

Rapport de recension des écrits sur les usages des jeux sérieux et de la simulation dans le domaine de la santé

Travail effectué dans le cadre du projet
Amélioration d'un cours inclusif en simulation pour une clientèle internationale

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Le travail de recherche

Le mandat

L'auxiliaire de recherche a été sollicité pour effectuer une recension des écrits assez récente sur le domaine de la simulation à réalité virtuelle (environnements virtuels ou réalité augmentée) et sur les jeux sérieux (*serious games*, principalement utilisés actuellement pour la formation des patients) dans le domaine de la santé et ce, pour deux raisons. D'abord, pour intégrer un module sur les jeux sérieux dans un microprogramme de deuxième cycle en simulation qui est actuellement en développement. Ensuite, pour enrichir la réflexion de la Chaire de leadership en enseignement (CLE) par simulation des sciences de la santé dont une des missions est de développer la simulation à réalité virtuelle.

Il ne s'agit pas de produire un rapport exhaustif, mais de faire les recherches et de synthétiser brièvement les trouvailles faites. Le responsable du projet escompte la présentation d'un rapport avec un tableau synthèse des résultats d'une recherche documentaire guidée par quatre questions portant essentiellement sur l'efficacité :

1. Quelle est l'efficacité des jeux sérieux pour l'enseignement des patients?
2. Quels usages ont été faits de la simulation à réalité virtuelle ou à réalité augmentée auprès des patients?
3. Quelle est l'efficacité des jeux sérieux pour l'apprentissage dans le domaine de la santé?
4. Quelle est l'efficacité de la simulation à réalité virtuelle ou à réalité augmentée pour l'apprentissage dans le domaine de la santé?

Le responsable du projet escompte aussi que le rapport note les nouvelles questions qui pourraient surgir lors de la revue de la littérature, par exemple : autres usages des jeux sérieux en santé, facteurs contribuant à l'efficacité, etc., mais ne les aborde pas spécifiquement. Ceci serait l'objet d'un futur travail de la CLE.

D'emblée, un nombre important d'études n'était pas attendu. Une année spécifique de début pour effectuer la recherche n'a pas été fixée. Puisque le domaine remonte à moins de dix ans, un nombre élevé d'études datant d'avant 2010 ne s'était pas escompté.

Afin de définir les sujets concernés par la recherche documentaire, l'auxiliaire de recherche a interrogé le responsable du projet à propos du type d'études à inclure. Spécifiquement, une clarification a été demandée sur l'inclusion d'articles portant sur des interventions faites auprès des patients, comme des traitements, des thérapies, etc. Le responsable du projet a répondu être d'accord pour inclure les documents sur l'ETP (éducation thérapeutique des patients), mais aussi les articles de revues, s'ils existaient, sur les autres sujets (traitements, etc.)

Le contrat d'embauche a octroyé un maximum de 80 heures pour réaliser ce mandat.

La recherche documentaire

- Textes écrits ou édités à partir de 2010.
- Textes rapportant l'efficacité des jeux sérieux pour l'Éducation Thérapeutique des Patients (ETP).
- Textes décrivant les usages de la simulation à réalité virtuelle ou à réalité augmentée auprès des patients.
- Textes rapportant l'efficacité des jeux sérieux pour la formation des professionnels ou des futurs professionnels du domaine de la santé.
- Textes rapportant l'efficacité de la simulation à réalité virtuelle ou à réalité augmentée pour la formation des professionnels ou des futurs professionnels du domaine de la santé.

Les principaux mots clés

Augmented Reality – Digital games – Health Promotion – Healthcare – Medical Education – Medical Training – Patient – Patient Education – Patient Training – Serious Games – Serious Games for Health – Simulation – Virtual Environments – Virtual Reality

Les critères d'exclusion

Les textes relatifs aux sujets suivants ont été exclus :

- Ludification de formations (*Gamification*) et d'applications informatiques (*Gamified Systems*).
- Applications sur des dispositifs mobiles pour le monitoring (Apps for monitoring).
- Plateformes technologiques à des fins médicales, de formation ou de *coaching*.
- Les nombreuses études portant sur l'usage de jeux sérieux et de simulation pour la réhabilitation physique et la physiothérapie qui mériteraient une revue exclusive.
- Usage de jeux sérieux et de simulation en biomécanique, psychologie, nutrition, pharmacie, médecine vétérinaire.
- Effets des *exergames* sur la performance physique.
- Usage des médias sociaux (Social Media) pour l'ETP.
- Description du développement d'instruments d'évaluation de la qualité ou du contenu des jeux sérieux pour la santé.
- Usage d'autre types d'applications technologiques, différentes aux jeux sérieux et à la simulation, comme les e-books interactifs, les posters numériques, *Entertainment Media*, les applications de *mHealth*, l'impression 3D, etc.
- Les articles de commentaires, les entrevues, les conversations, les éditoriaux, les articles d'opinion, les notes biographiques, les articles conceptuels.
- Les études portant sur des aspects psychosociaux.

- Les études décrivant le processus de design des jeux ou des logiciels de simulation ou ceux traitant des aspects technologiques ou de développement.

La procédure

1. Recherche exploratoire sur Google Scholar.
2. Recherche dans de bases de données généralistes :
 - Taylor and Francis online.
 - Wiley Online Library.
 - Science Direct.
3. Recherche dans des bases de données dont la spécialité est la médecine :
 - Medline à partir de EBSCO.
 - Embase.
 - Cochrane Library.

Exemples d'expressions de recherche

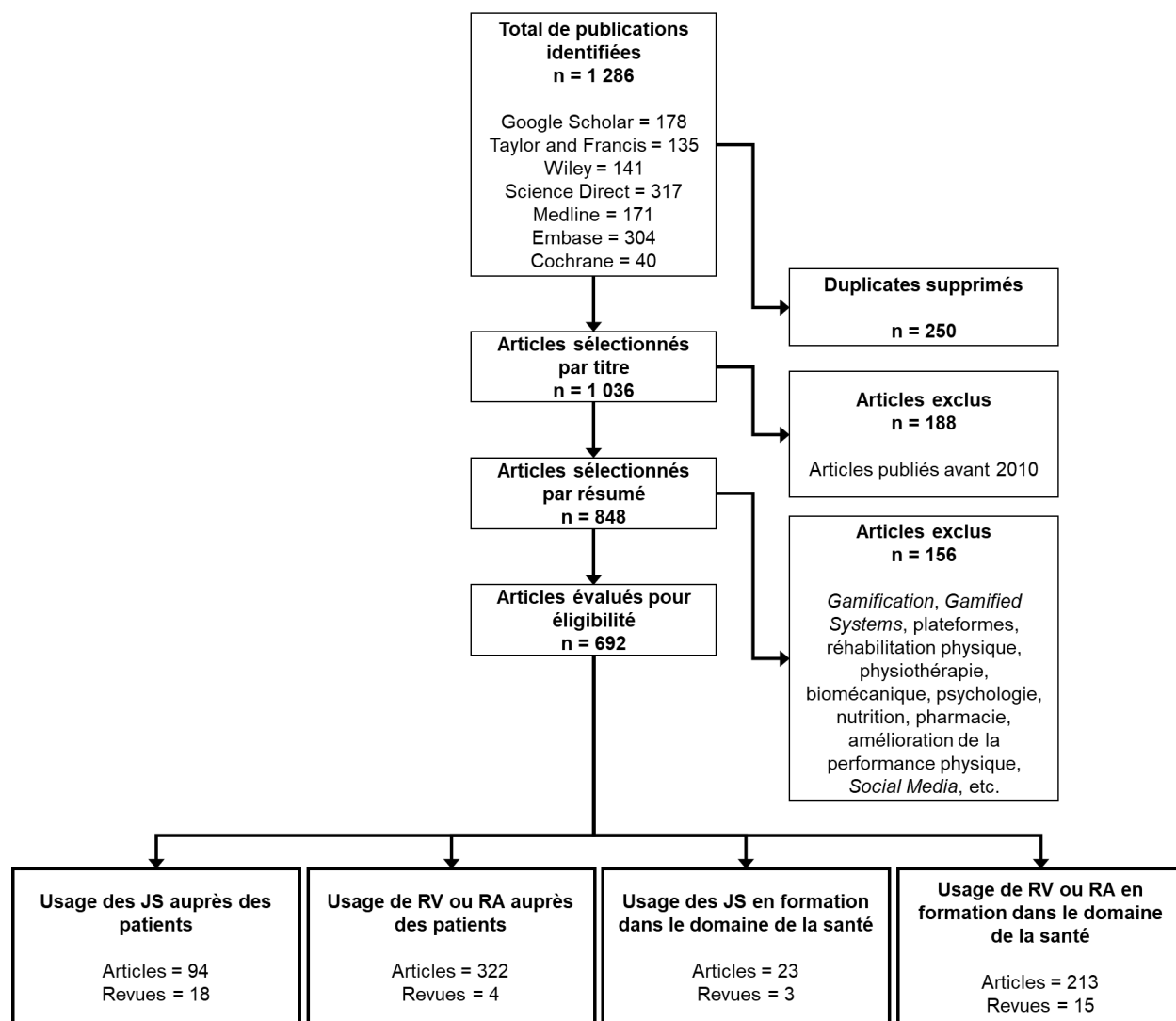
Sur MedLine :

1. SU **serious games** AND AB (**patient education** OR **patient training**)
2. SU (**virtual reality** OR **augmented reality**) AND TI **patients**
3. SU **serious games** AND AB (**medical education** OR **medical training**)
4. SU (**virtual reality** OR **augmented reality**) AND TI (**medical education** OR **medical training**)

Sur Embase :

1. '**serious games**':ti,ab,kw AND ('**patient education**':ti,ab,kw OR '**patient training**':ti,ab,kw)
2. '**virtual reality**':ti AND '**patients**':ti
3. '**augmented reality**':ti AND '**patients**':ti
4. '**serious games**':ti,ab,kw AND ('**medical education**':ti,ab,kw OR '**medical training**':ti,ab,kw)
5. '**virtual reality**':ti,ab,kw AND ('**medical education**':ti,ab,kw OR '**medical training**':ti,ab,kw)
6. '**augmented reality**':ti,ab,kw AND ('**medical education**':ti,ab,kw OR '**medical training**':ti,ab,kw)

Organigramme du processus de sélection des publications



Résultats

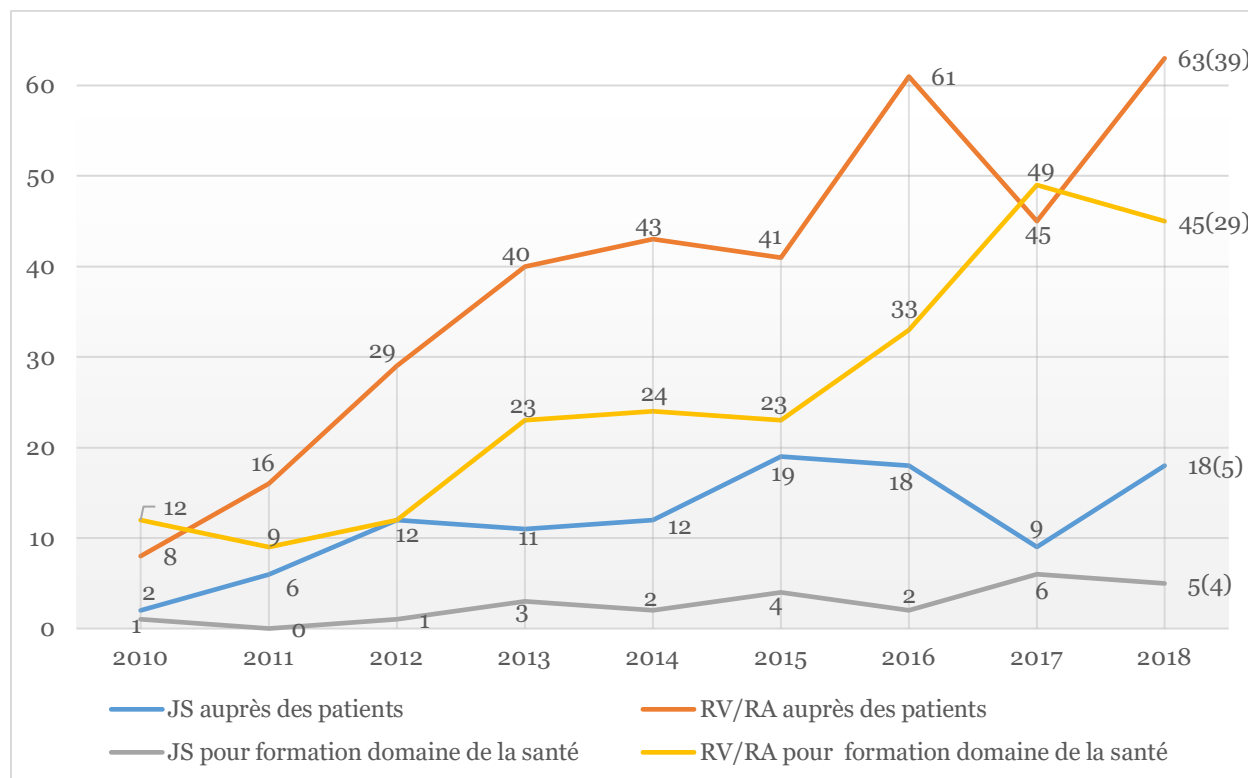


Figure 1. Nombre de publications par année dans chaque catégorie. Les revues de littérature ne sont pas incluses dans le graphique. Puisque l'année 2018 est en cours, les chiffres correspondants ont été estimés par régression linéaire simple. Le nombre de publications en 2018 recensées dans ce document est en parenthèses.

Études sur l'usage des jeux sérieux auprès des patients

18 revues de littérature ont été repérées ([voir la liste de références](#)).

94 études sur l'usage des jeux sérieux auprès des patients ont été recensées ([voir la liste de références](#)). Voici la classification des études selon le sujet/maladie traité :

- 2 Alzheimer ([voir la liste d'études](#))

Synthèse des résultats : Les jeux doivent garder une trace des capacités cognitives du patient, déterminer un nombre approprié d'étapes pour le défi, garder le joueur dans sa « zone de flux », favoriser les interactions naturalistes, tirer parti de l'aspect multimodal (pour entraîner les modalités sensorielles et motrices), prendre en compte les dégradations des utilisateurs, prendre en compte le contexte social et culturel de l'utilisateur.

- 2 Lésions cérébrales ([voir la liste d'études](#))

Synthèse des résultats : Amélioration des membres supérieurs et inférieurs, de l'amplitude des mouvements, de la fonction motrice, de la dextérité manuelle, de l'équilibre, de la mobilité corporelle, de la vitesse de déplacement, des activités

quotidiennes, de la motivation thérapeutique et de la dépense énergétique. Les jeux peuvent être utilisés indépendamment de la supervision des thérapeutes.

- 7 Brûlures ([voir la liste d'études](#))
Avantages potentiels: Amélioration de la fonction globale. Récupération des déficits moteurs. Distraction De La Douleur. Motivation croissante. Désavantages potentiels: Diminution de l'intérêt pour d'autres interventions. Espace et sécurité. Fatigue et vexation.
- 8 Cancer ([voir la liste d'études](#))
Synthèse des résultats : Augmentation de l'interaction du patient avec le traitement et de l'intercommunication entre les patients, augmentation de la confiance dans la prise de décision. Les jeux favorisent la distraction de la routine de traitement.
- 8 Paralyse cérébrale ([voir la liste d'études](#))
Synthèse des résultats : Amélioration de l'équilibre, de la marche, de l'agilité, de la vitesse en course, de la force, de la rétention de la force motrice, de la santé osseuse, de la performance fonctionnelle des membres supérieurs et de la motivation à suivre les thérapies. Les patients deviennent moins dépendants.
- 2 Dyspraxie ([voir la liste d'études](#))
Synthèse des résultats : Une intervention basée sur un jeu vidéo actif n'améliore pas les capacités motrices chez les enfants présentant un trouble de la coordination du développement. La perception des patients quant à leurs capacités physiques améliore après une utilisation d'un jeu vidéo actif. L'accès aux jeux vidéo actifs n'est pas suffisant pour améliorer les capacités motrices chez les enfants atteints d'un trouble de la coordination du développement. Des recherches supplémentaires sont nécessaires pour explorer les avantages potentiels des jeux vidéo actifs pour la participation à l'activité physique.
- 11 Diabète ([voir la liste d'études](#))
Synthèse des résultats : Apprentissage sur la nutrition, le comportement inadéquat et la prévention des maladies, y compris le diabète, surveillance du taux de sucre sanguin, soins médicaux à distance, promotion du comportement autosuffisant, amélioration de l'équilibre, diminution du temps de repos, augmentation de la vitesse, de la cadence et de l'efficacité pour éviter les chutes.
- 2 Gériatrie ([voir la liste d'études](#))
Synthèse des résultats : Amélioration des fonctions cognitives, de l'équilibre, de la posture, des réflexes, de la marche, de la force musculaire, de la prévention des chutes, des activités à double tâche, de la vitesse de traitement d'information, de la motivation à l'exercice et de la détection de problèmes cognitifs.

- 2 Arrêt cardiaque ([voir la liste d'études](#))
Synthèse des résultats : Des recherches sont nécessaires afin de disposer de preuves sur les effets à long terme des interventions abordables et disponibles, qui sont à la fois « conviviales pour le patient » et faciles à mettre en œuvre. Si l'utilisation d'un jeu commercialement accessible et disponible augmente efficacement la capacité d'exercice chez les patients souffrant d'insuffisance cardiaque, cela pourrait être une recommandation à donner aux patients, en plus des autres recommandations actuelles.
- 3 Patients neurologiques ([voir la liste d'études](#))
Synthèse des résultats : En conjonction avec des traitements courants, les jeux sérieux sont très efficaces. Les jeux faciles pour le grand public peuvent être utilisés dans divers domaines neurologique, mais des recherches supplémentaires sont nécessaires sur le sujet.
- 6 Obésité ([voir la liste d'études](#))
Synthèse des résultats : Adhésion à des activités physiques, changements comportementaux positifs, motivation lors d'exercices compétitifs, augmentation des dépenses caloriques, éducation nutritionnelle, consommation de fruits et légumes, changements positifs des mesures et de la composition corporelles, réduction des comportements sédentaires.
- 6 Parkinson ([voir la liste d'études](#))
Synthèse des résultats : Amélioration de l'adhérence à l'activité physique, de la coordination motrice, de l'équilibre statique et dynamique, de la force, des aptitudes fonctionnelles, de la cognition, de la santé physique. Les jeux permettent une surveillance à distance fournissant une assistance rapide.
- 14 Psychiatrie ([voir la liste d'études](#))
Synthèse des résultats : La thérapie assistée par des jeux vidéo ne peuvent remplacer les soins habituels, mais peuvent être utilisés comme thérapie d'appoint. Cependant, recommander leur utilisation semble prématuré en raison du caractère récent et préliminaire de la plupart des études. De plus, un lien fait encore défaut entre ce domaine de recherche en psychiatrie et d'autres domaines de recherche, en particulier les études sur les jeux. Enfin, il pourrait être intéressant d'analyser plus précisément l'impact neuropsychologique des jeux commerciaux existants qui pourraient être utiles pour la réadaptation psychosociale.
- 7 Accident vasculaire cérébral ([voir la liste d'études](#))

Synthèse des résultats : L'utilisation de jeux sérieux est une approche thérapeutique efficace pour améliorer la fonction motrice pendant la réadaptation après un AVC.

Une intervention basée sur les jeux vidéo utilisant Leap Motion Controller est un outil de rééducation utilisable pour entraîner la dextérité au début de la phase de réhabilitation des patients ayant subi un AVC.

- 14 Interventions non classées ([voir la liste d'études](#))

Domaines médicaux : Sclérose multiple, hémorragie post-partum, contrôle prothétique myoélectrique, dysphonie, maladies tropicales, arthrite rhumatoïde, arthrose de la main, syndrome de Down, fonctions exécutives chez les alcooliques, fonction vasculaire, paludisme, warfarine et vitamine K, prévention du virus de l'immunodéficience humaine, rééducation physique dans l'unité de soins intensifs.

L'efficacité des jeux pour changer les comportements en matière de santé et améliorer les connaissances suggère que les forces de ces outils devraient être sérieusement prises en compte lors de la conception d'interventions dans les soins de santé. Les résultats suggèrent également que les jeux et le divertissement peuvent être des bases efficaces pour des interventions sérieuses dans les soins de santé. Les jeux peuvent avoir une implication clinique indirecte car ils peuvent promouvoir la qualité des soins en améliorant les compétences chirurgicales des médecins et leurs compétences cliniques en matière de soins aux patients. Ils ont des implications cliniques directes car les jeux vidéo peuvent aider à améliorer la participation des patients à des tâches diagnostiques importantes, améliorer les connaissances des patients sur leur maladie et accroître l'adhésion des patients à des traitements aversifs, mais qui sauvent des vies.

Critères de recrutement

Les critères d'inclusion ou d'exclusion les plus courants pour le recrutement étaient l'état médical antérieur, les données démographiques et les indices de santé actuels (taille et poids). Le type d'affiliation avec certains centres de soins de santé et l'expérience antérieure en matière de technologie de jeu, y compris le fait d'avoir certaines consoles de jeu ont été moins mentionnés comme critères d'inclusion dans les études. Certaines publications n'avaient pas de critères explicites d'inclusion ou d'exclusion pour le recrutement, tandis que d'autres études avaient un processus de randomisation pour le recrutement. Très peu d'articles ont indiqué le statut socioéconomique des participants.

Méthodologies des études

Des nombreuses études utilisent un modèle de traitement contrôlé. D'autres études ont mené un groupe de discussion. Autres méthodologies utilisées :

- L'étude de cas
- Pré-Post
- Études pilote non expliquée
- Études quasi expérimentales

La majorité des études ont été menées en laboratoire, au contraire d'une minorité qui ont été faites sur le terrain.

Types de jeux

- **Jeux éducatifs** : jeux informant les utilisateurs sur une maladie.
- **Jeux comportementaux** : jeux visant l'amélioration de l'observance des médicaments.
- **Jeux cognitifs** : jeux d'entraînement à la mémoire.
- **Jeux d'exercice** : jeux visant l'amélioration de l'exercice physique.
- **Jeux de rééducation** : par exemple, jeux renforçant la rééducation d'un membre supérieur
- **Jeux hybrides** : jeux dont les caractéristiques correspondent à plusieurs des catégories précédentes.

Principales théories invoquées

- Théorie cognitive sociale.
- Théorie du comportement planifié.

Recherche future

- Des recherches suggèrent que l'exploration de nouveaux mécanismes de financement, la création de communautés de chercheurs, le développement de bases théoriques pour les jeux de santé permettront aux jeux sérieux en santé de devenir un domaine de recherche durable à long terme.
- Il est recommandé de mener davantage d'études de recherche qui établissent clairement un lien de causalité entre les jeux vidéo pour la santé, les soins de santé et les résultats. Cela peut être fait si les chercheurs effectuent des essais contrôlés randomisés sur ces jeux.
- On recommande d'inclure des tailles d'échantillon suffisamment puissantes pour détecter les différences entre les groupes de traitement et de contrôle. Cela est souvent difficile lorsque les populations réelles de participants potentiels sont faibles, comme pour certains groupes de maladies ou pour certaines spécialités médicales. C'est aussi difficile parce que développer des jeux vidéo peut être une entreprise coûteuse.
- De recherches portant sur des résultats objectifs et pertinents sur le plan clinique sont suggérées. Les évaluations des perceptions doivent être associées à des

données objectives, telles que le temps passé à jouer. De même, les mesures de la compétence chirurgicale doivent être démontrées non seulement sur des simulations, mais aussi avec de vrais patients, dans la mesure du possible.

Études sur l'usage de la réalité virtuelle auprès des patients

4 revues de littérature ont été repérées ([voir la liste de références](#)).

310 études sur l'usage de la réalité virtuelle auprès des patients ont été recensées ([voir la liste de références](#)). Voici la classification des études selon le sujet/maladie traité :

- 2 Alzheimer ([voir la liste d'études](#))
Synthèse des résultats : White and Moussavi (2016) montrent qu'un patient atteint de la maladie d'Alzheimer peut apprendre à naviguer parfaitement vers les cibles souhaitées dans un environnement de RV au cours d'un programme de formation. Les commentaires subjectifs du proche aidant ont indiqué que son aptitude à naviguer en conduisant s'est nettement améliorée et qu'il a bénéficié d'une amélioration cognitive dans sa vie quotidienne à la maison. Ces résultats suggèrent que les traitements en RV pourraient bénéficier à d'autres personnes atteintes de la MA.
Foloppe et al. (2018) montrent qu'un patient atteint de la maladie d'Alzheimer pourrait réapprendre certaines activités de cuisine en utilisant des techniques de réalité virtuelle. Le transfert à la vie réelle a également été observé.
L'amélioration des performances de la tâche est restée stable dans le temps.
- 4 Trouble d'équilibre ([voir la liste d'études](#))
Synthèse des résultats : La simulation par RV est une intervention efficace pour les patients avec un trouble d'équilibre. Aucun effet de transfert de l'intervention sur les habiletés liées à l'équilibre n'a été constaté. L'approche orientée vers les tâches combinée à un mode d'apprentissage implicite semblerait être une solution efficace.
L'exposition à des environnements VR dynamiques devrait être considérée comme un complément utile aux programmes de rééducation vestibulaire pour les patients présentant des troubles vestibulaires périphériques et des symptômes de vertigo visuel.
- 20 Lésions cérébrales ([voir la liste d'études](#))
Synthèse des résultats : Les patients présentant une lésion cérébrale traumatique montrent à la fois une performance réduite et un taux d'apprentissage plus lent dans des jeux de réalité virtuelle par rapport aux individus en bonne santé. De nombreuses corrélations entre la performance globale et plusieurs des domaines de la capacité cognitive ont été révélées, le meilleur prédicteur étant la capacité cognitive globale.

- 11 Brûlures ([voir la liste d'études](#))
Synthèse des résultats : La réalité virtuelle réduit considérablement la douleur et ses conséquences, comme l'anxiété. Les résultats des études soulignent la nécessité de normaliser la définition de la RV. Il est nécessaire de souligner l'importance de la rigueur méthodologique dans les études cliniques pour améliorer les preuves de l'utilisation de la RV.
- 7 Cancer ([voir la liste d'études](#))
Domaines de traitement : Patients atteints de cancer du sein subissant une radiothérapie. Réduction de l'anxiété et augmentation de la compréhension chez les patients recevant une radiothérapie. Fatigue subissant un traitement adjuvant chez des patients atteints d'un cancer du poumon après thoracotomie. Biopsie du ganglion sentinelle par laparoscopie chez des patients atteints d'un cancer de la prostate. Interventions psychologiques pour les patients atteints d'un cancer avancé en milieu hospitalier. Perception du temps chez les patients recevant une chimiothérapie.
- 9 Paralyse cérébrale ([voir la liste d'études](#))
Synthèse des résultats : La réadaptation par réalité virtuelle est une intervention prometteuse pour améliorer l'équilibre et la motricité chez les patients atteints de paralysie cérébrale. La technique est en croissance et un suivi à long terme et des recherches plus approfondies sont nécessaires pour déterminer sa place exacte dans la prise en charge de la paralysie cérébrale.
- 3 Épilepsie ([voir la liste d'études](#))
Domaines de traitement : Mémoire réelle et navigation spatiale. Apprentissage des capacités cognitives de la vie quotidienne. Troubles de la navigation spatiale chez les patients atteints d'épilepsie du lobe temporal réfractaire.
- 2 Fibromyalgie ([voir la liste d'études](#))
Domaines de traitement : Stimulation transcrânienne par courant continu. Caractéristiques perçues de la douleur.
- 2 Fibrose kystique ([voir la liste d'études](#))
Synthèse des résultats : Holmes et al. (2013) montrent que la simulation par RV représente un exercice à haute intensité chez les adultes atteints de fibrose kystique et peut constituer une alternative appropriée aux modalités d'exercice conventionnelles.
Christenson et al. (2012) montrent que la simulation par RV contribuerait à modifier les attitudes des patients atteints de fibrose kystique à l'égard de l'adhésion au traitement.

- 1 Arrêt cardiaque ([voir la liste d'études](#))
Synthèse des résultats : La RV peut encourager les activités physiques. Les études montrent une augmentation de l'activité physique chez les participants en bonne santé, les participants obèses, les personnes âgées handicapées et les patients ayant un AVC ou des maladies cardiaques. Les applications de réalité virtuelle ont également amélioré la motivation, l'exercice de l'auto-efficacité, l'humeur positive et la réduction de la dépression. Aucun effet indésirable ou accident n'a été signalé dans les études et les applications ont été jugées sûres et réalisables. Les applications de réalité virtuelle sont utilisées avec succès chez les personnes âgées et chez les patients ayant subi un AVC ou une maladie cardiaque. Les applications de réalité virtuelle destinées à accroître l'activité physique peuvent constituer un outil potentiellement utile pour les patients souffrant d'insuffisance cardiaque.
- 13 Patients neurologiques ([voir la liste d'études](#))
Synthèse des résultats : L'insertion de la technologie de réalité virtuelle dans la thérapie de réadaptation traditionnelle pour les patients atteints de troubles neurologiques a produit des résultats positifs. L'avancement continu de la technologie annonce des résultats plus prometteurs dans ce secteur. Une évaluation plus poussée de ces méthodes de réadaptation en réalité virtuelle est suggérée pour mesurer l'efficacité et leur impact sur la procédure thérapeutique.
- 4 Ophtalmologie ([voir la liste d'études](#))
Synthèse des résultats : La RV peut fournir un nouveau paradigme pour quantifier et surveiller les performances et les déficiences visuelles, permettant aux cliniciens de mieux comprendre, du point de vue des patients, comment la déficience visuelle affecte les activités de la vie quotidienne.
- 23 Traitement de la douleur ([voir la liste d'études](#))
Synthèse des résultats : La distraction de la RV pour la réduction de la douleur s'est avérée efficace pour réduire la douleur expérimentale, ainsi que l'inconfort associé aux soins des brûlures. Les études sur la douleur liée aux aiguilles ont fourni des résultats moins cohérents. L'utilisation d'une technologie de réalité virtuelle plus sophistiquée capable d'immerger complètement l'utilisateur dans un environnement virtuel était associée à un plus grand soulagement.
- 30 Parkinson ([voir la liste d'études](#))
Synthèse des résultats : Bien que la maladie de Parkinson (MP) soit une maladie neurodégénérative progressive, les résultats démontrent que les patients atteints de la MP conservent ou même améliorent leur contrôle postural dans toutes les positions. Le facteur principal influençant ces résultats serait que les patients utilisent davantage leur traitement cognitif disponible pour améliorer

leur contrôle postural. Le système *Active Balance Rehabilitation* permet d'établir cette hypothèse car le système nécessite une attention continue des patients, favorisant le traitement cognitif.

- 9 Psychiatrie ([voir la liste d'études](#))

Domaines de traitement : Psychose, idées paranoïaques et évitement social chez des patients psychotiques, déficience cognitive, démence, stimulation cognitive, effets anxiolytiques aigus de la quétiapine, agoraphobie, trouble obsessionnel compulsif, anxiété.

- 15 Schizophrénie ([voir la liste d'études](#))

Domaines de traitement : Solitude et cognition sociale, déficits de navigation allocentriques et égocentriques, variation du stress social, déficits d'attention, intimité perçue dans la prise de décision sociale, perturbations du traitement empathique spontané liées à la gravité des symptômes négatifs, réduction de la distorsion de la réalité, amélioration des aptitudes sociales, apprentissage, cognition et mémoire spatiaux, flexibilité cognitive dans la vie réelle, la reconnaissance des émotions faciales, la cognition et l'alexithymie.

- 2 Anxiété préopératoire ([voir la liste d'études](#))

Synthèse des résultats : La VR permet aux patients d'être immergés dans un environnement relaxant et paisible. Il s'agit d'un moyen non invasif de réduire les niveaux de stress préopératoire sans effets secondaires et sans besoin de personnel médical ou paramédical supplémentaire. La RV peut constituer une technique complémentaire efficace pour gérer le stress chez les patients opérés. Des essais randomisés sont nécessaires pour déterminer des méthodes et des avantages précis.

- 8 Sclérose multiple ([voir la liste d'études](#))

Synthèse des résultats : La RV représente une alternative motivante et efficace à la rééducation motrice traditionnelle pour les patients atteints de sclérose multiple. Les résultats ont montré que les programmes de RV pourraient être une méthode efficace pour les patients en réhabilitation de sclérose multiple afin de réduire les déficits cognitifs ou moteurs. Des recherches supplémentaires sont nécessaires pour soutenir les protocoles de réadaptation avec VR et augmenter les effets du traitement.

- 4 Lésion de la moelle épinière ([voir la liste d'études](#))

Synthèse des résultats : La RV peut être une intervention complémentaire pour améliorer la posture et l'équilibre en position assise chez les paraplégiques dorsaux. L'effet de la RV sur l'humeur et la fonctionnalité des patients atteints d'une lésion de la moelle épinière doit être étudié plus en profondeur.

- 115 Accident vasculaire cérébral ([voir la liste d'études](#))
Synthèse des résultats : Les interventions de réalité virtuelle améliorent l'équilibre statique et dynamique et développent les compétences d'indépendance fonctionnelle autant que la rééducation conventionnelle. Ni les interventions en réalité virtuelle ni les approches thérapeutiques conventionnelles ne sont supérieures les unes aux autres dans cette population de patients. Des études supplémentaires avec des échantillons de grande taille et une bonne qualité méthodologique sont nécessaires pour établir des preuves solides.
- 26 Interventions non classées ([voir la liste d'études](#))
Domaines de traitement : Acouphènes subjectifs chroniques, perte vestibulaire, imagerie médicale, syndrome de conflit sous-acromial, dyskinésie scapulaire, arthroplastie totale du genou, communication médecin-patient, trouble destructif et contrôle des impulsions, patients sous assistance ventriculaire gauche, hémopathies malignes, entorse de la cheville, orientation exogène de l'attention en audition, simulateur de chirurgie côté patient, chirurgie de l'os temporal, paralysie obstétricale, hémophilie, interaction du chirurgien et du patient en temps réel, insuffisance rénale sous hémodialyse, équilibre, rééducation après chirurgie du genou, présentation du schéma posologique aux patients, leucodystrophie métachromatique

Études sur l'usage de la réalité augmentée auprès des patients

12 études sur l'usage de la réalité augmentée auprès des patients ont été recensées ([voir la liste de références](#)). Voici

- **Maladie de Parkinson**
 L'étude d'Espay et al. (2010) révèle que des dispositifs utilisant un retour sensoriel en boucle fermée, par le biais d'un programme de formation basée sur réalité augmentée, semblent des interventions non pharmacologiques efficaces et souhaitables pour améliorer la marche chez les patients atteints de la maladie de Parkinson. Le dispositif a aidé les personnes atteintes de la MP en améliorant la marche, ce qui devrait avoir un impact sur la mobilité fonctionnelle et la qualité de vie. Des recherches supplémentaires sont nécessaires pour quantifier la durée du bénéfice résiduel et l'applicabilité à d'autres situations cliniques chez les patients atteints de la MP.
- **Prescription de médicaments**
 Nifakos et Zary (2014) ont étudié une nouvelle méthode d'intégration des patients virtuels dans des appareils mobiles avec la technologie de la réalité augmentée, enrichissant la formation du praticien au comportement de prescription. De plus, ils ont également exploré les informations critiques pendant l'éducation au comportement de prescription et ils ont visualisé ces informations sur le contexte réel avec la technologie de réalité augmentée, en

même temps que le scénario d'un patient virtuel en cours d'exécution. À la suite de ce processus, ils ont défini le cadre éducatif des connaissances expérientielles dans un environnement mixte (virtuel et réel).

- **Douleur au membre fantôme**

Ortiz-Catalan et al. (2014, 2016) étudient un traitement dans lequel un membre virtuel répond directement à l'activité myoélectrique du moignon, tandis que l'illusion d'un membre restauré est renforcée par la réalité augmentée (RA). De plus, les mouvements fantômes sont facilités et encouragés par le jeu.

Rothgangel et al. (2018) ont comparé les effets sur la douleur du membre fantôme de la thérapie traditionnelle par miroir (MT), un télétraitement centré sur le patient (PACT) et des exercices sensomoteurs sans miroir.

- **Accident vasculaire cérébral**

L'étude de Lee et al. (2018) a été le premier essai clinique à utiliser le programme d'exercices à domicile avec système AR chez les patients ayant subi un AVC. En outre, les résultats de la présente étude ont révélé que le programme d'exercices à domicile associé au système AR avait un potentiel thérapeutique pour améliorer l'équilibre chez les patients ayant subi un AVC. Une étude plus approfondie avec un plus grand nombre de patients sera nécessaire pour clarifier les effets du programme d'exercices à domicile avec le système AR.

Les résultats de l'étude de Lee, Kim, et Lee (2014) apportent des preuves à l'appui de l'incorporation d'un environnement AR dans la formation au contrôle postural pour améliorer la démarche des patients ayant subi un AVC.

- **Microsomie hémifaciale**

L'étude de Qu et al. (2015) fait état d'une approche efficace pour guider l'ostéogénèse par distraction peropératoire. Des outils de réalité augmentée peuvent être utiles pour le positionnement précis des distracteurs intra-buccaux chez les patients atteints de microsomie hémifaciale en chirurgie crânio-faciale.

- **Réhabilitation neurologique**

Le travail de Correa-Agudelo et al. (2016) encourage l'utilisation de l'imagerie générée par ordinateur (comme des illusions visuelles) pour accélérer l'apprentissage moteur en rééducation. Les auteurs adhèrent aux principes de la neuroplasticité dépendante de l'expérience et à l'impact positif de la réalité augmentée.

- **Rééducation de la marche**

Les résultats de l'étude de Rossano et Terrier (2016) fournissent de nouvelles connaissances sur la récupération chez les patients neurologiques et contribuent à la conception de meilleurs programmes de réadaptation pour accompagner ce processus. Les résultats aident également les organismes de financement de la

santé à décider si les tapis roulants équipés de capacités de réalité augmentée constituent un investissement rentable.

- **Obésité**

Les résultats de l'étude de Pallavicini et al. (2016) montrent que les stimuli alimentaires basés sur AR étaient perçus comme pouvant être considérés comme de vrais stimuli, et ils ont également déclenché une réaction d'éveil similaire. L'étude révèle aussi que les personnes obèses ont montré un plus faible sentiment de bonheur après l'exposition aux aliments par rapport aux participants témoins, en ce qui concerne les réponses psychologiques et physiologiques. L'étude montre que tous les participants ont considéré que les stimuli alimentaires riches en calories étaient plus appétissants (vs les stimuli faibles en calories), et ils ont déclenché une plus grande réaction d'excitation.

- **Diabète**

Calle-Bustos et al. (2017) présentent un jeu de réalité augmentée pour soutenir l'éducation thérapeutique des patients diabétiques. Le jeu aide les enfants (âgés de 5 à 14 ans) à apprendre la teneur en glucides de différents aliments. Le jeu montre des aliments virtuels sur un vrai plat. Le jeu indique également le nombre de choix de glucides correspondant à l'aliment visualisé. L'étude détermine l'efficacité du jeu en termes d'apprentissage, de satisfaction perçue et de convivialité a été réalisée.

Études sur l'usage des jeux sérieux pour la formation des professionnels ou des futurs professionnels du domaine de la santé

3 revues de la littérature ont été repérées ([voir la liste de références](#)).

23 études sur l'usage des jeux sérieux pour la formation des professionnels ou des futurs professionnels du domaine de la santé ont été recensées ([voir liste de références](#)). Voici la liste de sujets traités par les études :

- **Études généralistes sur les jeux en formation dans le domaine de la santé**

- Kron et al. (2010) examinent les attitudes des étudiants en médecine à l'égard des jeux vidéo et des nouvelles technologies dans l'enseignement médical.
- Hannig et al. (2012) ont évalué un jeu sérieux collaboratif basé sur le Web pour l'enseignement du design optimal de la pratique médicale.
- Graafland, Bemelman, and Schijven (2013) ont étudié l'efficacité d'un jeu sérieux pour améliorer la connaissance de la situation en chirurgie laparoscopique.

- Pasquier et al. (2015) présentent certaines stratégies basées sur l'usage des jeux sérieux pour l'évaluation initiale et continue des professionnels de santé.
 - Richey Smith et al. (2016) documentent l'utilisation d'un jeu en ligne pour évaluer les attitudes des futurs professionnels de la santé à l'égard des personnes en situation de pauvreté.
 - Huang et al. (2018) ont testé un jeu pour des stagiaires en médecine d'urgence qui vise à développer une meilleure compréhension du flux de patients et de la gestion des ressources au service des urgences.
- **Réanimation**
L'étude de Buttussi et al. (2013) montre qu'un jeu sérieux en 3D pour la reconversion basée sur des scénarios s'avère efficace pour la formation continue en support de vie avancé et permet de conserver les connaissances et compétences acquises.
 - **Santé mentale**
Albright et al. (2013) soulignent l'efficacité d'une simulation basée sur les jeux utilisant des « humains virtuels » pour former les médecins au dépistage et à la gestion des soins des patients souffrant de troubles mentaux.
 - **Troubles du spectre de l'autisme**
Ferguson et al. (2013) analysent l'utilisation stratégique des jeux dans le développement des élèves d'une institution pour les enfants et les adultes atteints du trouble du spectre de l'autisme. Les jeux ont été utilisés auprès des élèves, du personnel, des professeurs, des parents, des amis et des employeurs. Les jeux ont contribué à l'amélioration de la qualité de vie des élèves et, par conséquent, leurs relations, leur productivité et leur bonheur.
 - **Gériatrie**
Lagro et al. (2014) décrivent l'expérience d'utilisation de GeriatriX, un jeu sérieux pour la formation à la prise de décision médicale à partir d'une évaluation des préférences des patients, la pertinence et les coûts des soins médicaux. Après avoir utilisé le jeu, les étudiants ont une meilleure auto-évaluation de leur compétence pour pondérer les préférences des patients, leur pertinence et les coûts des soins médicaux, le tout afin de prendre des décisions médicales gériatriques complexes. L'utilisation du jeu a également entraîné une meilleure prise en compte des coûts.
 - **Anesthésiologie**
Kitchen et Humphreys (2014) explorent les jeux sérieux en tant que média alternatif pour le développement professionnel continu. Les auteurs décrivent la manière dont de nombreuses écoles d'anesthésie peuvent utiliser des simulations

pour couvrir des scénarios (par exemple, la gestion de l'hyperthermie maligne ou de l'anaphylaxie) pour leurs stagiaires et pour certains hôpitaux pour lesquels elles réalisent de travaux de consultant.

- **Médecine d'urgence**

Les résultats de l'étude de Nicolaidou et al. (2015) donnent une bonne indication d'un jeu sérieux en tant qu'outil éducatif pour la formation en cas d'urgence. La contribution des professionnels est nécessaire pour l'amélioration continue du jeu. Les auteurs déclarent que d'autres recherches seront nécessaires pour valider le jeu et pour examiner le développement des compétences de résolution de problèmes des participants dans le traitement des symptômes d'un patient en situation d'urgence.

- **Médecine factuelle**

Gleason (2015) a documenté le développement d'un jeu sérieux pour enseigner la médecine factuelle aux étudiants des sciences de la santé.

- **Blessures au bas du dos**

Les données recueillies par Kuipers et al. (2016) montrent que la mécanique d'un jeu sérieux a obligé les joueurs à utiliser des techniques correctes de levage et de transfert statiques, mais ont également révélé la nécessité d'un développement futur d'un système social et, notamment, d'évaluer l'acceptation des interventions. Les facteurs du système social ont eu un impact important sur les capacités de persuasion des jeux et leur intention autogène.

- **Formation préhospitalière**

Heldal et al. (2017) discutent des ressources nécessaires à la planification et à l'exécution de scénarios de formation contextuels collaboratifs. Sur la base d'une étude pratique impliquant des infirmières préhospitalières et différentes technologies de simulateur, ont été exemplifiées les chaînes d'activités récurrentes dans la formation préhospitalière. Les auteurs illustrent les avantages de l'utilisation de récits et de jeux sérieux pour la formation contextuelle contribuant à des meilleures expériences utilisateur. Les avantages d'utiliser des technologies de simulation peuvent être plus facilement définis par les récits des praticiens.

- **Laparoscopie**

Kowalewski et al. (2017) ont validé un jeu sérieux (*Touch Surgery*) pour l'enseignement et l'évaluation de la cholécystectomie laparoscopique (CL). *Touch Surgery* s'avère une application de jeu sérieux acceptée pour apprendre les aspects cognitifs de la CL. Les auteurs ont établi la validité de construction ainsi que du contenu. Il semble y avoir une synergie entre le jeu et l'usage de la réalité virtuelle. Par conséquent, les deux modalités de formation doivent s'accompagner dans une approche d'entraînement multimodale.

Overtoom et al. (2017) ont évalué l'opinion des résidents sur un nouveau simulateur laparoscopique pour la plateforme Nintendo Wii-U. La plupart des résidents ont aimé le jeu. L'utilité et la pertinence en tant qu'outil de formation laparoscopique ont été jugées acceptables à un niveau élevé. Cependant, le jeu nécessite des améliorations telles que l'inclusion d'un bon système de notation avant de pouvoir être intégré dans les programmes de formation des résidents.

- **Sécurité des patients**

Dankbaar et al. (2017) ont démontré que les vidéoconférences dans un jeu sérieux peuvent être tout aussi efficaces pour développer des connaissances sur des sujets spécifiques que les cours magistraux dans un module de formation en ligne. Bien que les jeux sérieux engagent fortement les étudiants et les incitent à étudier plus longtemps, ils n'entraînent pas nécessairement de meilleures performances en matière de sécurité des patients.

- **Chirurgie**

Graafland, Bemelman, and Schijven (2017) analysent un jeu sérieux pour la formation en chirurgie laparoscopique.

- **Insertion du tube thoracique**

Friedrich et al. (2017) ont effectué un essai randomisé afin de déterminer la valeur de l'apprentissage avec un jeu sérieux pour l'insertion du drain thoracique en utilisant le score OSATS (*objective structured assessment of technical skills*). L'étude montre le potentiel du jeu pour la formation chirurgicale en cas de traumatisme.

- **Pédiatrie**

Schmidt et Grigull (2018) documentent le développement d'une nouvelle application, basée sur l'usage des jeux sérieux, pour l'apprentissage pour la pédiatrie

- **Anatomie**

Sochocka, Les, et Strypan (2018) présentent un jeu qui vise à aider à apprendre l'anatomie d'un œil humain normal et pathologique.

Études sur l'usage de la réalité virtuelle pour la formation des professionnels ou des futurs professionnels du domaine de la santé

13 revues de littérature sur l'usage de la réalité virtuelle pour la formation des professionnels ou des futurs professionnels du domaine de la santé ont été repérées ([voir liste de références](#)). Les revues gravitent autour des sujets suivants :

- Chirurgie buccale et maxillo-faciale (Chen and Hu 2018).
- Chirurgie ouverte (Davies, Khatib, and Bello 2013)

- Résultats pour les patients (Cox, Seymour, and Stefanidis 2015)
- Formation neurochirurgicale (Kirkman et al. 2014)
- Mastoïdectomie (Lui and Hoy 2017)
- Chirurgie de la colonne vertébrale (Pfandler et al. 2017)
- Médecine clinique (Pourmand et al. 2017)
- Formation endovasculaire (See et al. 2016)
- Formation en otorhinolaryngologie (Stobbs and Kumar 2014)
- Arthroscopie (Tay, Khajuria, and Gupte 2014)
- Formation en chirurgie cardiothoracique (Trehan, Kemp, and Yang 2014)
- Chirurgie laparoscopique (Zendejas et al. 2013)
- Formation en radio-oncologie (Zhu et al. 2017)

183 études sur l'usage de la réalité virtuelle pour la formation des professionnels ou des futurs professionnels du domaine de la santé ont été recensées ([voir liste de références](#))

Sujets les plus récurrents dans les études : Laparoscopie, chirurgie, neurochirurgie et neuroanatomie, orthopédie, endoscopie

D'autres sujets abordés dans les études : Ophtalmologie, compétences cliniques, gynécologie, techniques chirurgicales minimalement invasives, communication médicale, tumeurs cérébrales, mastoïdectomie, vaporisation photosélective de la prostate, oto-rhino-laryngologie, arthroscopie, urologie, ventriculostomie, suture, anesthésie, hystérectomie, tomographie, anatomie stéréoscopique, hémophilie, imagerie préopératoire, soins primaires, hygiène des mains, cholécystectomie, gastroentérologie, compétences diagnostiques en boulimie, prostatectomie radicale, entraînement locomoteur chez les patients atteints de paralysie cérébrale, bronchoscopie, anesthésie rachidienne, phacoemulsification, réhabilitation vasculaire, pédiatrie, canalisation intraveineuse, demande excessive d'antibiotiques, médecine dentaire, imagerie médicale, appendicectomie, injection intramédullaire, cardiologie, activation corticale chez des patients atteints de lésions médullaires, varicocélectomie.

Études sur l'usage de la réalité augmentée pour la formation des professionnels ou des futurs professionnels du domaine de la santé

2 revues de littérature sur l'usage de la réalité augmentée pour la formation des professionnels ou des futurs professionnels du domaine de la santé ont été repérées ([voir liste de références](#)).

28 études sur l'usage de la réalité augmentée pour la formation des professionnels ou des futurs professionnels du domaine de la santé ont été recensées ([voir liste de références](#)). Voici les sujets traités par les études :

- **Études généralistes sur l'usage de la réalité augmentée en formation dans le domaine de la santé**
(Monkman and Kushniruk 2015)

(Tworek et al. 2010)
(L. Wang et al. 2016)
(S. Wang et al. 2017)

- **Médecine légale**
(U.-V. Albrecht, Noll, and Von Jan 2013)
(U. Albrecht, Kruckeberg, and Haussermann 2010)
(Urs-Vito Albrecht et al. 2013)
- **Cancer au pancreas**
(Andolfi et al. 2017)
- **Cardiologie**
(Dai and Song 2017)
(Vallurupalli et al. 2013)
- **Anatomie générale**
(Fuerst, Hollensteiner, and Schrempp 2014)
(Küçük, Kapakin, and Göktaş 2016)
(Kugelmann et al. 2018)
(Ma et al. 2016)
(Mahmoud et al. 2017)
(Moro et al. 2017)
(Adegboye and Mehta 2017)
(Armstrong et al. 2016)
- **Trachéotomie de dilatation percutanée**
(Gan, Cohen, and Tan 2018)
- **Cathéters veineux centraux**
(Huang et al. 2018)
(Rochlen, Levine, and Tait 2017)
- **Procédures guidées par ultrasons**
(Jeon, Choi, and Kim 2014)
(Moult et al. 2013)
- **Chirurgie**
(Juanes et al. 2016)
(Sugimoto 2017)
(Wu et al. 2014)
- **Ophthalmoscopie**

Limites du travail de recension

Ce travail de révision de littérature nous permet de constater que la recherche sur l'usage des jeux sérieux et de la simulation (par réalité virtuelle ou augmentée) dans le domaine de la santé est en plein essor. En effet, le nombre croissant d'études sur le sujet est un indicateur univoque de l'intérêt de la communauté scientifique sur la question de l'efficacité de ces applications technologiques pour l'éducation thérapeutique des patients, la mise en place de traitements non traditionnels et la formation des professionnels et des futurs professionnels du domaine de la santé.

Cette profusion d'études a été à la fois un levier pour le travail de recension et un frein pour l'approfondissement de l'analyse des écrits. Un levier, car les résultats des études nous permettent de conclure qu'il s'agit d'un terrain de recherche très fertile et que l'efficacité des applications des jeux sérieux et de la simulation semble prometteuse. Un frein, étant donné les limitations du temps rattaché à l'engagement de l'auxiliaire de recherche. Ces limitations ont imposé des contraintes à la portée des analyses, compte tenu du grand nombre de publications.

En soustrayant le temps investi dans la recherche, le triage, l'évaluation par titre des documents et la rédaction du présent rapport, l'auxiliaire de recherche a disposé de moins de 40 heures pour analyser les 692 textes retenus (3,5 minutes par texte, approx.) C'est pourquoi la méta-analyse a été effectuée à partir de la lecture des résumés des textes. Des travaux d'approfondissement seront donc nécessaires afin de peaufiner les résultats ici présentés. Toutefois, étant un travail préliminaire, ce recension permet de cartographier le domaine de recherche et d'identifier les bonnes pratiques d'exploitation des jeux sérieux et de la simulation dans le domaine de la santé.

Ces mêmes limitations ont conditionné l'analyse des méthodologies mises en place dans les recherches, de regrouper les études ayant des résultats semblables ou confirmatoires et de contraster ceux qui auraient présenté des résultats contradictoires. Malgré ces défauts, nous avons réussi à compléter les demandes du mandat qui nous a été confié.

Le lecteur est prié de considérer ces contraintes au moment de juger la valeur du travail effectué.

Liste de textes retenus

Jeux sérieux

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Simulation – Réalité augmentée

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