire. Aucune différence n'a été observée pour les scores obtenus initialement entre le groupe expérimental et le groupe de contrôle (t = 0.065; dl = 98, p > 0.05). Le score du sous-groupe IG2, qui a eu accès au rappel à la mi-période (présentation PowerPoint à 8-10 semaines), s'est amélioré de 16.4% au post-test par rapport au score obtenu au pré-test (moyenne du changement et écart-type entre le pré-test et le post-test de 0.785 (1.53), IC 95% -0.92 à 1.59). Cette performance était significativement supérieure à celle du groupe de comparaison IG1 (F = 4.486; dl = 1 et 30, p < 0.05). Le sous-groupe IG2 (avec rappel) a continué de démontrer une amélioration à 14-16 semaines comparativement à la mesure initiale (amélioration de 13.2%) mais, dans l'ensemble, les scores obtenus entre le pré-test et le test final pour les

quatre groupes ne différaient pas significativement (F = 1.117, df = 1 et 74, p>0.05). Ainsi, lorsque comparé aux scores initiaux, il n'y avait virtuellement aucun changement pour la performance des sujets qui n'avaient reçu aucun rappel et n'avaient pas complété de post-test (changement du groupe expérimental IG3 = 1.3%) et une légère augmentation du groupe témoin (CG = 5.5%). Notons enfin que le sous-groupe de comparaison qui n'avait pas eu accès au rappel à la mi-période (IG1) a vu une régression (non significative) de sa performance comparativement à l'évaluation initiale tant lors du post-test (–11.2%) que du test final (–5.8%).

Analyses secondaires : Chaque version du test de compétence contenait trois cas sans aucun indice de pathologie potentiellement grave exigeant des radiographies. L'adhésion aux lignes directrices (la proportion de cas non recommandés à l'imagerie parmi les cas sans indice de pathologie) était de 50.5% (95% IC, 39.1-61.8) pour le groupe expérimental et 43.7% (95% IC, 23.7-63.6) pour le groupe témoin au pré-test. L'adhésion du sous-groupe IG2 avec accès au rappel à la mi-période était de 38.1% (95% IC, 12.4-63.8) comparée à 29.3% (95% IC, 7.5-51.4) pour le sous-groupe IG1 (sans accès au rappel). Enfin, l'adhésion au test final était de 33.9% (95% IC, 20.4-46.3) pour le groupe expérimental versus 19.5% (95% IC, 3.5-35.4) pour le groupe témoin. La mesure secondaire d'adhésion (la proportion des cas contenant au moins un IPPG et où des imageries ont été recommandées) était de 51.5% (95% IC, 40.2-62.9) et 51.7% (95% IC, 33.5-69.9) pour le groupe expérimental et le groupe témoin respectivement au pré-test. Au post-test, cette mesure était de 63.3% (95% IC, 37.8-88.6) pour le groupe IG2 (avec rappel) versus 56.3% (95% IC, 32.6-79.9) pour le groupe sans rappel (IG1), alors qu'au test final, la mesure était de 56.3% (95% IC,

43.0-69.9) pour le groupe expérimental et 59.5% (95% IC, 39.8-79.2) pour le groupe témoin.

Discussion

Cet essai clinique visait à comparer la prescription d'imagerie diagnostique chez un groupe de chiropraticiens suisses avant et après une stratégie d'intervention éducative utilisant une méthode mixte. Les caractéristiques cliniques du groupe expérimental et du groupe témoin étaient similaires, sauf pour ce qui a trait à l'accès à un appareil de radiologie sur le lieu habituel du travail. Certains auteurs proposent que l'autoréférence est susceptible d'accroître l'utilisation de l'imagerie diagnostique, cependant un tel comportement n'a pas été observé dans notre étude. L'intention de prescrire des études d'imageries à partir de scénarios cliniques telle que mesurée lors du pré-test et du test final n'était pas influencée par le fait d'avoir ou non un accès direct à un appareil de radiographie. Employée seule, l'intervention éducative n'est pas parvenue à améliorer le taux de bonnes réponses à partir de scénarios cliniques, alors que la combinaison de deux interventions, un séminaire de radiologie et un rappel « en ligne » à la mi-période, a permis d'améliorer significativement le taux de réponses appropriées. Cette tendance ne s'est cependant pas maintenue à long terme. Bien que ces résultats semblent supporter la notion que l'éducation continue en ligne peut stimuler le transfert des connaissances, les résultats de l'étude devraient être interprétés avec prudence, considérant la relation inverse entre les scores des deux sous-groupes qui peut fort bien expliquer les différences observées.

Le fait de ne pas avoir mesuré l'intention de prescrire des études d'imagerie diagnostique immédiatement ou peu après le séminaire de radiologie de septembre limite en quelque sorte l'interprétation de la faible performance du sous-groupe IG1. On pourrait argumenter que la présentation du séminaire de radiographie a davantage confondu les participants, suggérant soit un manque de pertinence du contenu, soit que le format utilisé pour expliquer les recommandations était inapproprié. Considérant que le séminaire était offert par des universitaires, experts dans le domaine de la radiologie et de la clinique, et que tous deux sont coauteurs des lignes directrices en imagerie diagnostique publiées récemment, il apparaît raisonnable de croire que le contenu du séminaire était pertinent. Les caractéristiques particulières des participants suggèrent que ce groupe de praticiens très compétents adhérait déjà aux principes des lignes directrices, ce qui aurait pour effet de causer un seuil plafond ne permettant pas de mesurer l'amélioration significative des performances malgré une intervention efficace. Ceci ne semble cependant pas avoir été le cas puisque l'adhésion globale initiale aux lignes directrices était d'environ 50% pour tous les groupes. Une autre explication pour les résultats obtenus dans notre étude est en lien avec la confection des questionnaires eux-mêmes. Les coefficients de consistance alpha de Cronbach étaient plutôt faibles pour les trois questionnaires, suggérant que des domaines différents étaient évalués et que l'objet de mesure (la compétence de la prescription de l'imagerie diagnostique) pourrait être multidimensionnel. Par ailleurs, il est possible que la présentation offerte à tous les groupes avant l'expérimentation ait influencé l'attitude des praticiens. Cette conférence contenait des informations visant à convaincre l'auditoire que les recommandations des lignes directrices étaient fondées sur des données probantes et que l'utilisation sélective de l'imagerie était importante. Or, cette

démarche représente un des trois éléments de la théorie du comportement planifié (Ajzen, 2001) et pourrait avoir constitué une intervention en soi. Enfin, une étude récente sur le même sujet suggère qu'il serait plus souhaitable de proposer seulement une à deux recommandations à la fois. Dans une étude quasi expérimentale comparant les résultats avant et après une stratégie d'intervention éducative (Ammendolia, Côté, Hogg-Johnson, et Bombardier, 2007), une réduction significative de l'intention de prescrire des radiographies conventionnelles était notée pour les cas de lombalgie aiguë non compliquée et ceux avec lombalgie aiguë de moins d'un mois en faveur du groupe ayant reçu l'intervention éducative. La taille de notre échantillon, les contraintes de temps, de budget et la distance importante ont malheureusement limité l'inclusion de plusieurs des stratégies jugées efficaces pour cette étude.

Limites de l'étude

Cette étude a plusieurs limites. D'abord, l'échantillon était relativement petit pour ce genre d'étude, et il n'y avait pas de mesure immédiatement ou peu après l'intervention éducative, limitant ainsi l'interprétation. Bien que des questions du pré-test étaient incluses dans le post-test et dans le test final, et d'autres questions du post-test et du test final étaient également incluses dans l'un et l'autre, il n'a pas été possible d'inclure des questions des deux derniers tests dans le pré-test. Rappelons que ceci a cependant été partiellement compensé par le croisement des versions B et C lors des dernières mesures. De plus, bien qu'une évaluation qualitative des trois versions des questionnaires ait été faite par quatre experts indépendants, l'évaluation psychométrique rigoureuse n'a pas été pratiquée. Bien entendu, des vignettes cliniques écrites ne peuvent remplacer les interactions docteur-patient et elles reflètent l'intention

de prescrire plutôt que l'action elle-même. Enfin, des difficultés techniques rencontrées durant l'étude pourraient avoir démotivé certains participants, expliquant possiblement la faible participation à la mi-période et à la fin de l'étude. Ceci ne semble cependant pas avoir influencé les résultats obtenus.

Conclusion: Les résultats de cette étude suggèrent que l'accès à des recommandations en ligne lors de la prise de décision clinique afin d'influencer l'intention de prescrire des imageries diagnostiques en conformité avec des lignes directrices sur les affections rachidiennes chez l'adulte mérite d'être étudié davantage. De plus, ces données sont conformes aux notions actuelles concernant les présentations didactiques. Les résultats de la présente étude doivent être interprétés prudemment considérant le petit échantillon.

Contributions des auteurs

André E. Bussières a conçu l'étude, développé les objectifs, révisé la littérature, conçu les scénarios cliniques et les tests de compétence, supervisé les analyses statistiques, interprété les résultats et rédigé l'article scientifique en anglais et le présent exposé en français. Louis Laurencelle a assisté à la conception de l'étude, fait les analyses statistiques et a aidé à rédiger une partie de l'article. Cynthia Peterson a aidé à élaborer les scénarios cliniques et les tests de compétence, a co-géré l'intervention et a participé à la rédaction d'une partie de l'article. Tous les auteurs ont lu et approuvé l'article scientifique. Louis Laurencelle a relu le présent exposé.

Référence

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Diagnostic imaging guidelines implementation study: A randomized trial with postal follow-ups.

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Abstract

Purpose: To compare the perceived need for diagnostic imaging among a group of Swiss chiropractors before and after an educational intervention strategy, using a combined method, a radiology workshop and an online reminder.

Methods:

Study design: A randomized trial with postal follow-ups conducted in the fall of 2007.

Intervention: 120 Swiss chiropractors attending a continuing education conference were randomly assigned to receive either a radiology workshop (experimental group, 80 practitioners), reviewing appropriate indications for diagnostic imaging studies for adult spine disorders, or a workshop on an unrelated topic (control group, 40 practitioners). One group of 40 individuals was excluded due to logistic reasons. The intervention group was further subdivided into three equal subgroups (IG1, IG2, and IG3), to evaluate the effect of introducing a reminder at mid-point.

Measurements: Three outcome measures were included. All participants underwent a pre-test and a final test at 14-16 weeks. At mid-point, subgroup IG2 was invited to review online recommendations initially presented during the educational workshop. Post-test performance was compared to subgroup IG1. Statistical analysis included Chi-squared tests, ANOVA, and Student *t* tests. Differences were considered significant at $p < .05$. Measures of adherence were calculated using 95% confidence intervals.

Results: No group differences were found for baseline clinical characteristics, except for having on site access to radiography. This did not influence intention to prescribe imaging studies however ($t = 0.640$; $df = 102$, $p > .05$). Seventy practitioners in the intervention groups and 29 in the control group completed the pre-test measures, 31 participants from two subgroups completed the post-test at

mid point, and 53 participants from the intervention groups and 24 in the control group completed the final test at 14-16 weeks. Eight subjects were excluded from analysis due to incomplete questionnaires or not returning forms before the submission deadline. There was no difference between scores obtained at baseline for the intervention group and the control group (unpaired Student *t*-test = 0.065; *df* = 98, *p*>.05) and overall scores for the pre-test and the final test for all four groups were not significantly different (*F* = 1.117, *df* = 1 and 74, *p*>.05). However, the subgroup provided with access to an online PowerPoint presentation at mid-point while completing the post-test at 8-10 weeks performed significantly better than the subgroup with which they were compared (*F*=4.486, *df* = 1 and 30; *p*<.05). Guideline adherence (the proportion of cases not recommended for radiography among cases without red flags) was 50.5% (95% CI, 39.1-61.8) for the intervention group and 43.7% (95% CI, 23.7-63.6) for the control group at baseline. Adherence at follow up was lower but mean group differences remained un-significant.

Conclusions: Having online access to specific recommendations while making a clinical decision may favourably influence the intention to either prescribe or not prescribe diagnostic imaging studies. However, a didactic presentation alone in a group of trained professionals did not appear to change the perception for the need of diagnostic imaging studies.

Key Indexing Terms: Practice Guidelines; Guidelines; Diagnostic Imaging; Radiology; Diagnostic X-Ray; Education, Continuing, Knowledge Acquisitions (Computer); Randomized Controlled Trial

Background

Imaging technology can improve patient outcomes by allowing greater precision in diagnosing and treating patients. However, evidence of overuse, underuse, and misuse of imaging services has been reported in the literature [1-4]. Although an integral part of chiropractic practice for over a century, the role of diagnostic imaging remains a source of controversy [5-7]. We previously developed diagnostic imaging guidelines for chiropractors and other primary health care professionals to assist clinical decision-making and to allow more selective use of imaging studies for adult spine disorders [8]. Clinical guidelines are particularly useful where significant variation in practice exists as they aim to describe appropriate care based on the best available scientific evidence and broad consensus while promoting efficient use of resources [9, 10].

Current guideline dissemination and implementation strategies can encourage practitioners to conform to best practices and lead to improvements in care [11]. However, high quality studies documenting effectiveness and efficiency of guidelines dissemination and implementation strategies are scarce [12]. Interventions designed to improve professional practice and the delivery of effective health services may include continuing education, quality assurance programs, computer based information and recalls, financial incentives, and organizational and regulatory interventions [13]. Educational strategies are thought to have mixed effects. These include the distribution of educational materials to professionals, guideline implementation information, printed educational materials, continuing education activities and small group interactive education with active participation, educational outreach by experts or trained facilitators, and use of local opinion leaders [14]. Used alone, two of the most common strategies for dissemination of new knowledge, publication of educational material and meetings, including seminars and conferences, appear to have a small impact on practice [15-18]. However, combined workshops and didactic presentations, and interactive workshops can result in moderately large

changes in professional practice [17]. Among a group of chiropractors, an educational intervention strategy emphasizing the use of evidence-based diagnostic imaging guidelines was shown to decrease the perceived need for plain film radiography in uncomplicated low back pain patients in specific case scenarios [19]. Furthermore, information recall has been shown to be important in achieving behaviour change in interventions providing information [20], and "Online" support may be an effective way to deliver reminders [21]. Rational for selecting these interventions is further discussed in the latter part of this paper.

Rationale for the study

Introducing new scientific findings, best practice or clinical guidelines into routine daily practice is challenging. The authors were interested in exploring educational strategies that would facilitate the use of recently developed evidence based diagnostic imaging guidelines for chiropractors and other health care providers [22]. Ultimately, application of these guidelines should help avoid unnecessary radiographs, increase examination precision, and decrease health care costs without compromising the quality of care. These guidelines suggest that imaging studies should be reserved for patients with "red flags" or clinical indicators suggestive of serious underlying pathologies. For instance, a combination of the following four red flags has a 100% sensitivity for cancer: considerable low back pain starting after age 50, a history of cancer/carcinoma in the last 15 years, unexplained weight loss, and failure of conservative care [23]. This study was designed to compare the self reported diagnostic imaging practices of a group of Swiss chiropractors before and after an educational intervention strategy using a combined method, an educational workshop and an online reminder. The following hypotheses were tested: 1) between the pre and the post-test, subjects receiving an educational intervention strategy will demonstrate a more discriminating selection of diagnostic imaging based on presence of red-flags for case scenario compared to the control group; 2) subjects receiving a combined intervention, i.e. an educational strategy plus online information, will have a

greater improvement in the self-reported need for diagnostic imaging compared to those receiving an educational intervention strategy alone.

Research methods

Study setting and population

Eligibility: 207 English speaking licensed chiropractors in Switzerland out of 254 practitioners attending a continuing education conference in Davos in September 2007 were candidates for this study. Inclusion criteria were: 1) to be a member in good standing of the Swiss Chiropractic Association, 2) attending the September 2007 continuing education conference in Davos, 3) willingness to complete the consent form to participate, 4) available at the time of the pre-test, and 5) to complete or return any of the assigned questionnaires (outcome measures).

Setting and location: Volunteers were recruited in Davos prior to a yearly mandatory continuing education conference. All licensed chiropractors in Switzerland work in private-practice, providing ambulatory care. To be a member in good standing, practitioners are required to 1) have completed their undergraduate training in an accredited school as listed on the Swiss government registry, 2) have completed a mandatory 4 month hospital training program and a two year post-graduate training program in a private chiropractic practice, and 3) have successfully passed the Swiss National Board Exams. The prescribers were therefore trained in diagnostic imaging studies according to the standards of the International Council on Chiropractic Education, and had hospital-based training, including the prescription of specialized diagnostic imaging such as computed tomography, magnetic resonance imaging, bone scanning and ultrasound.,

Study design

We conducted a randomized trial with postal follow-ups among a group of Swiss chiropractors attending a continuing education conference. For the purpose of a separate study taking place simultaneously on an unrelated topic (Patient Safety and Critical Incident Reporting), investigators made a list of all members of the Swiss Chiropractic Association who had agreed to participate. 160 participants were randomly assigned to one of four groups of 40 individuals according to a computerized random-number generator.[1] Numbers were randomly generated using a "Math.random" method within the JavaScript programming language by use of a complex algorithm (seeded by the computer's clock). Allocation sequence was concealed until the interventions were assigned. Investigators of the Patient Safety study generated the allocation sequence, enrolled participants, and assigned participants to their groups. All subjects were asked to return a signed consent form. One group of 40 practitioners initially allocated to the control group was excluded from the current study for logistic reasons, having been assigned to a presentation on Patient Safety by organizers of the conference at the time the pre-test was administered. Due to the busy conference schedule, it was not possible for this group to undertake the pre-test at a latter time. The remaining 120 subjects were assigned to either the intervention (N = 80) or the control group (N = 40) and underwent pre and post-tests. Ethical approval was obtained from the university (UQTR). All participants were instructed not to discuss or share any information related to the study to limit group contamination.

Intervention

The intervention group, composed of 80 chiropractors, attended a workshop on the topic of radiology, reviewing appropriate indications for diagnostic imaging

[1] http://www.randomizer.org/form.htm

studies for adult spine disorders. The control group, composed of 40 chiropractors, attended a seminar on a chiropractic technique that does not specifically involve using imaging studies. This seminar was entitled *'Unique Neuro-mobilization Technique for Treating Spinal Pain'.* Registered participants received a conference package from the Swiss Chiropractic Association indicating the schedule (time, room and title) of presentations they were assigned to and were asked to sign a list of attendance. All participants also signed a consent form for the current study before completing the pre-test during the 30 minute afternoon break. For all measurements (pre-test, post-test, and final test), participants were instructed to complete questionnaires by themselves, and to select a single answer per question.

Pre-intervention presentation: All participants in both the experimental and control groups first attended a 20 minute platform presentation entitled: *Diagnostic Imaging Practice Guidelines for Musculoskeletal Complaints in Adults. An Evidence-based Approach.* The objectives of this presentation were 1) to familiarize the audience with the methodology used to develop a new set of diagnostic imaging guidelines, 2) to improve understanding of factors involved in clinical decision making for diagnostic imaging studies, and 3) to briefly discuss potential risks associated with ionizing radiation exposure. None of the recommendations contained in the diagnostic imaging guidelines were specifically discussed during this first presentation.

Intervention group: A 90 minute educational workshop was presented to the intervention group by two chiropractic specialists, one in clinical sciences and one in radiology. Topics covered included: Evidence-based recommendations contained in the Diagnostic Imaging Guidelines on Spine Disorders [8], underpinned with ten (10) case scenarios. Information provided to participants pertained to appropriate indications for the ordering of imaging studies. The target audience was a group of 80 Swiss chiropractors attending a continuing education conference. The intervention group was further subdivided into three subgroups (IG1, IG2, and IG3), each composed of 26 or 27 participants. This

strategy allowed evaluating the effect of introducing a reminder at mid-point. Participants were allocated to subgroups in a consecutive manner, according to the test number distributed at random before the pre-test. Only one subgroup (IG2) was invited to review the PowerPoint presented at the educational workshop 6-8 weeks after the conference, acting as a reminder. Other subgroups were not informed of this reminder/additional intervention (Table 1).

Control group: In order to determine if the proposed guideline implementation strategy was effective, the control group, composed of 40 Swiss practitioners, did not attend the radiology workshop, but instead, a chiropractic technique seminar where no discussion on the use of imaging took place. The control group (CG) completed the pre-test and the final test at 14-16 weeks.

Measurements

All participants were asked to answer seven demographic questions at the pre-test. Baseline clinical characteristics included the following: 1) year of graduation (<1960, 1961-1980, 1981-1990, 1991-2000, 2001-2007); 2) post graduate degree (Yes, No); 3) Practice (full time, part time, no longer in practice); 4) type of practice (solo, group or multidisciplinary); 5) on site access to radiography (Yes, No); 6) average number of spine x-ray series ordered per week (None, <5, 5-15, >15); and 7) average number of referrals for special imaging per month (None, <5, >5).

The primary endpoint with respect to rate of appropriate responses for the use of diagnostic imaging were three questionnaires, each consisting of 10 different spine case scenarios (A, B, C), all different from those presented during the educational intervention workshop, included in a pre-test, a post-test at 6-8 weeks, and a final test at 14-16 weeks after the conference. The clinician's decision to provide any of the listed clinical services (plain films radiography, CT, MRI or ultrasound, urgent referral, conservative therapy without imaging) was

also assessed for consistency with the guidelines for each clinical vignette. The evidence-based Diagnostic Imaging Guidelines for Spinal Disorders represented the gold standard. These were published soon after administering the final test of this study, decreasing the risk of between group contaminations. Plain films radiographs were consistent with the guidelines when 'ordered' in the presence of any indicators of potentially serious pathologies (red flags). Computed tomography, magnetic resonance imaging (MRI), bone densitometry (DEXA), bone scan or ultrasound were consistent with the guidelines at any time in the presence of progressive neurological deficits, painful or progressive structural deformity, potentially serious pathology (suspected cauda equina syndrome, neoplasia, infection, fracture, abdominal aortic aneurysm and nonmusculoskeletal causes of chest wall pain including disorders of the heart and lungs), or failed conservative care after 4-6 weeks. Urgent referrals were consistent with the guidelines at any time in the presence of potentially serious pathology (suspected cauda equina syndrome, neoplasia, infection, fracture, abdominal aortic aneurysm and nonmusculoskeletal causes of chest wall pain including disorders of the heart and lungs). Conservative therapy without imaging was consistent with the guidelines in the presence of uncomplicated musculoskeletal disorders (nontraumatic pain without neurologic deficits or indicators of potentially serious pathologies).

The pre-test and the final test were administered to all participants included in the intervention and in the control groups. In order to evaluate the reminder (access to the PowerPoint at mid-point), a post-test was administered at 6-8 weeks to subgroup IG1 and IG2. Subgroup IG2 was instructed to review the PowerPoint, either prior to or while answering the 10 spine case scenarios.

In addition, versions B and C of the questionnaires were crossed over within each of the subgroups undergoing both the post-test and the final test (IG1 and IG2), so that for the post-test, half of participants within each subgroup were first assigned to version B of the questionnaire, while the remaining subjects completed version C, and vice versa at the final test. Similarly, half of the

participants who were not administered a post-test at mid-point (subgroup IG3, and controls) were assigned to either version B or version C of the questionnaires at the final test (Table 1). This strategy aimed to compensate for possible dissimilarities between successive test versions. All three versions of the questionnaires were balanced and evaluated by four chiropractic experts in the field of radiology (Diplomates of the American Chiropractic Board of Radiology) to determine face validity and the level of difficulty. For all versions of the questionnaires, approximately one third of cases did not require any imaging prior to administering conservative care, plain film radiography was in order for one third of cases, and the remaining scenarios called for specialized imaging studies. All 10 questions were answered using either Yes/No or multiple choice (A-E). Each appropriate answer was used to generate a sum score.

Implementation

Each participant was asked to indicate whether or not imaging studies were indicated for each of the 10 cases presented. The estimated time to complete each of the tests was 15-20 minutes.

1. The pre-test was administered to the intervention and control groups simultaneously on September 7th, 2007 before workshops took place;
2. The radiology workshop was provided to the intervention group only;
3. Versions B and C of the questionnaires were administered electronically on a protected Website after the conference at 6-8 weeks (post-test) and at 14-16 weeks (Final test). A username and password were provided to all participants either by e-mail or mail before launching the website. Two electronic reminders were sent to participants failing to complete the online questionnaires by the due date. Assigned questionnaires were mailed to the remaining participants and to those who could not be reached by e-mail due to incorrect addresses.

Completion of the post-test and/or final test also required the participant to enter the following information: 1) group number, 2) username, and 3) password. Responses were later transcribed onto an Excel spread sheet by the principal investigator. While participants could not be blinded to the assigned workshop, groups were blinded to the version of the questionnaire received, and subgroup IG1 and IG3 were blinded to the reminder IG2 received at mid-point (online access to the PowerPoint presentation).

Data quality assurance

Appropriate responses to case scenarios were compared to the gold standard by two independent evaluators. Other methods used to enhance the quality of the data included checking for accuracy, completion and cross-form consistency of data forms after each measure.

Statistical analysis

Primary analysis. All data analyses were carried out according to a pre-established plan (two way factorial design with repeated measures ($A \times B_R$). Chi-squared tests were used to compare demographic data between subjects from the intervention and control groups (year of graduation, post graduate degree, practice frequency, type of practice, on site access to radiography, average number of spine x-ray series ordered per week, and average number of referrals for special imaging per month). Mean differences before and after the intervention at mid-point and end-point were tested using analysis of variance. Differences were considered significant at $p < .05$. Where such differences were found to be significant, follow-up analyses of single items were performed using unpaired t-tests. Post-hoc breaking down of a complex interaction term was performed using Dunnett's control-group criterion.

Secondary analysis. The measure of adherence to guideline recommendations was estimated by calculating (using a 2 X 2 contingency table) the proportion of patients who were not recommended for radiography among cases who did not present any red flags as we were interested in determining if imaging were not ordered unnecessarily [24]. Since the guideline state that all patients recommended for radiography should have at least one red flag, the proportion of participants who indicated the need for imaging studies in agreement with guideline recommendations was also calculated (Table 2). Both primary and secondary measures of adherence were calculated using 95% confidence intervals.

Results

Description of the population studied

Among the 207 licensed Swiss chiropractors registered to attend a continuing education conference in Davos in September of 2007, 160 were randomly assigned to four groups of 40 participants; one group was excluded from this study as they could not attend the pre-test during the afternoon break. Of the remaining 120 participants, 99 (82.5%) subjects completed the pre-test in Davos, and 79 (65.8%) respondents returned the final tests (53 in the intervention group and the 26 in the control group). The intervention group was further divided into three subgroups. Only two subgroups were asked to complete a test at midpoint. Seventeen of the 27 subjects (62.9%) from subgroup IG1 and 14 of 27 subjects (51.8%) from subgroup IG2 completed and returned the post-test. The final test was administered at 14-16 weeks, between January 31st and February 15th 2008. The total number of questionnaires sent by mail, either because e-mails failed to reach participants or they had not yet responded, was 27 for the post-test and 35 for the final test. Among those, 8 and 14 subjects respectively answered and mailed back the questionnaires. Six participants were excluded from the main

analysis: four questionnaires in the intervention group were incomplete at pre-test, one participant in subgroup IG1 returned the final test but failed to complete the pre-test, and one in subgroup IG3 passed the submission deadline for the final test. The flow of participants through each stage is shown in Figure 1.

Baseline clinical characteristics of the study sample are presented in table 3. Globally, 58% of participants graduated after 1991 and less than 20% had a post-graduate degree. Over 2/3 of participants were in full time practice, approximately 30% ordered more than five spine x-ray series per week, and between 14-21% referred patients for special imaging of the spine each month. Those in solo practice tended to have on site access to radiography. A larger proportion of practitioners in the intervention group were in group or multidisciplinary practice. Differences were found for baseline clinical characteristics on two items, 'On site access to radiography' ($\chi 2 = 5.80$; $df = 1$, $p< .05$), where the experimental group had greater access (82.4%) than the control group (58.5%) and 'Type of practice' ($\chi 2 = 5.03$; $df = 1$, $p< .05$) where the experimental group was more likely to be in group or multidisciplinary practice (63.5%) than the control group (37.0%). The effect of this on scores obtained for the pre-test and at the pre-test and at the final test for both intervention and control groups was further investigated. For the pre-test, means and standard deviations were respectively 4.872 ± 1.242 (n = 78) and 4.680 ± 1.492 (n = 25). The Student t test was not significant ($t = 0.640$; $df = 102$, $p>.05$), suggesting that having onsite radiography did not influence general attitude pertaining to ordering imaging studies based on case scenarios presented to participants. Furthermore, scores obtained at the pre-test vs. the final test, for both intervention and control groups combined, when considering 'onsite radiography' did not appear to differ ($t = 0.933$; $df = 71$, $p>.05$). To test for variability between the intervention and the controls groups at the pre-test and at the final test, interactions were further dissected using Dunnett's control-group method [25]. Subgroup interactions with the control group were not significant ($t = 0.398$ for IG1; $t = 1.1255$ for IG2 and $t = - 0.213$ for IG3) with Dunnett's criteria (critical $t = 2.097$; $df = 73$, $k = 4$). Similarly,

for the pre-test, means and standard deviations for both intervention and control groups were respectively 5.013 ± 1.566 (n = 43) and 5.121 ± 1.061 (n= 58) for 'Type of practice'. The Student *t* test was not significant (t = 0.375; df = 99, p>.05), suggesting that being in solo practice did not influence general attitude pertaining to ordering imaging studies based on case scenarios presented to participants. Furthermore, differences between scores obtained at the pre-test and the final test (intervention and control groups combined) when considering 'Type of practice' did not reach significance (t = 1.197; df = 73, p>.05).

Baseline clinical characteristics of participants in the intervention (IG) and control groups (CG) are presented in Table 3. Respondents and non respondents, both in the intervention and control groups, had similar characteristics, whether the non-response occurred for the post-test or the final test. Non-respondents typically fall into one of two groups: people who refuse to participate in the survey and those who cannot be reached during data collection. We were unable to distinguish between refusal and non-contact however (Tables 4 and 5).

Primary analysis

There was no difference between scores obtained at baseline for the intervention group and the control group (unpaired student t-test = 0.065; df = 98, p>.05). Summary results for each study group (total score averages and standard deviations) obtained at the pre-test, post-test and final tests are presented in Table 6.

Analysis also revealed a significant increase in guidelines-consistent behaviour among clinicians assigned to receive both the radiology workshop and the reminder at mid-point. Scores for the subgroup which was provided access to the online PowerPoint presentation at 8-10 weeks (IG2) increased at the post-test by 16.4% compared to baseline (change mean and standard deviation between the pre-test and the post-test were 0.785 (1.53), 95% CI -0.92 to 1.59. Mean difference reached 5% significance level (t = *1.924; df = 13, p<.05*) and this

performance was significantly greater than the comparison group (IG1) for the same period (0.647 (2.06), 95% CI -0.33 to 1.63) (F = 4.486; df = 1 and 30, p<.05) (Table 7).

One subject from an intervention group (IG1) and two from the control group (CG) were excluded from analysis due to missing data at the final test. One other subject from subgroup IG1 was excluded because the questionnaire was received after the deadline. The subgroup with access to the reminder at mid-point (IG2) continued to perform better at 14-16 weeks compared to baseline (13.2% improvement), although overall scores for the pre-test and the final test for all four groups were not significantly different (F = 1.117, df = 1 and 74, p>.05). The performance of the comparison group (IG1) which was not provided access to a reminder at mid-point, had decreased by 5.8% at the final test compared to baseline. There were virtually no changes in performance for the intervention group receiving no reminder and no post-test (IG3 = 1.3%), and a slight increased guideline-consistent performance from baseline for the control group at the end of the study (5.5%). Mean scores obtained for each study group for the pre-test and post-test, and for the pre-test and final test, are presented in Tables 7 and Table 8 respectively.

Secondary analysis

Each of the competency tests contained three case studies without mention of any red flags and where no disease was expected. Adherence (the proportion of cases not recommended for radiography among cases without red flags) was 50.5% (95% CI, 39.1-61.8) for the intervention group and 43.7% (95% CI, 23.7-63.6) for the control group at baseline (Table 9). The student t test was not significant (t = 1.260; df =101, p>.05). At mid-point, the adherence for the subgroup with access to the 'online' reminder (IG2) was 38.1% (95% CI, 12.4-63.8) compared to 29.3% (95% CI, 7.5-51.4) for the subgroup without access

(IG1) (unpaired Student *t*-test = 0.604; *df* =29, *p*>.05). Adherence at the final test was 33.9% (95% CI, 20.4-46.3) for the intervention group compared to 19.5% (95% CI, 3.5-35.4) for the control group (unpaired Student *t*-test = 1.840; *df* = 73, *p*=.07) (Table 10).

Secondary measure of adherence (the proportion of cases containing at least one red flag among all cases scenarios where imaging studies were recommended) for the remaining cases was 51.5% (95% CI, 40.2-62.9) and 51.7% (95% CI, 33.5-69.9) for the intervention and the control group respectively at the pre-test. For the post-test, this value was 63.3% (95% CI, 37.8-88.6) in the group (IG2) having access to the reminder at mid-point versus 56.3% (95% CI, 32.6-79.9) in the comparison group (IG1). For the final test, the result was 56.3% (95% CI, 43.0-69.9) for the intervention group compared to 59.5% (95% CI, 39.8-79.2) for the control group (Table 9 and 10).

Protocol deviation from study as planned

The post-test and the reminder were administered two weeks after the intended date (at 8-10 weeks) due to technical problems encountered.

Discussion

This study aimed to compare the self-reported diagnostic imaging ordering practices of a group of Swiss chiropractors before and after an educational intervention strategy using a combined method. Forty four percent of participants were in solo practice while 56% were in either a group or multidisciplinary practice. Results from a 2003 survey among 254 Swiss chiropractors suggested that 60% were working in a solo practice, 30% in a practice with more than one chiropractor, and 10% in a multidisciplinary environment [26]. This difference,

significant at 1% ($z = 2,844$), may be a reflection of a recent trend to join group or multidisciplinary practices [27, 28].

Group characteristics were similar for both the intervention and control groups, except for the number of practitioners having onsite radiography and for type of practice (solo or group/multidisciplinary). It has previously been shown that self-referral increases utilisation of diagnostic imaging [29, 30]; however, in our study, intention to prescribe imaging studies based on case scenarios provided at the pre-test or at the final test was not influenced by having onsite access to radiography or by the type of practice. Nonetheless, the fact that groups were not balanced does not rule out the possibility of high level interactions.

An educational intervention strategy alone did not improve self-reported decision making ability as to whether or not imaging studies were needed based on the case scenarios presented, whereas a combined intervention consisting of an educational workshop on radiology and reminder at mid-point, significantly improved the appropriate response rate (Table 7). While previous studies have suggested that online continuing education (CE) can stimulate knowledge transfer [21] our results should be interpreted with caution in light of the reverse relationship between scores obtained for the two subgroups receiving the original educational intervention (Figure 2). Furthermore, results at end-point were not statistically significant (Table 8).

Overall performance of the subgroup who could not access the PowerPoint Presentation at 8-10 weeks (IG1) declined over time whereas scores for subgroup IG3 and the control group did not truly change compared to baseline. Failing to measure the intention to prescribe diagnostic imaging studies immediately or soon after the initial lecture presentation somewhat limits the interpretation of the lower performance of subgroup IG1. It could be argued that the onsite presentation (radiology workshop) actually confused some participants, suggesting that the radiology workshop lacked relevance or that the

format used to disseminate recommendations was inappropriate. Since the workshop was provided by academic experts in the fields of radiology and clinical sciences, both primary authors of the recently published diagnostic imaging guidelines [31] that were used as the gold standard to compare responses for the current study, one may assume that the content was relevant. Although the level of appreciation from participants allocated to this workshop was high according to the conference organizing committee evaluation, level of satisfaction does not necessarily translate into better understanding or an intention to change practice. Alternatively, the radiology workshop may have sensitized participants to the importance of x-ray, resulting in fewer prescriptions of specialized imaging studies even when required.

High baseline scores in both the intervention and the control groups would suggest adherence to guidelines was already high, possibly explaining the lack of difference after the intervention (already high adherence with little room for further improvement). In addition to a mandatory two year post-graduate training prior to obtaining a full license in Switzerland, the number of mandatory continuing education hours per year for Swiss chiropractors is among the highest in the world. Such characteristics influence guidelines acceptance, an important feature of knowledge transfer [14]. More training could lead to better overall performance, thereby causing a ceiling effect. This did not seem to be the case however as the proportion of vignettes without red flags and where no radiography was prescribed (primary measure of adherence) and those with red flags where imaging studies where appropriately asked for (secondary measure of adherence) was approximately 50% for all groups at baseline. This suggests adherence to evidence-based diagnostic imaging guidelines was fair to moderate at the onset of the study. Secondary analysis of intervention effectiveness revealed a 7% increase in guideline-consistent behaviour among clinicians assigned to receive the radiology workshop and the reminder at mid-point (post-test), Measures of guideline adherence did not differ significantly at end-point.

Another explanation for the absence of significance of the study results may be that the questionnaires themselves failed to test similar domains or to measure a unified construct, as Cronbach alpha scores were quite low for all three questionnaires, suggesting a lack of internal consistency. Furthermore, the pre-intervention platform presentation offered to all practitioners prior to the workshop may have influenced participants' attitudes towards the behaviour we intended to change, that is the self-reported practice of ordering images. *Attitudes towards behaviour* constitute one of three variables which the theory of planned behaviour suggests will predict the intention to perform a behaviour [32]. According to this motivational theory, intentions are the precursors of behaviour. These intentions are determined largely by perceived social norms, perceived behaviour control and attitudes towards behaviour. The radiology workshop may have influenced perceived social norms (social pressure to perform or not perform the target behaviour considering the continuing education conference was organized by the Swiss Chiropractic Association), and perceived control related to the behaviour (extent to which a person feels able to enact the behaviour considering the interactive format of the case presentations during the workshop). The pre-intervention presentation discussed the various phases involved in the guideline development process, and reviewed basic concepts relating to clinical decision-making and ionizing radiation exposure, thereby aiming to convince practitioners that the proposed recommendations were sound and that appropriate use of imaging was important. Such discussion may have influenced participants' attitudes towards imaging. In addition, attitudes towards behaviour are proposed to arise from a combination of beliefs about its consequences (behavioural beliefs) and evaluations of those consequences (outcome evaluations) [33]. Information provided during the pre-intervention also aimed to address potential questions from the audience, such as: What would happen if no x-rays were ordered? What is the risk/benefit ratio of imaging? What are the costs of imaging and what are the costs of the consequences? Additionally, does the evidence suggest that routine imaging is a good practice? These questions compose the theoretical constructs of the *beliefs about*

consequences, one of the 12 domains recently identified to explain behaviour change [34]. While normally included in interviews of health care professionals to assist in explaining a behaviour and in designing a behaviour change intervention [34, 35], information covering these various topics during the pre-intervention may have had an important role to play. Attitude toward prescribing imaging studies and beliefs about consequences were shown to be significant components of behaviour change in previous studies [33, 36]. It is therefore possible that the pre-intervention platform presentation significantly influenced participants' attitudes toward self-reported ordering practice and beliefs about consequences, both apparent determinants of the intention to perform a simulated behaviour. Between group contamination may explain the lack of differences observed in our study. However, this post-hoc interpretation remains speculative as variables underlying behavioural theories were not measured in our study.

Using multiple interventions and focusing only on one or two recommendations at a time may be preferable. In a quasi-experimental method comparing outcomes before and after the educational intervention with those of a control community, a significant reduction in self-reported need for plain radiography for uncomplicated acute LBP and for patients with acute LBP of less than one month was seen in the intervention community compared to controls. [19]. The interventions in that study included the following strategies: focus group session, workshop meeting, handout material (key research papers), decision aid tool (check list for x-ray use), one on one meeting with researcher, and news release (educating public). Unfortunately the size of the audience, time constraints, long distance and budget constraints prevented several of the strategies found useful in the study by Ammendolia et al. [19] from being applied to the current study.

Chiropractic students undergo extensive training in the field of radiology in all accredited colleges. Recently, interns in their final year were shown to have the ability to detect and recognize the need to x-ray patients according to published

evidence-based guidelines [37]. While interns were not consistent in choosing the correct views, agreement with the gold standards for the question of whether or not they would take x-rays ranged from 63.2% to 100%. A high level of adherence to guidelines was also reported in a clinical cohort study for patients with a new episode of low back pain who presented to one of 6 out-patient teaching chiropractic clinics [24]. The proportion of patients without red flags who were not recommended for radiography ranged from 89.4% to 94.7%, suggesting a strong adherence to radiography evidence-based guidelines. Of interest, radiography was only recommended for 12.3% of patients, although the proportion of patients with red flags ranged from 45.3 to 70.5%. This low utilisation rate may be partly explained by the fact that many common red flags are nonpathologic, such as age over 50, decision regarding career or athletics, and pain worst lying and /or at night in bed. [23]. Current utilisation rates observed in community practice are estimated at approximately 25% in Switzerland [38] and 37% in Canada [27]. It is envisioned that adherence to imaging guidelines in professional practice will continue to improve in the upcoming years as new graduates enter practice and more effective educational intervention strategies are implemented.

Study limitations

This study has several limitations. The sample size was small and there were no measurements immediately or soon after the educational intervention, thereby limiting interpretation of the immediate effect of the intervention. Sample size estimates for a larger trial with a group receiving a reminder at mid-point suggest that the number of subjects needed for a 50% power level at a significance of 0.05 is 71 and 222 subjects for a power level of 90%. While some questions from the pre-test were included in both the post-test and final test, and some questions from the post-test and from the final test were included in each other, it was not possible to include questions from the two post-tests into the pre-test. This was partially compensated for however by the fact that version B and C of the questionnaires were crossed-over at the post-test and at the final test. In

addition, while levels of difficulty for all questions were assessed qualitatively by four independent experts, quantitative assessments were not done systematically, and a thorough study of the content and concurrent validity of the questionnaires was missing. A written clinical vignette does not replace patient-doctor interactions and can only measure intention to prescribe. Finally, technical difficulties encountered may have disenchanted some participants, partly explaining the lower level of participation at mid-point and possibly at end-point measurements. However, this does not seem to have significantly influenced test results.

Generalizability of the trial findings

In addition to the study limitations previously discussed (lack of internal consistency and absence of test-retest reliability of the questionnaires, small sample size, and unbalanced study groups.

It is now suggested that the choice of dissemination and implementation strategies be based on characteristics of the evidence or the guidelines themselves, the obstacles and incentives for change, and the likely costs and benefits of different strategies [14, 39, 40]. Interventions tailored to prospectively identify barriers may improve care and patient outcomes [41]. While barriers to the diagnostic imaging guidelines were partly addressed in a previous study [22], surveys were not based on psychological theories. Since the interaction of factors at multiple levels may influence the success or failure of quality-improvement interventions, an understanding of these factors, including the theoretical assumptions and hypotheses behind these factors is a recommended initial step, as it enables the consideration of theory-based interventions for quality improvement [42, 43].

Future studies should limit the number of behaviours that are targeted, aim to identify perceived barriers and facilitators to the utilisation of diagnostic imaging guidelines for management of adult musculoskeletal disorders according to a

theoretical approach, identify the best strategies to overcome these barriers, and apply tailored interventions to influence implementation of evidence-based practice [11, 12, 41, 44].

Conclusion

Results from this study suggest that online access to specific recommendations while making a clinical decision to prescribe diagnostic imaging studies for adult spinal disorders deserves further study., The findings in this study are in agreement with the current appreciation regarding didactic presentation ability to influence on behavior change. These findings should be interpreted with caution considered the small sample size.

Competing interests

The author(s) declare that they have no competing interests.

Authors' contributions

AEB conceived the study, developed the objectives, reviewed the literature, elaborated the case scenarios and designed the questionnaires, supervised the analysis, interpreted results and drafted the manuscript. LL helped conceive the study, performed the statistical analysis and helped to draft part of the manuscript. CP helped design the questionnaires, co-administered the intervention and helped to draft part of the manuscript. All authors read and approved the final manuscript.

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Table 1: Administration of the three competency tests for the diagnostic imaging guidelines implementation study.

120 Swiss practitioners randomized* to either IG or CG	**Pre-test** (prior to the educational workshop)	**Post-test** (at 6-8 weeks)	**Final test** (at 14-16 weeks)
IG (n=80)	**IG 1** A (27)	B (14) C (13)	C (14) B (13)
	IG 2 A (27)	Reminder + B (13) Reminder + C (14)	C (13) B (14)
	IG 3 A (26)	Nil	B (13) C (13)
CG (n=40)	A (40)	Nil	B (20) C (20)

* One group of 40 participants was excluded as they were not available for the pre-test. IG = intervention group and CG = control group, whereas A, B et C are the three equivalent versions of the competency test.

Table 2: A 2 X 2 contingency table outlining how the secondary measure of adherence to the imaging guidelines was calculated.

	Self reported radiography		
	Yes	No	Total
Red flags yes	a	b	a + b
Present based on guidelines no	c	d	c + d
Total	a + c	b + c	
Adherence = percentage of cases without red flags not recommended for radiography among all cases without red flags = d/c + d X 100%			

Table 3: Baseline clinical characteristics (number and percentage) of the study sample.

Characteristics	Intervention group (n=74)	Control group (n=29)	$\chi 2$ (*d.f.*)
	No. (%)	No. (%)	
1. Years in practice			
A) <1960-1980	8 (10.8)	6 (20.7)	
B) 1981-1990	23 (31.1)	6 (20.7)	
C) 1991-2000	26 (35.1)	9 (31)	2.538 *(3)*^{NS}
D) 2001-2007	17 (22.9)	8 (27.6)	
2. Post graduate degree			
A) Yes	13 (17.6)	4 (13.8)	0.137 *(1)*^{NS}
b) No	61 (82.4)	25 (86.2)	
3. Practice :			
A) Full Time	49 (66.2)	21 (72.4)	0.24 *(1)*^{NS}
B) Part Time	25 (33.8)	8 (27.6)	
4. Type of practice :			
A) Solo	27 (36.5)	18 (62.1)	5.03 *(1)*$^{0.05**}$
B) Group or multidisciplinary	47 (63.5)	11 (37.0)	
5. On site access to radiography			
A) Yes	61 (82.4)	17 (58.6)	5.80 *(1)*$^{0.05**}$
b) No	13 (17.6)	12 (41.4)	
6. Average number of spine x-ray series ordered per week:			
A) Less then 5	42 (56.8)	21 (72.4)	1.83 *(1)*^{NS}
B) Over 5	32 (43.2)	8 (27.6)	
7. Average number of referrals for special imaging of the spine per month:			
A) Less then 5	58 (78.4)	25 (86.2)	0.59 *(1)*^{NS}
B) Over 5	16 (21.6)	4 (13.8)	

** Significant difference at 5%
$\chi 2$ = *Chi square; d.f.* = degrees of freedom

Table 4: Comparison of practice characteristics of respondents and nonrespondents to both pre-test and post-test.

Characteristics	Intervention subgroup IG1		Intervention subgroup IG2	
	Respondents (n=17)	Non respondents (n=9)	Respondents (n=14)	Non respondents (n=9)
	No. (%)	No. (%)	No. (%)	No. (%)
1. Graduate after 1991	12 (70.6)	5 (55.5%)	7 (50)	4 (44.4)
2.Post graduate degree	1 (5.88)	2 (22.2)	2 (11.7)	3 (33.3)
3. Full time practice	12 (70.6)	8 (88.8)	7 (50)	6 (66.7)
4. Solo practice	7 (41.2)	4 (44.4)	4 (28.6)	3 (33.3)
5. On site access to radiography	13 (76.5)	7 (77.7)	12 (85.7)	8 (88.9)
6. Between 5 and 14 spine x-ray series ordered per week	16 (94.1)	9 (100)	9 (64.3)	5 (55.6)
7. Less then 5 referrals for special imaging of the spine per month	15 (88.2)	6 (66.7)	12 (85.7)	6 (66.7)

IG = intervention groups (IG1 = subgroup unexposed to reminder but undergoing a post test at mid-point; IG2 = subgroup exposed to reminder and a post-test at mid-point)

Table 5: Comparison of practice characteristics of respondents and nonrespondents to both Pre-test and Final test.

Characteristics	Intervention		Control	
	Respondents (n= 53)	Non respondents (n= 21)	Respondents (n= 24)	Non respondents (n= 5)
	No. (%)	No. (%)	No. (%)	No. (%)
1. Graduate after 1991	32 (60.4)	10 (47.6)	15 (62.5)	2 (40,0)
2. Post graduate degree	8 (15)	5 (23.8)	4 (16.6)	0 (0,0)
3. Full time practice	34 (64.1)	15 (71.4)	18 (75)	3 (60,0)
4. Solo practice	18 (34)	9 (42.8)	14 (58.3)	4 (80,0)
5. On site access to radiography	43 (81.1)	18 (85.7)	14 (58.3)	3 (60,0)
6. Between 5 and 14 spine x-ray series ordered per week	23 (43.3)	9 (42.8)	5 (20.8)	2 (40,0)
7. Less then 5 referrals for special imaging of the spine per month	40 (75.5)	16 (76.2)	21 (87.5)	4 (80,0)

IG = intervention groups CG = control group

Table 6: Summary results (total average scores and standard deviations) for each study group for the three measurements (Pre-test, Post-test, and Final test)

Group	Pre-test		Post-test		Final test	
	(n)	Total average (SD)	(n)	Total average (SD)	(n)	Total average (SD)
IG1	26	5.35 (1.52)	17	4.82 (1.55)	21	4.86 (1.53)
IG2	21	4.70 (0.93)	14	5.57 (1.02)	14	5.43 (1.60)
IG3	23	4.84 (1.40)			17	4.65 (1.37)
CG	29	4.45 (1.15)			24	4.79 (1.38)

IG = intervention groups (IG1 = subgroup unexposed to reminder but undergoing a post test at mid-point; IG2 = subgroup exposed to reminder and a post-test at mid-point; IG3 subgroup unexposed to reminder and receiving no post-test); CG = control group, n = number of participants completing the competency tests; SD = standard deviation.

Table 7: Means scores obtained in the pre-test and post-test (8-10 weeks) for two groups of practitioners exposed to an educational intervention (IG1 and IG2), where only one group (IG2) had a reminder at mid-point: Results from ANOVA (AxBr) among respondents attending the September 2007 continuing education conference.

Groups*	Pre-test Mean (SD)	Post-test Mean (SD)	Change Mean (SD)	95% CI	*P* Value
IG1 (n=17) Percent change	5.412 (1.33)	4.765 (1.52)	0.647 (2.06) -11.9%	-0.33 to 1.63	<0,05 F = 4.486
IG2 (n=14) Percent change	4.786 (0.89)	5.571 (1.02)	0.785 (1.53) +16.4%	-0.92 to 1.59	

* Includes respondents who completed both pre-test and post-test.
IG = intervention groups: IG1 = subgroup unexposed to reminder but undergoing a post-test at 8-10 weeks, and IG2 = subgroup exposed to reminder at mid-point and to a post-test at 8-10 weeks; n = participants completing the competency tests; SD = standard deviation.

Table 8: Mean scores obtained in the pre-test and the final test (14-16 weeks) for four groups of practitioners: three exposed to a radiology workshop (IG1, IG2, and IG3), and a control group (CG) allocated to a workshop on an unrelated topic: Results from ANOVA (AxBr) among respondents attending the September 2007 continuing education conference.

Groups*	Pre-test Mean (SD)	Final test Mean (SD)	Change Mean (SD)	95% CI	*P* Value
IG 1 (n=20) Percent change	5.200 (1.28)	4.900 (1.55)	0.300 (1.45) -5.8%	-0.34 to 0.94	> 0.05 F = 1.117
IG 2 (n=14) Percent change	4.857 (0.95)	5.500 (1.56)	0.643 (1.55) +13.2%	-0.17 to 1.45	
IG 3 (n=17) Percent change	4.588 (1.46)	4.647 (1.37)	0.059 (1.71) +1.3%	-0.75 to 0.87	
CG (n=24) Percent change	4.542 (1.07)	4.791 (1.38)	0.25 (0.89) 5.48%	-0.11 to 0.61	

* Includes respondents who completed both pre-test and final test.
IG = intervention groups (IG1 = subgroup unexposed to reminder but undergoing a post test at mid-point; IG2 = subgroup exposed to reminder and undergoing a post-test at mid-point; IG3 subgroup unexposed to reminder and receiving no post-test); CG = control group; n = participants completing the competency tests; SD = standard deviation.

Table 9: Summary of clinicians' responses at the pre-test compared with the gold standard

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Experimental (n=74)										
YES	6	40	16	62	64	40	38	72	6	33
NO	68	34	58	12	10	34	36	2	68	41
Gold standard	No	No	Rx	CT/MRI	No	US	MRI	MRI	Rx	Rx + add
% agreement	91.9	45.9	21.6	83.8	13.5	54	51.4	97.3	8.1	44.6
Control (n=29)										
YES	4	18	6	19	27	14	13	29	7	17
NO	25	11	23	10	2	15	16	0	22	12
Gold standard	No	No	Rx	CT/MRI	No	US	MRI	MRI	Rx	Rx + add
% agreement	86.2	37.9	20.7	65.5	6.9	48.3	44.8	100	24	58.6

Rx = Plain films; Rx + add = Plain films conventional views and additional views; CT = Computed Tomography scans; MRI = Magnetic resonance scans; US = Diagnostic ultrasound.

Table 10: Summary of clinicians' responses at the final test compared with the gold standard

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Experimental										
Version B (n=26)										
YES	24	24	17	3	12	19	16	11	22	6
NO	2	2	9	23	14	7	13	15	4	20
Gold standard	MRI	Ref	No	Rx	Bone S	Rx + add	US	Rx	No	No
% agreement	92.3	92.3	34.6	11.5	46.2	73.1	61.5	42.3	15.4	76.9
Version C (n=25)										
YES	18	11	11	21	7	21	20	11	20	11
NO	8	15	24	5	19	4	5	14	6	22
Gold standard	No	Rx	MRI	No	DEXA	Rx	Ref	MRI	No	Rx
% agreement	30.8	42.3	45.8	19.2	26.9	84	80.	44	23	42.1
Control										
Version B (n=11)										
YES	11	10	8	2	2	6	6	1	10	4
NO	0	1	3	9	9	4	5	10	1	7
Gold standard	MRI	Ref	No	Rx	Bone S	Rx + add	US	Rx	No	No
% agreement	100	90.9	27.3	15.4	18.2	54.5	54.5	9.1	9.1	63.6
Version C (n=13)										
YES	12	7	9	11	6	13	10	9	13	8
NO	1	6	4	2	7	0	3	4	0	5
Gold standard	No	Rx	MRI	No	DEXA	Rx	Ref	MRI	No	Rx
% agreement	7.7	53.8	69.2	15.4	46.2	100	76.9	69.2	0	61.5

Rx = Plain films; Rx + add = Plain films conventional views and additional views; CT = Computed Tomography scans; MRI = Magnetic resonance scans; US = Diagnostic ultrasound; Bone S = Bone scans; DEXA = Dual energy X-ray absorptiometry; Ref = urgent medical referral.

Figure 1. Flow of participants through each stage

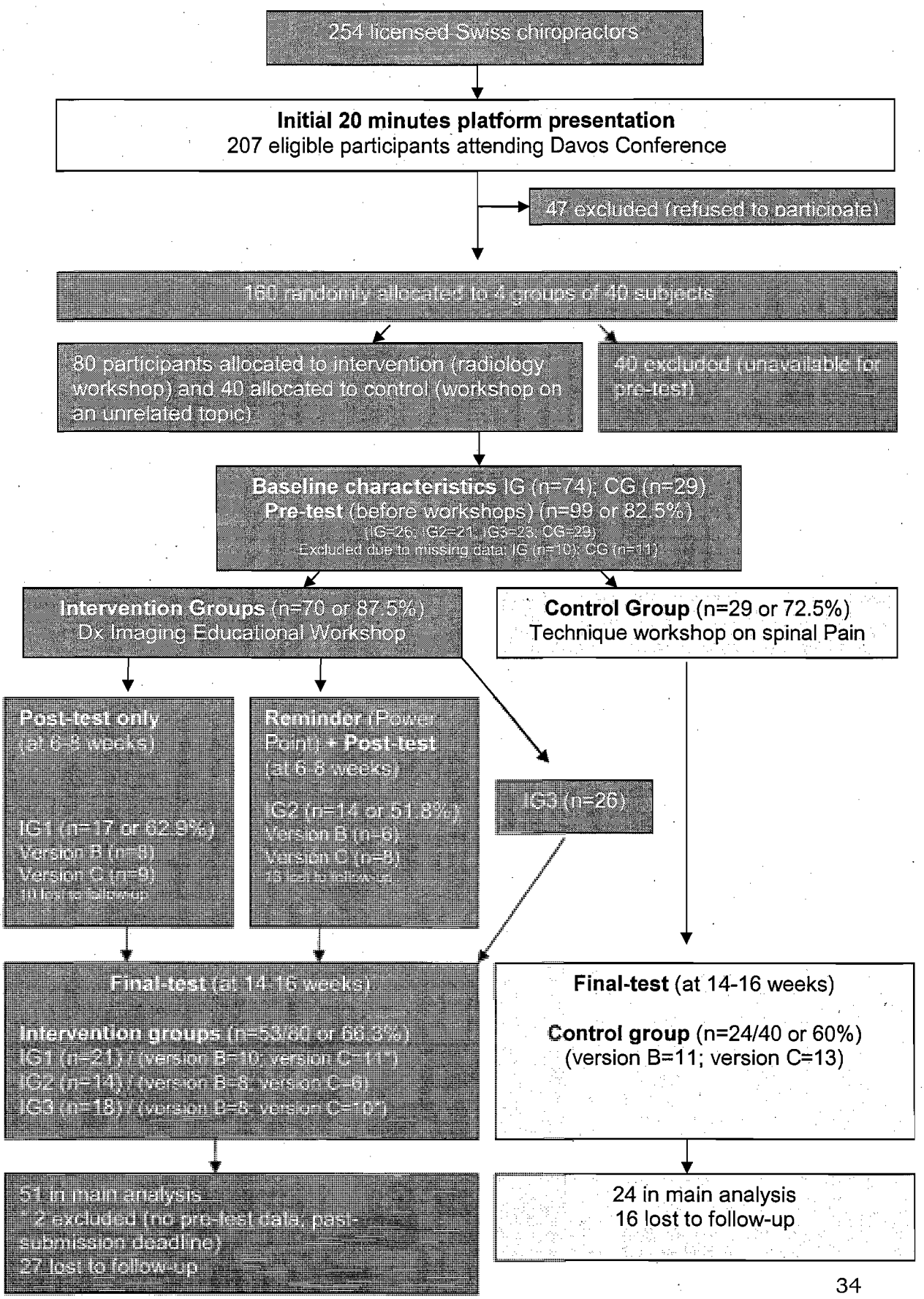
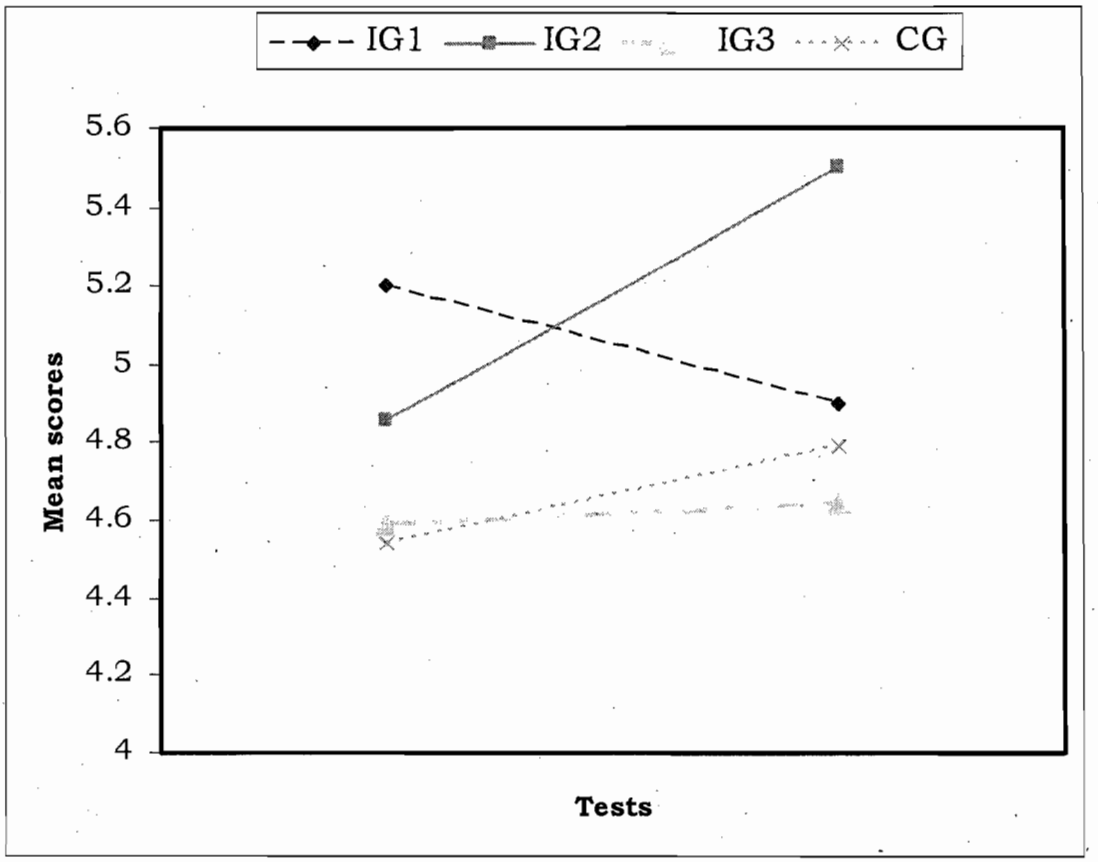


Figure 2 Scores obtained in the Pre-test (1) and in the Final test (2) for all three Intervention groups (subgroups IG1, IG2, IG3) and the control group (CG).



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