Centre universitaire de santé McGill

McGill University Health Centre

Technology Assessment Unit of the McGill University Health Centre (MUHC)

Offering Proton Beam Therapy for selected types of cancer in children and adults at the MUHC: A Budget Impact Analysis

Report number: 85

DATE: May 01, 2020

Report available at https://muhc.ca/tau

Report prepared for the Technology Assessment Unit (TAU) of the McGill University Health Centre (MUHC)

by

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Approved by the Committee of the TAU on Oct 23, 2019

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Suggested citation

Forero DF, Dendukuri N. Montreal (Canada): Offering Proton Beam Therapy for selected types of cancer in children and adults at the MUHC: A Budget Impact Analysis. Technology Assessment Unit (TAU) of the McGill University Health Centre (MUHC); December 12, 2019. Report no. 85. 48 pages

ACKNOWLEDGEMENTS

The expert assistance of the following individuals is gratefully acknowledged:

- Tarek Hijal, Radiation oncologist, Division of Radiation Oncology, MUHC
- Carolyn Freeman, Radiation oncologist, Division of Radiation Oncology, MUHC
- Jan Seuntjens, Professor of Medical Physics, Medical Physics Unit, McGill University
- Catherine Goudie, Assistant Professor, Department of Pediatrics, Hematology-Oncology Division, McGill University.
- Andre Guigui, Financial analyst, Department of Finance, MUHC

REPORT REQUESTOR

This report was requested by Dr. Tarek Hijal in April 2018.

TYPES OF RECOMMENDATIONS ISSUED BY TAU

No recommendation was issued to the MUHC administration as it was not the principal stakeholder. Nonetheless, the findings of this report are relevant to the MUHC administration. It provides information on the maximum and minimum possible values of the payment per patient to the MUHC if proton therapy is offered onsite.

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ABSTRACT

Background: Proton therapy is an alternative to conventional radiotherapy that is preferred for cancers in sensitive locations such as the head, neck, and central nervous system. It is not available in Canada. Eligible patients from Quebec, predominantly pediatric and young adult patients, are sent to receive treatment in the United States (US) at a cost of over $300,000 per patient. The steady growth in the number of cases being sent to the US annually suggests that a Quebec-based proton therapy centre may be more affordable for the Quebec Ministry of Health (MoH) despite a high upfront construction cost of $44 million ($44 M).

Objectives: To estimate the budget impact of constructing and operating a proton therapy centre at the McGill University Health Centre (MUHC) and the amount the MUHC needs to be reimbursed per patient treated.

Methods: A budget impact analysis was carried out from the perspective of the MoH assuming costs of construction during 2019-2020 would be financed by a loan from the MoH and a grant from the MUHC Foundation. Different scenarios were considered by varying numbers of patients treated and by considering the MUHC Foundation investment as a loan.

Results: The number of patients eligible for referral to the US is projected to increase from 60 in 2022 to 139 in 2030. The corresponding cost per patient treated in the US will increase from $341,050 to $399,594 during the same time. The total expenditure in 2022 will be $20.3M and will increase every year for a cumulative expenditure of $377.3M in 2030.

More patients are expected to receive treatment when offered in Quebec, increasing from 66 in 2022 to 153 in 2030. The cost per patient treated at the MUHC decreases from $56,715 in 2022 to $31,378 in 2030. The reimbursement to the MUHC per patient treated, which covers the loan amount repaid during the first five years, is projected to decrease from $124,631 in 2022 to $25,535 in 2030. The annual expenditure for the MoH will increase from $3.7M in 2022 to $4.5M in 2030 for a cumulative expenditure of $64.2M in 2030.
Immediately following construction, the budget impact is negative, reflecting savings for the MoH, from -$16.6M in 2022 to -$50.8M in 2030. Similar observations were made when considering scenarios where the number of patients is higher and when the MUHC

Foundation investment is treated as a loan instead of a grant. Sensitivity analyses showed that these findings are robust to assumptions about growth rate of patients treated and cost of referral to the US.

Conclusions: Despite a high upfront cost, investment in a proton therapy centre in Quebec will be cost saving for the province in the long run within a period of 3 years.

RÉSUMÉ

Contexte : La protonthérapie est une alternative à la radiothérapie conventionnelle qui est le traitement préféré pour les cancers dans les régions sensibles telles que la tête, le cou et le système nerveux central. Elle n'est pas disponible au Canada. Les patients admissibles du Québec, en majorité les enfants et les jeunes adultes, sont envoyés aux États-Unis (É.-U.) pour recevoir un traitement qui coûte plus de 300 000 $ par patient. La croissance constante du nombre de cas qui sont envoyés aux É.-U. annuellement suggère qu'un centre de protonthérapie québécois serait un choix plus abordable pour le Ministère de la santé du Québec (MSSS), malgré un coût initial de construction élevé qui remonte à 44 millions $ (44 M$).

Objectifs : Estimer l'impact budgétaire pour la construction et l'opération d'un centre de protonthérapie au Centre universitaire de santé McGill (CUSM) et le montant que nécessite le CUSM pour être remboursé par patient traité.

Méthodes : Une analyse de l'impact budgétaire a été effectuée du point de vue du MSSS, en supposant que le coût de construction en 2019-2020 serait financé par un prêt du MSSS et une subvention de la part de la Fondation du CUSM. Différents scénarios ont été pris en compte en variant le nombre de patients traités et en considérant l'investissement de la Fondation du CUSM comme un prêt.

Résultats : Nous prévoyons une augmentation du nombre de patients admissibles d'être envoyés aux É.-U. qui va de 60 en 2022 à 139 en 2030. Le coût correspondant par patient traité aux É.-U. augmentera de 341 050 $ à 300 594 $ au cours de la même période. Les dépenses totales en 2022 seront de 20,3 M$ et augmenteront à chaque année pour des dépenses cumulatives de 377,3 M$ en 2030.

Si le traitement est offert au Québec, nous nous attendons à ce que plus de patients le reçoivent, soit 66 en 2022 à 153 en 2030. Le coût par patient traité au CUSM diminuerait de 56 715 $ en 2022 à 31 378 $ en 2030. Nous prévoyons que le remboursement au CUSM par patient traité, ce qui inclut la somme du prêt remboursée au cours des cinq premières années, diminuera de 124 631 $ en 2022 à 25 535 $ en 2030. Les dépenses annuelles pour le MSSS augmenteront de 3,7 M$ en 2022 à 4,5 M$ en 2030 pour des dépenses totales de 64,2 M$ en 2030.

Immédiatement après la construction, l'impact budgétaire sera négatif, reflétant des économies pour le MSSS allant de - 16,6 M$ en 2022 à - 50,8 M$ en 2030. Des observations similaires ont été faites lors de l'étude de scénarios où le nombre de patients était plus élevé et lorsque l'investissement de la Fondation du CUSM était traité comme un prêt au lieu d'une subvention. Les analyses de sensibilité ont montré que ces résultats sont robustes aux hypothèses concernant le taux de croissance du nombre de patients traités et le coût de les envoyer aux É.-U.

Conclusions : Malgré un coût initial élevé, le fait d'investir dans un centre de protonthérapie au Québec sera économique pour la province à long-terme dans un délai de 3 ans.

LIST OF ABBREVIATIONS

AETMIS	Agence d'évaluation des technologies et des modes d'intervention en santé
BIA	Budget Impact Analysis
CADTH	Canadian for Drugs and Technologies in Health
CI	Confidence interval
EBRT	External beam radiotherapy
HTA	Health technology assessment
IMRT	Intensity modulated radiation therapy
INESSS	Institut National d'Excellence en Santé et en Service Sociaux
MoH	Ministry of Health
MUHC	McGill University Health Centre
NICE	National Institutes for Health and Clinical Excellence
OCR	Out-of-country referral
QoL	Quality of life
RAMQ	Régie de l'assurance maladie du Québec
RD	Risk difference
RCT	Randomized controlled trial
RT	Radiotherapy
SBRT	Stereotactic body radiation therapy
TAU	Technology Assessment Unit
US	United States

EXECUTIVE SUMMARY

BACKGROUND

Proton therapy is an alternative to conventional radiation that can minimize radiation to healthy tissues, making it a preferred technique for cancers in sensitive locations. As this therapy is not available in Canada, eligible patients from Quebec, in the pediatric and young adult age group, are sent to the United States (US) at a cost of over $300,000 per patient. Construction of a proton therapy centre in Quebec would be an expensive upfront investment of close to $44 million ($44M). However, the rapid growth in the number of patients being sent to the US, from 8 in 2010 to 33 in 2019, the associated rising costs and anticipated clinical benefit, have raised the question as to whether a Quebec-based proton therapy centre is more affordable for the Quebec Ministry of Health (MoH).

OBJECTIVES

To estimate the budget impact of constructing and operating a proton therapy centre at the McGill University Health Centre (MUHC) and the amount the MUHC needs to be reimbursed per patient treated.

METHODS

A budget impact analysis (BIA) was carried out from the perspective of the MoH comparing referral to the US (the base case) vs. construction and operation of a proton therapy centre at the MUHC (the proposed alternative), over a time horizon of 12 years (2019 to 2030). Under the base case, the Quebec Ministry of Health (MoH) is the payer of the total cost. Under the proposed alternative, the MoH and the MUHC Foundation would be co-financers for the construction phase during 2019-2020, while the MoH will pay the operating cost per patient.

Target population and patients treated:
Under the base case, we assumed that the number of patients sent to the US would increase annually by 18% within the first 5 years and then slow down to 9% for the rest of the model.

Based on the expected number of cases in the population, it is estimated that only 25% of eligible Quebec patients are sent to the US for treatment due to the challenges posed by

traveling. Therefore, under the proposed alternative of proton therapy being offered at the MUHC, we assumed the introduction of this technology on-site would enable treatment of an additional 10% of the total number of eligible patients to receive the treatment.

Cost input:
For the base case, the cost of treating a patient in the US was estimated based on data from the Régie de l'Assurance Maladie du Québec (RAMQ). For the proposed alternative, it was assumed that the MoH would contribute $24M in form of a loan to the cost of constructing the proton therapy centre, while the remaining $20M would be obtained in the form of a grant from the MUHC Foundation. First and second-year costs included a portion of the construction costs as well as the total cost for referring patients to the US in those years. From the third year onwards, when all patients are treated at the MUHC, physicians' costs, number of patients treated and the amount received by the MUHC per patient treated were used to determine the total cost for the MoH. The amount the MUHC needs to be reimbursed per patient treated in order to break even was estimated based on the operational costs incurred at the MUHC. During the first 5 years of operation, it also included the loan amount returned to the MoH.

Scenario Analysis:
Under the proposed alternative, we considered scenarios where: 1) All eligible patients received proton therapy, 2) The money disbursed by the MUHC Foundation is an interest-free loan to be returned in a term of 10 years ($2M per year), 3) Combination of scenarios 1 and 2.

Sensitivity Analysis:
A Probabilistic Sensitivity Analysis (PSA) was carried out to study the impact of varying the annual growth in the number of patients treated from 1-20% and varying the cost per patient treated in the US from $275,000-$350,000. We estimated the probability of savings at 2025, 5 years after the project was implemented, and at the end of the simulation in 2030.

RESULTS

Base Case:
The number of patients eligible for referral to the US is projected to increase from 60 in 2022 to 91 in 2025 to 139 in 2030; with an estimated cost per patient of $341,050, $

$361,924 and $399,594, respectively, for the same years. The total expenditure for the first year (2019) is close to $11.6M and will continually increase every year for an estimated cumulative expenditure at 7 years (in 2025) of $149.7M and $377.3M in 2030.

Proposed alternative:
The number of patients treated is expected to increase from 66 in 2022 to 100 in 2025 to 153 in 2030. The reimbursement to the MUHC per patient treated was highest in the second year of operation (2022) in every scenario evaluated. In the primary analysis, it is $124,630. It reduces to $70,632 in Scenario 1 when more patients are treated and increases to $155,115 in Scenario 2 when the investment from MUHC foundation is treated as an interest-free loan. In the subsequent years, as the number of patients treated increases, and the loan to the government or MUHC Foundation is paid, the amount reimbursed to the MUHC per patient treated decreases under all scenarios, especially after 2025. By the end of the simulation in 2030 it is $25,534 in the primary analysis.

The total expenditure is estimated at $23.8M for the first year (2019) and $26M for 2020 and includes the construction costs as well as the cost of treating patients abroad. However, for the following years, after including the return of the loan and the estimated amount received by the MUHC per patient treated, the total cost per year reflects an increasing negative budgetary impact (savings), from -$16M in 2021 to -$51M in 2030. The cumulative budget impact is close to -$57M in 2025, and -$261M in 2030. The same trend in the budget impact was also true in Scenarios 1-3. In all scenarios, from the third year of operation onwards, the MoH would obtain cumulative savings when compared to the base case of sending patients to receive treatment in the U.S.

Sensitivity analysis:
The lower (optimistic) limits of the budget impact are -$18.7M in 2021 to -$76M in 2030 leading to cumulative savings of -$400M by the end of the 2030. The upper (pessimistic) limits of the budget impact are -9.5M in 2022 to -$16.6M in 2030 resulting in cumulative savings of -$80.5M at the end of the model in year 2030. Finally, it is observed that in 34.5% and 100% of the 2000 scenarios evaluated, the construction of a proton therapy centre at the MUHC will produce savings greater than $50M at years 2025 and 2030 respectively.

CONCLUSION

In most of the scenarios explored, the Quebec Ministry of Health will obtain savings as soon as the proton therapy centre is operating. The magnitude of the savings depends greatly on the estimate of the number of patients treated. Building a proton therapy centre is an expensive mid-term investment; however, the results obtained from our simulations seem to support pursuing this approach for its budgetary impact in the long term.

RECOMMENDATION

No recommendation was issued to the MUHC administration as it was not the principal stakeholder. Nonetheless, the findings of this report are relevant to the MUHC administration. It provides information on the maximum and minimum possible values of the reimbursement to the MUHC that is necessary if proton therapy is offered on-site.

SOMMAIRE

CONTEXTE

La protonthérapie, qui est une alternative à la radiation conventionnelle, peut minimiser la radiation des tissus sains, ce qui en fait une technique privilégiée pour les cancers dans les régions sensibles. Étant donné la non-disponibilité de cette thérapie au Canada, les patients admissibles du Québec, soit les enfants et les jeunes adultes, sont envoyés aux États-Unis (É.-U.) à un coût de plus de 300 000 $ par patient. La construction d'un centre de protonthérapie au Québec serait un investissement initial coûteux de près de 44 $ millions (44 M$). Par contre, la croissance rapide du nombre de patients envoyés aux É.-U., soit de 8 en 2010 à 33 en 2019, ainsi que la hausse des coûts associée et les bénéfices cliniques prévus, ont soulevé la question de l'abordabilité d'un centre de protonthérapie pour le Ministère de la santé du Québec (MSSS).

OBJECTIFS

Estimer l'impact budgétaire pour la construction et l'opération d'un centre de protonthérapie au Centre universitaire de santé McGill (CUSM) et le montant que nécessite le CUSM pour être remboursé par patient traité.

MÉTHODES

Une analyse de l'impact budgétaire (AIB) a été effectuée du point de vue du MSSS, et compare l'envoi de patients aux É.-U. (cas de base) avec la construction et l'opération d'un centre de protonthérapie au CUSM (alternative proposée), à l'intérieur d'un horizon temporel de 12 ans (2019 à 2030). Dans le cas de base, le Ministère de la santé du Québec (MSSS) serait le payeur du coût total. Dans l'alternative proposée, le MSSS et la Fondation du CUSM cofinanceraient la phase de construction au cours de l'année 2019-2020, tandis que le MSSS paierait le coût de traitement par patient.

<u>Population cible et patients traités :</u>
Dans le cas de base, nous avons supposé que le nombre de patients envoyés aux É.-U. augmenterait annuellement de 18 % dans les 5 premières années et ralentirait à 9 % pour le restant du modèle.

Selon le nombre de cas prévus dans la population, il est estimé que seulement 25 % des patients québécois admissibles sont envoyés aux É.-U. pour être traités dû aux enjeux liés au voyage. Ainsi, dans l'alternative proposée d'offrir la protonthérapie au CUSM, nous avons supposé que l'introduction de cette technologie sur place permettrait de traiter un 10 % de plus que le nombre total de patients admissibles au traitement.

Coûts :

Dans le cas de base, le coût de traiter un patient aux É.-U. a été estimé en fonction des données de la Régie de l'Assurance Maladie du Québec (RAMQ). Dans l'alternative proposée, nous avons supposé que le MSSS contribuerait 24 M$ sous forme de prêt pour la construction d'un centre de protonthérapie, tandis que les 20 M$ restants seraient obtenus sous forme de subvention de la part de la Fondation du CUSM. Les coûts de la première et la deuxième année incluaient une portion des coûts de construction ainsi que le coût total pour envoyer les patients aux É.-U. durant cette période. À partir de la troisième année, lorsque tous les patients seraient traités au CUSM, les frais de médecin, le nombre de patients traités et le montant reçu par le CUSM par patient traité ont été utilisés pour déterminer le coût total pour le MSSS. Le montant que nécessite le CUSM pour être remboursé par patient traité afin d'atteindre le seuil de rentabilité a été estimé en fonction des coûts opérationnels engagés au CUSM. Durant les 5 premières années d'activité, la somme du prêt remboursé au MSSS a aussi été incluse.

Analyse de scénario :

Dans l'alternative proposée, nous avons a pris en compte des scénarios dans lesquels : 1) tous les patients admissibles ont reçu la protonthérapie, 2) la somme versée par la Fondation du CUSM est un prêt sans intérêt à rembourser dans un délai de 10 ans (2 M$ par an), 3) combinaison des scénarios 1 et 2.

Analyse de sensibilité :

Une analyse de sensibilité probabiliste (ASP) a été réalisée pour étudier l'impact qu'a de varier l'augmentation annuelle du nombre de patients traités de 1-20 %, et de varier le coût par patient traité aux É.-U. de 275 000 $ à 350 000 $. Nous avons estimé la probabilité d'économies à l'année 2025, 5 ans après la mise en œuvre du projet, et à la fin de la simulation en 2030.

RÉSULTATS

Cas de base :

Nous prévoyons une augmentation du nombre de patients admissibles d'être envoyés aux É.-U. qui va de 60 en 2022, à 91 en 2025, et à 139 en 2030; ainsi qu'un coût estimé par patient de 341 050 $, 361 924 $ et 399 594 $, respectivement, pour les mêmes années. Les dépenses totales pour la première année (2019) sont à près de 11,6 M$, et augmenteront continuellement à chaque année, pour des dépenses totales estimées à 149,7 M$ à la 7e année (en 2025) et de 377,3 M$ en 2030.

Alternative proposée :

Nous prévoyons une augmentation du nombre de patients traités qui va de 66 en 2022, à 100 en 2025, à 153 en 2030. Dans chaque scénario évalué, le montant du remboursement au CUSM par patient traité était le plus élevé dans la deuxième année d'activités (2022). Dans l'analyse primaire, la somme est de 124 630 $. Elle diminue à 70 632 $ dans le scénario 1 lorsque plus de patients reçoivent le traitement et augmente à 155 115 $ dans le scénario 2 lorsque l'investissement de la Fondation du CUSM est traitée comme un prêt sans intérêt. Au cours des années suivantes, à mesure que le nombre de patients traités augmente et que le prêt du gouvernement ou de la Fondation du CUSM est payé, la quantité remboursée au CUSM par patient traité diminuera dans tous les scénarios, surtout après 2025. Avant la fin de la simulation en 2030, elle sera de 25 534 $ dans l'analyse primaire.

Les dépenses totales sont estimées à 23,8 M$ pour la première année (2019) et à 26 M$ pour 2020. De plus, elles comprennent le coût de construction et le coût du traitement à l'étranger. Toutefois, au cours des années suivantes, après avoir inclus le remboursement du prêt et le montant estimé reçu par le CUSM par patient traité, le coût total par année reflètera un impact budgétaire négatif croissant (économies), allant de - 16 M$ en 2021 à - 51 M$ en 2030. L'impact budgétaire total est à près de - 57 M$ en 2025, et - 261 M$ en 2030. Les Scénarios 1-3 présentaient la même tendance dans l'impact budgétaire. Dans tous les scénarios, à partir de la troisième année d'activités, le MSSS obtiendrait des économies réalisées comparé au cas de base qui est celui d'envoyer des patients aux É.-U pour recevoir le traitement.

Analyse de sensibilité :

Les limites inférieures (optimistes) de l'impact budgétaire vont de - 18,7 M$ en 2021 à - 76 M$ en 2030, ce qui mène à des économies totales de - 400 M$ d'ici la fin de 2030. Les limites supérieures (pessimistes) de l'impact budgétaire vont de - 9,5 M$ en 2022 à - 16,6 M$ en 2030, ce qui mène à des économies totales de - 80,5 M$ à la fin du modèle à l'année 2030. Finalement, nous constatons que dans 34,5 % et 100 % des 2000 scénarios évalués, la construction d'un centre de protonthérapie au CUSM engendrerait des économies supérieures à 50 M$ aux années 2025 et 2030 respectivement.

CONCLUSION

Dans la plupart des scénarios explorés, le Ministère de la santé du Québec réalisera des économies aussitôt que le centre de protonthérapie sera opérationnel. L'ampleur des économies dépend grandement de l'estimation du nombre de patients traités. La construction d'un centre de protonthérapie est un investissement moyen terme coûteux, mais les résultats obtenus à partir de nos simulations semblent soutenir la poursuite d'une telle démarche étant donné son impact budgétaire à long-terme.

RECOMMANDATION

Aucune recommandation n'a été adressée à l'administration du CUSM, car celle-ci ne représente pas le principal groupe d'intéressés. Les conclusions de ce rapport sont néanmoins pertinentes pour l'administration du CUSM. Il fournit des informations sur les valeurs maximales et minimales possibles du remboursement au CUSM si la protonthérapie est offerte sur place.

OFFERING PROTON BEAM THERAPY FOR SELECTED TYPES OF CANCER IN CHILDREN AND ADULTS AT THE MUHC: A BUDGET IMPACT ANALYSIS

1. BACKGROUND

Cancer is the main cause of death in Canada and Quebec[1,2]. Cancer patients are treated with conventional radiotherapy either alone or combined with other therapies such as chemotherapy, surgery or both. Conventional radiation therapy, which uses photons – *photon beam radiation therapy*- to deliver the radiation dose to a tumoral target, is associated with radiation to the surrounding healthy tissue, which may lead to adverse events including an increased risk of secondary cancers[3,4].

Proton beam therapy is an alternative to conventional radiation with the benefit that protons can deliver the desired radiation dose at the exact depth desired[5,6]. This minimizes radiation to healthy tissues beyond the tumour, making proton radiation therapy a preferred technique for tumours located inside *or* in proximity to radiosensitive tissues; such as the head and neck and central nervous system, as well as in some other tumour types seen in the pediatric and young adult age groups[7-9]. In 2017, *L'Institut national d'excellence en santé et en services sociaux* (INESSS) conducted a systematic review to support the use of proton radiation therapy in Quebec, identifying several clinical indications and circumstances where it would be preferred instead of conventional radiotherapy[10]. However, as this technology is not available in Canada (with one proton radiation therapy centre in Vancouver focusing exclusively on eye tumours having recently closed[a]) eligible patients from Quebec (see eligibility criteria in Appendix A) have been treated in the United States (US) since 2005 (Table 1). Quebec is the Canadian province that sends the greatest number of patients annually[9,11]. The cost per patient has overall increased from $138,333 to $353,472 in the last 10 years, with an

[a] TRIUMF centre treated patients from 1995 until a few weeks ago. Its closure was accorded after weighting multiple variables such as the need for capital investment, a reduction in the budget from the partners and a decrease in the number of patients. According to internal communications with the centre.

overall increment of 47% in the number of eligible patients (n=8 in 2010; n=33 in 2019) being covered by the *Régie de l'assurance maladie du Québec* (RAMQ) (Table 1).

Construction of a proton radiation therapy centre in Montreal would be an expensive investment with an upfront estimated cost for the construction and operation of a single vault proton accelerator being close to $44 million (M) CAD[9]. However, the increasing number of eligible patients, the associated rising costs of sending patients abroad and the anticipated clinical benefit, has raised the question as to whether a proton radiation therapy centre at the McGill University Health Centre (MUHC) that receives patients from Quebec and Canada, is affordable for the government of Quebec. The *Canadian Agency for Drugs and Technologies in Health* (CADTH) has also recently addressed the subject of a Canadian proton therapy centre through a health technology assessment (HTA) report and a budget impact analysis[9] (BIA), demonstrating its relevance to all Canadian provinces.

The Department of Radiation Oncology of the MUHC is interested in evaluating the financial burden for the interested parties (i.e. the Quebec Ministry of Health as financer and payer, and the MUHC as provider of services) of acquiring a single vault proton accelerator at the MUHC that can serve all eligible candidates from Quebec. The Technology Assessment Unit (TAU) was requested to carry out a budget impact analysis related to the acquisition and implementation of this technology at our institution.

It should be noted that the current report does not assess the comparative efficacy or safety of proton beam therapy over conventional radiotherapy, as this was previously assessed by INESSS and CADTH (separately) in 2017; they found an equivalent or superior tumour control for certain indications, and a reduction in radiation dose[9,10] (see indications recognized in Quebec for presenting higher benefits when treated with protons than photons in Appendix A). This report focuses exclusively on the financial burden that would have to be incurred by the parties involved in case of its adoption. Further, this report will not provide any recommendations from the TAU Policy Committee whose mandate is limited to providing recommendations to the MUHC administration. Although this report focuses on the Quebec perspective for the economic analysis, it is expected that this technology could benefit patients from all

over Canada as well as other countries. Therefore, financial projections considering additional patients are explored in the sensitivity analysis.

2. POLICY QUESTION

What is the budget impact of constructing and implementing a single vault proton radiation therapy centre at the MUHC, compared with the current strategy of referral to the United States, from the perspective of the Quebec Ministry of Health (MoH) as payer and co-financer, and from the perspective of MUHC as health care provider and co-financer?

3. OBJECTIVES

The objectives of this report are to:

- Estimate the budget impact of constructing and operating a proton therapy centre at the MUHC from the perspective of the MoH.
- Determine the amount that the MUHC must be reimbursed per patient treated to break even.

4. METHODS

4.1 The two strategies being compared

The primary analysis compares the current strategy of referral to the US, (called *Base Case* here) with the *proposed alternative* of constructing a proton therapy centre at the MUHC. Quebec patients must be able to travel abroad as part of a list of requirements to receive proton therapy (Appendix A). The number of patients treated is different for the base case and the proposed alternative because we anticipate that Quebec patients and their families are more likely to travel to Montreal for the treatment than to the US.

4.1.1 The base case : Refer patients to receive proton therapy in the United States (US)

The government of Quebec, through the RAMQ, funds travel, treatment and accommodation for the patient and one caregiver[11]. Not all eligible patients are currently

being sent to the United States for proton therapy due to logistical or medical conditions precluding travel. The 2010 report from INESSS (called AETMIS at the time)[12] estimated that the potential number of patients in Quebec that could benefit from this technology in 2018 would be 119 assuming a rate of 15 patients/million population. However, only 28 patients received the treatment in 2018, suggesting that the number of patients treated is roughly 25% of eligible patients. According to the INESSS report and data obtained from RAMQ for 2017-2019, more than 90% of requests to the provincial proton therapy committee are approved for treatment in the US. Eligible patients who do not receive treatment abroad are treated locally with conventional radiation according to our clinical team.

4.1.2 The proposed alternative: Offer proton therapy at the MUHC

Only one proton therapy accelerator has received approval in Canada so far; a single vault system, the ***Mevion S250***. The costs of utilization of the following resources were considered for estimating the total cost of this alternative (Table 2 and Table 3):

- Capital costs: cost of the system, planning and construction.
- Operational costs: cost of electricity, the maintenance cost and cost of human resources.

The total capital cost for the project has been estimated by MUHC Radiation Oncology at $44M (projection for 2020). The number of patients treated under this alternative is expected to include a greater percentage of eligible patients compared to the base case (Appendix A).

The capital cost will be financed by different sources: MUHC Foundations ($20M) and the Quebec MoH ($24M) through a loan that will be incorporated in the reimbursement to the MUHC during the first 5 years of operation[13].

4.2 Budget impact analysis

A budget impact analysis comparing the base case and the proposed alternative was carried out using Microsoft Excel. For the base case, we estimated the future costs to be assumed if eligible patients continue being sent to be treated in the United States. In this context, the costs incurred are estimated from the perspective of the Quebec Ministry of

Health as payer of the total cost. For the proposed alternative, we estimated the cost of construction and implementation of a proton therapy centre at the MUHC. In this scenario, costs are incurred by both the MUHC and the Quebec Ministry of Health (MoH) as co-financers of the construction costs for the new technology. Further, the Quebec Ministry of Health will serve as the payer of the amount received by the MUHC per patient treated. Therefore, this budget impact analysis is a comparison of the two alternatives from the perspective of MoH. All savings are presented from the perspective of the Quebec Ministry of Health.

The time horizon for both strategies is 12 years, from 2019 until 2030. For the proposed alternative, the first two years are spent on construction of the proton therapy centre at the MUHC followed by 10 years of operation. The cumulative results of the Budget Impact analysis are presented by year and over 6 (2025) and 12 years (2030).

A gross costing method was adopted with input from multiple sources: our panel of experts, the MUHC clinical plan[13], costs provided by the Department of Finance of the MUHC and estimates of efficacy reported by INESSS and CADTH in their most recent reports. Costs are presented in 2019 Canadian dollars and are forecasted using an inflation of 2% according to the midpoint inflation control target established by the bank of Canada and applied to all costs. There is no discounting[14] and only direct costs are included.

4.2.1 Scenario analyses

We compared the primary analysis with the following scenarios:

1. Scenario 1: All patients (vs. only a fraction of eligible patients assumed in the primary analysis) received proton therapy based on the theoretical incidence and prevalence of the indications under the proposed alternative
2. Scenario 2: The money disbursed by the MUHC Foundation is an interest-free loan to be returned in a term of 10 years ($2M per year) under the proposed alternative.
3. Scenario 3: Combination of scenarios 1 and 2.

4.2.2 Annual growth rate and number of patients treated

Defining the annual growth of the number of eligible patients was challenging. Reports on annual numbers of cancer cases that can be treated by proton therapy suggest a relatively slow increase between 1% - 2%[1,15-20]. Whereas, the CADTH report adopted a 3% growth rate for all of Canada, a recent INESSS report relied on the actual number of patients sent to the US by Quebec between 2010 – 2016 resulting in an annual growth rate of 47%. We obtained numbers for 2017-2018 from RAMQ.

In our budget impact analysis, we assumed that the number of patients sent to the US under the base case would increase annually by 18% within the first 5 years and then slow down to 9% for the rest of the model. Under the proposed alternative; we assumed the introduction of this technology on site would enable treatment of an additional 10% of the total number of eligible patients; as those whose requests are turned down under the base case scenario would also receive the treatment.

Following input from our expert committee and taking into consideration the high number of eligible patients estimated by INESSS[12], under Scenario 1 we assumed a cohort of 110 patients would be treated with proton radiation therapy in 2021 (15 patients/million). Further, we assumed an annual growth rate of 5% in the first 5 years followed by a growth rate of 3% in the next 5 years. This reduction was assumed for both cohorts (base case and alternative), as it was more conservative than using fixed annual increments and gave more realistic results. Nevertheless, the impact of lower and higher patient growth rates on our conclusions were explored in the sensitivity analyses.

4.3 Cost input

4.3.1 MoH perspective for the base case and the proposed alternative

The total cost for the base case of referring patients to the US is determined by using the estimated number of treated patients and the referral cost per patient. The referral cost is calculated as the mean cost per patient in the last 5 years 2014 - 2019[10] (Table 1).

Under the proposed alternative, the first and second-year costs included a portion of the construction costs assumed by the MoH ($12M each year) as well as the total cost for referring patients to the US in those years. From the third year onwards when all patients are treated at the MUHC, physicians' costs and the reimbursement to the MUHC per

patient treated were considered. The return of the loan to the MoH is seen in five equal instalments starting in 2021.

4.3.2 MUHC Foundations' input

The remaining part of the acquisition and construction costs in the first two years, will be covered by a grant from the MUHC Foundation ($20M). Although this is not considered to be part of the MUHC budget, this amount reflects the opportunity cost of investing it elsewhere into the hospital and hence has been taken into account in Scenario 2 and Scenario 3 – where this amount will be considered in the budget analysis by treating it as an interest-free loan to be reimbursed to the MUHC Foundation over a term of 10 years; that is $2M of dollars/year since the first year of operation. This additional cost is reflected in the estimate of the reimbursement to the MUHC per patient treated.

4.3.3 MUHC Perspective for the proposed alternative

From the first year of operation in 2021 onwards, costs incurred by the MUHC include electricity costs, salaries of technical support staff and portion of the loan to be returned (government and MUHC foundation). Maintenance costs are included from the second year of operation onwards as they are covered under the construction costs during the first year of operation (Table 2).

4.4 Sensitivity Analyses

Uncertainty around the budget impact estimates was examined through a probabilistic sensitivity analysis of the variables *growth rate (of the number of patients treated under the base case and alternative)* and the *cost per patient treated in the US*, which were associated with the greatest uncertainty and which had the greatest influence on the budget impact. The growth rate could range from 1-20% during the first 5 years and the cost per patient treated in the US was allowed to range from $275,000-$350,000 (Appendix C). Additionally, following the rationale behind the declining annual growth rate mentioned in the primary analysis, for the number of patients to be sent to the US, we assumed the growth rate will decrease to half its value if it is larger than 5% during the first five years and to a quarter of its value if it is larger than 10% during the first five years. These settings were selected to limit unrealistically high or low values for the lower and upper limits of the growth rate.

We carried out a Monte Carlo simulation by drawing 2000 random values from the joint distribution of these variables centred at the values used in the primary (deterministic) analysis (Appendix C). The 50% quantile of the draws was used to report a point estimate of the budget impact while the 2.5% and 97.5% quantiles were used to produce 95% confidence intervals. Additionally, the probability of achieving a saving of $50M was determined.

5. RESULTS

5.1 Primary Analysis

Results are presented in the following order. First, we present the base case. This is followed by the proposed alternative from the perspective of the MUHC in order to obtain the amount paid to the MUHC per patient treated. Finally, we present the proposed alternative from the perspective of the MoH, which relies on the payment to the MUHC per patient treated (refer to section 4.3 for costs associated with the different perspectives).

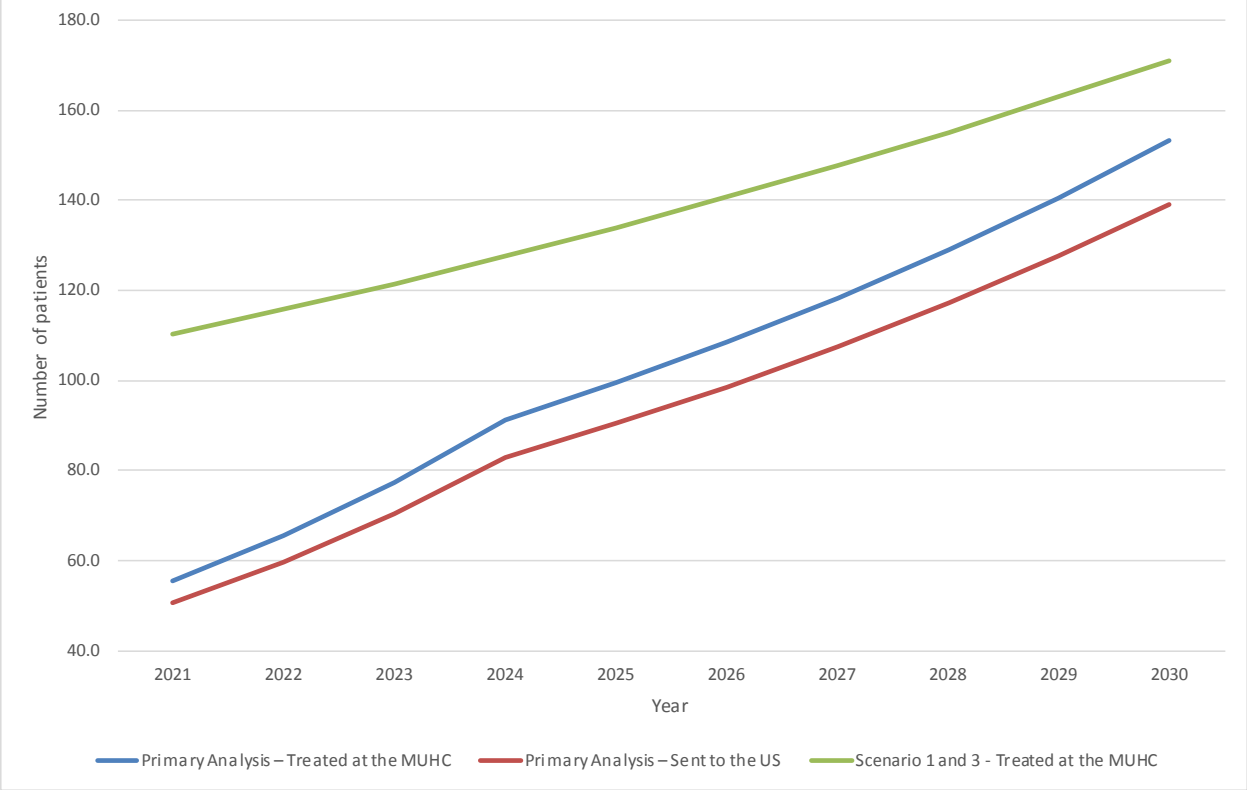


Figure 1. A comparison of the number of patients treated in the primary analysis and in Scenarios 1 and 3

5.1.1 Base Case: Refer patients to receive proton therapy in the United States (US)

RAMQ / MoH Perspective

The projected number of patients eligible for referral to the US is projected to increase from 51 in 2021 to 91 in 2025 to 139 in 2030 (Figure 1 (red line) and Table 3); with an estimated cost per patient of $334,362, $ $361,924 and $399,594 for the same years respectively (Figure 2 (red line) and Table 3). The total expenditure for the first year (2019) is close to $11.6M and will continually increase every year for an estimated cumulative expenditure at 7 years (in 2025) of $149.7M and $377.3M in 2030 (Table 3).

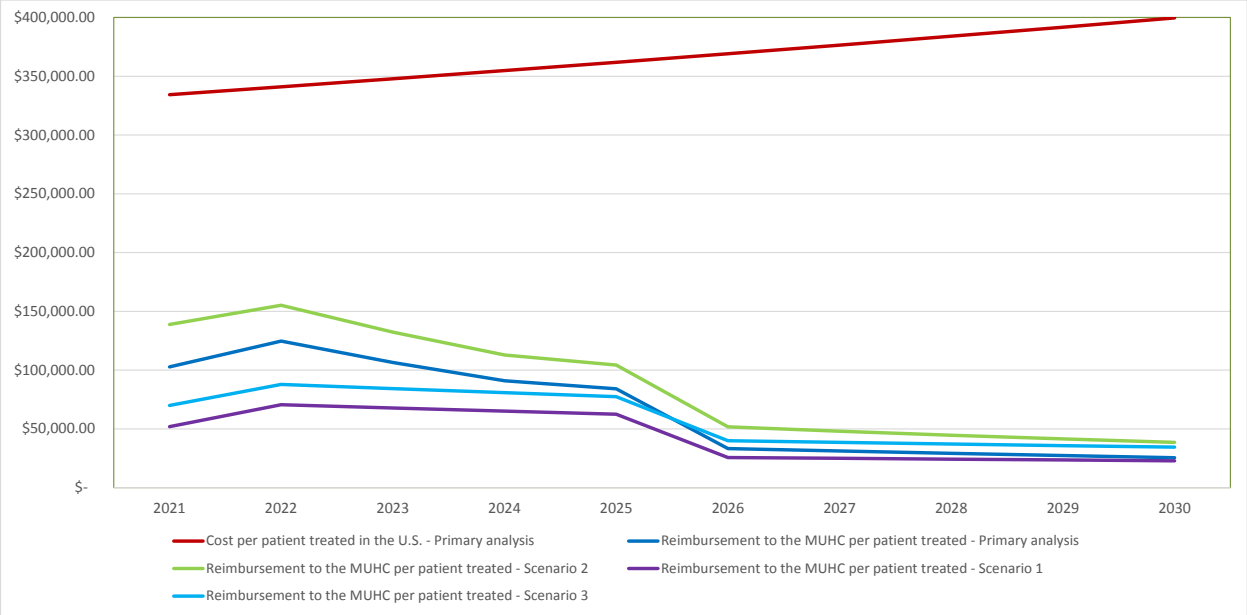


Figure 2. Cost per patient treated in the US and amount reimbursed to the MUHC per patient treated under different scenarios over time

5.1.2 Proposed alternative: Offer proton therapy at the MUHC

MUHC Perspective

The costs were highest in the year 2022 in every scenario evaluated, due to the ratio between the number of patients treated and the operational costs incurred. In the primary analysis, a total of 66 patients were projected to receive treatment in this year, resulting in a total cost of $8.1M. In the same year, the reimbursement to the MUHC per patient treated is $124,630 (Figure 1 and Figure 2 (blue line); Table 2). When the number of patients treated is increased (Scenario 1), this amount reduces to $70,632 (Figure 2 (purple

line) and Appendix F). Under Scenario 2, when the contribution of the MUHC Foundation is treated as an interest-free loan, it increases to $155,115. Under Scenario 3, when the number of patients treated is increased and the amount from the MUHC Foundation is treated as a loan, it is $87,909.

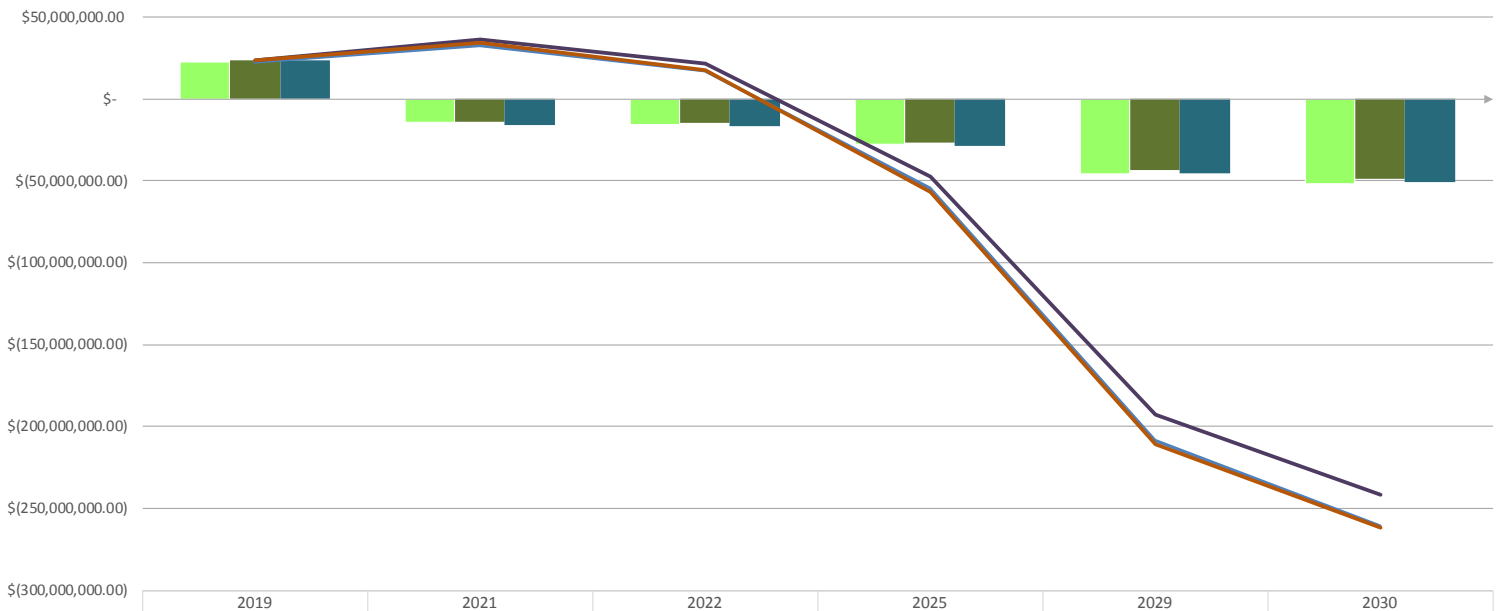
In the subsequent years, as the number of patients treated increases, and the loan to the government or MUHC Foundation is paid, the amount received by the MUHC per patient treated decreases under all scenarios, especially after 2025 (Figure 2).

MoH Perspective

The total expenditure is estimated at $23.8M for the first year (2019) and $26M for 2020. However, for the following years, after including the return of the loan and the estimated amount received by the MUHC per patient treated, the total cost per year reflects an increasing negative budgetary impact (savings), with a cumulative estimation close to -$57M in 2025, and -$261M at the end of the simulation (2030) when compared with the base case. The same trend in the budget impact was also true in Scenarios 1-3 (Figure 3).

In all scenarios, from the third year of operation onwards the payer would obtain cumulative savings when comparing with the base case of sending patients to receive treatment in the U.S. See all costs included in the comparison of both alternatives in Table 3 and the results of Scenarios 1-3 in Appendix F.

Finally, the cost per patient treated from the perspective of the government is seen to range from $56,715 in the most expensive year, decreasing to $31,378 at the end of the simulation.



	2019	2021	2022	2025	2029	2030
BI primary analysis	$22,507,447.04	$(14,395,138.65)	$(15,435,175.42)	$(27,771,954.13)	$(45,949,016.98)	$(51,962,266.12)
BI Primary analysis Scenario 2	$23,760,350.00	$(13,646,221.05)	$(14,620,030.34)	$(26,407,279.47)	$(43,344,427.28)	$(48,846,584.69)
BI Primary analysis Scenario 1	$23,760,350.00	$(15,646,221.05)	$(16,620,030.34)	$(28,407,279.47)	$(45,344,427.28)	$(50,846,584.69)
Cumulative BI primary analysis	$22,507,447.04	$32,952,722.78	$17,517,547.36	-$54,682,752.71	-$208,598,403.03	-$260,560,669.15
Cumulative BI Primary analysis Scenario 2	$23,760,350.00	$36,249,687.64	$21,629,657.31	-$47,060,364.92	-$192,757,193.40	-$241,603,778.09
Cumulative BI Primary analysis Scenario 1	$23,760,350.00	$34,249,687.64	$17,629,657.31	-$57,060,364.92	-$210,757,193.40	-$261,603,778.09

Figure 3. Cumulative and yearly budget impact (BI) analysis results in the primary analysis (MoH perspective).

5.2 Sensitivity analysis

The upper and lower limits of varying the growth rate and cost per patient values in the probabilistic sensitivity analysis are presented in Figure 4 and Figure 5, respectively. The impact on the BIA is presented in Figure 6. Full details of the results obtained in the probabilistic sensitivity analysis are presented in Table 4, Table 5, Table 6, Table 7 and Table 8.

5.2.1 Base Case - Refer patients to receive proton therapy in the United States (US)

RAMQ / MoH Perspective

The average number of patients eligible for referral to the US is projected to be 48 in 2021 to 107 in 2030, with an estimated cost per patient of $324,467 to $387,768, respectively. The total expenditure will continually increase every year for an estimated cumulative expenditure in 2025 of $110M and $290M in 2030.

When the growth rate is at its lower limit of 5%, the total number of patients to be treated in 2030 is projected to be only 61 (Figure 4, dashed green line), the cost per patient is $362,004 (Figure 5, dashed green line) and the cumulative expenditure at the end of the simulation will be $166M. At the upper limit of the growth rate of 33%, we expect 238 patients will be treated in 2030 (Figure 4, solid green line), a cost per patient of $415,496 (Figure 5, solid green line) resulting in a cumulative expenditure of $619M in 2030.

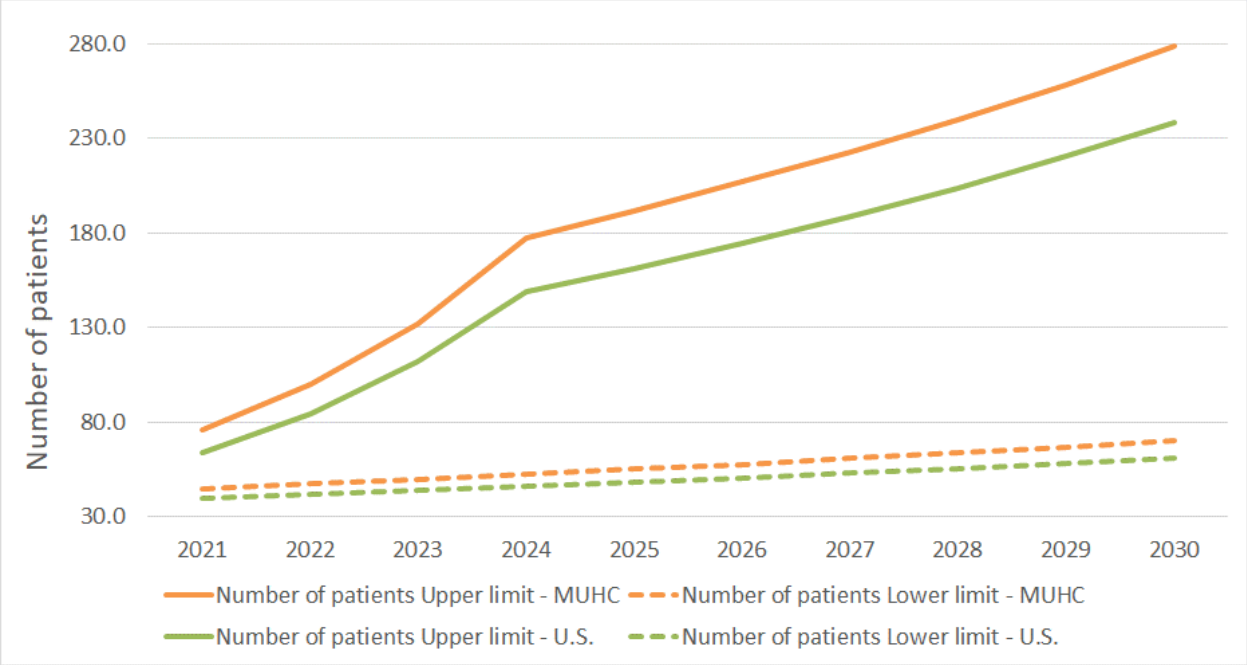


Figure 4. Number of eligible patients to be treated: US compared to MUHC. Lower and upper limits input to the probabilistic sensitivity analysis

5.2.2 Proposed alternative: Offer proton therapy at the MUHC

MUHC Perspective

With a projected average of 56 patients treated in 2021 the amount reimbursed to the MUHC per patient treated is estimated at $104,148. The lower limit of the number of eligible patients increases from 45 in year 2021 to 70 in 2030 (Figure 4; dashed orange line). The upper limit in contrast goes from 76 eligible patients in 2021 to 278 in year 2030 (Figure 4, solid orange line). The corresponding lower and upper limits of the amount received by the MUHC per patient treated are $15,744 and $78,552 in 2030 respectively (orange lines, Figure 5). This amount drops significantly once the loan has been fully paid, plateauing after 2026 (Figure 5).

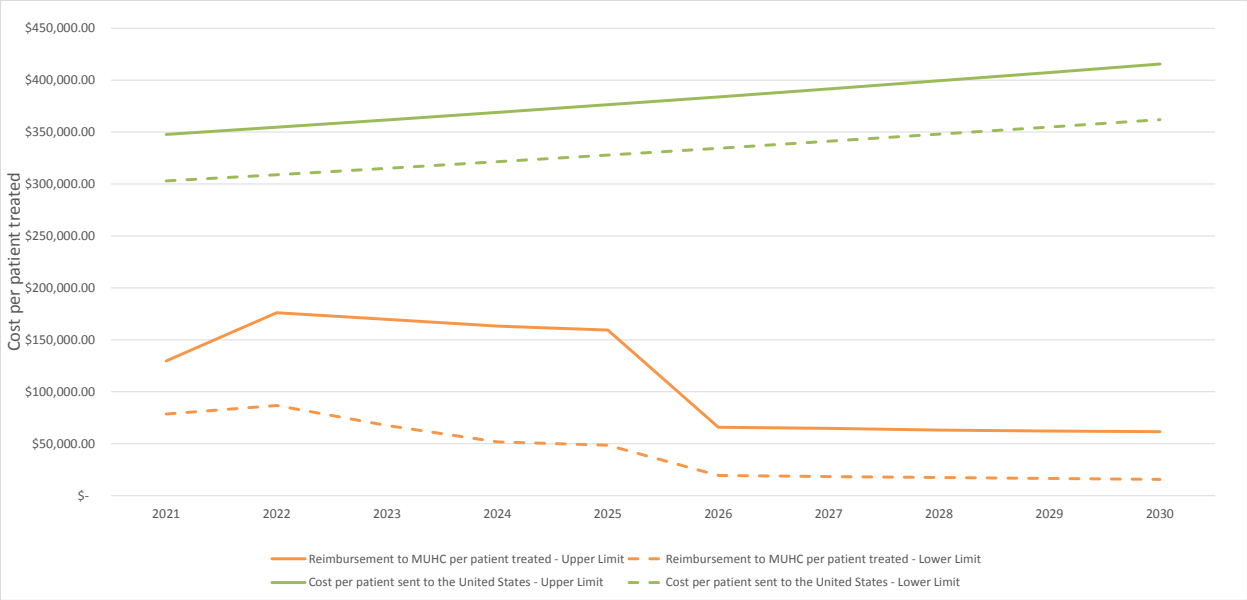


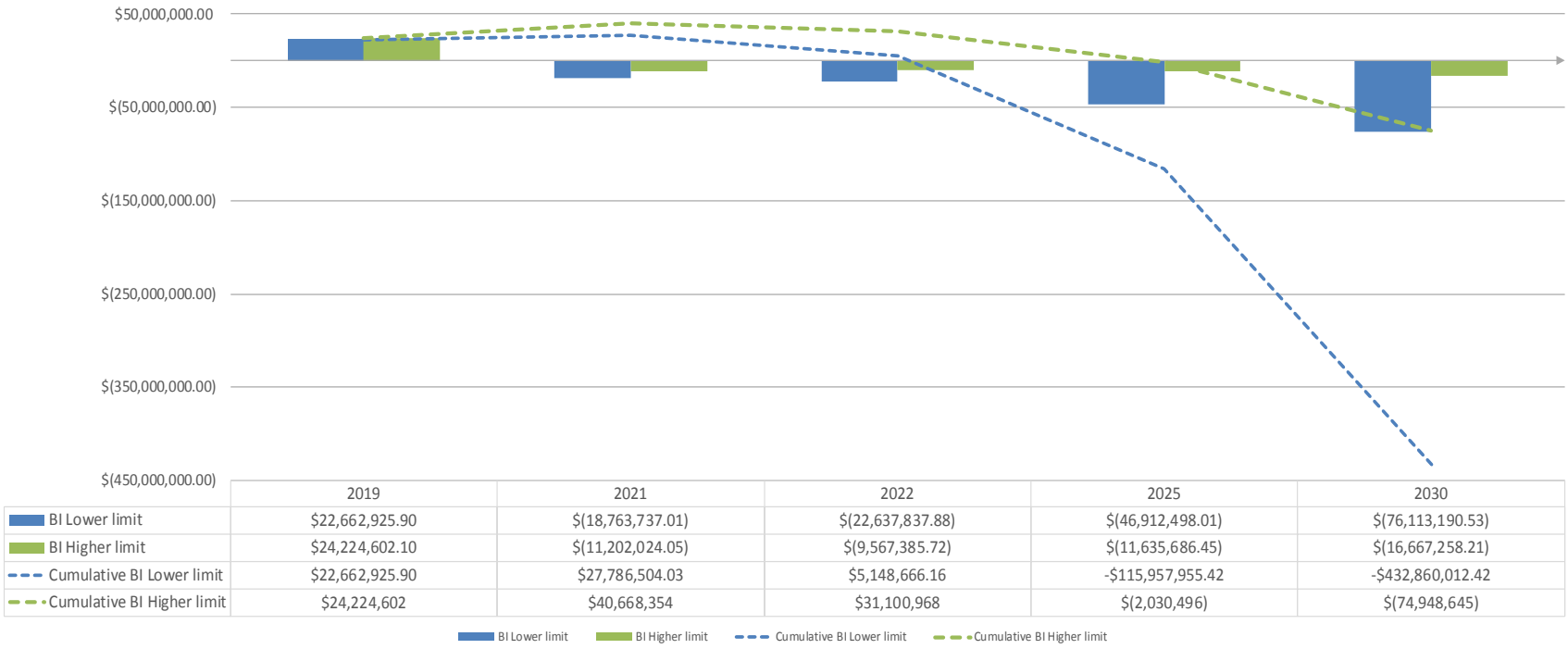
Figure 5. Cost per patient treated in the US and reimbursement to the MUHC per patient treated. Lower and upper limits input to the probabilistic sensitivity analysis

MoH Perspective

After the capital investment in the two first years, the average budget impact analysis displays yearly savings that increase over time from -$14.4M in 2021 to -$36.7M in 2030. This is equivalent to cumulative savings of -$45M after 5 years of operation to -$200M at the end of the model in year 2030.

The lower limits of the budget impact are -$18.7M in 2021 to -$76M in 2030. This is equivalent to cumulative savings of -$112M after 5 years of operation to over -$400M at the end of the model in year 2030, producing cumulative savings by year 2022, making this the most optimistic scenario.

The upper limit of the budget impact which corresponds with smaller savings or a more pessimistic scenario also reflects savings in each year, increasing from -9.5M in 2022 to -$16.6M in 2030 and producing a positive return over the investment by 2026 (Figure 6), with a cumulative budgetary impact of -$6.9M at year 2025 and -$80.5M at the end of the model in year 2030.



	2019	2021	2022	2025	2030
BI Lower limit	$22,662,925.90	$(18,763,737.01)	$(22,637,837.88)	$(46,912,498.01)	$(76,113,190.53)
BI Higher limit	$24,224,602.10	$(11,202,024.05)	$(9,567,385.72)	$(11,635,686.45)	$(16,667,258.21)
Cumulative BI Lower limit	$22,662,925.90	$27,786,504.03	$5,148,666.16	-$115,957,955.42	-$432,860,012.42
Cumulative BI Higher limit	$24,224,602	$40,668,354	$31,100,968	$(2,030,496)	$(74,948,645)

Figure 6. Cumulative and yearly budget impact analysis results. Lower and upper limits of the probabilistic sensitivity analysis (MoH perspective)

Finally, it is observed that in 34.5% and 100% of the 2000 scenarios evaluated, the construction of a proton therapy centre at the MUHC will produce savings greater than $50M at years 2025 and 2030 respectively, compared to continuing to send patients for treatment in the US. Even in the other 65.5% of the scenarios explored in 2025, there were savings (>$0).

6. DISCUSSION AND CONCLUSION

Proton beam therapy is a technology available in many industrialized countries[9,11] for treatment of patients particularly at risk for damage to surrounding healthy tissues with the widely available photon therapy. Building a single vault proton therapy centre is an expensive investment and that is why patients in Canada are currently being sent to receive treatment in the United States at a high cost. However, the number of patients is rapidly increasing, as are the costs of treating these patients abroad.

This report attempted to forecast different scenarios that could arise when considering construction and implementation of a proton therapy centre at the MUHC. We estimated the difference in costs incurred by the payer (the Quebec Ministry of Health) when spending on treatment abroad vs. treatment at the MUHC in a time horizon of 12 years. We found that in the vast majority of scenarios explored, despite the high initial investment, the payer would obtain savings once the proton accelerator vault is operating, i.e. after the third year in the model.

The number of eligible patients is not only the main cost driver in this analysis but also the variable associated with the highest level of uncertainty. Our primary analysis relied on numbers from the RAMQ to forecast the number of patients treated. Our clinical experts opined that that the number treated will increase in the next few years due to the expansion of clinical indications. They also believe that the number of eligible patients could be far greater than the number of patients treated. Therefore, we considered a scenario based on a forecast made in 2010 of over 100 eligible patients per year[12]. These numbers should be validated by comparing with actual numbers of diagnoses obtained in recent years. Additionally, during the production of this document, we learned about a Canadian Centre *TRIUMF* that observed a reduction in the number of patients in the last years. Although their experience is based only in ocular cancer (5% of proton therapy patients in Quebec[10]) it supports the need to be conservative in estimating growth rate in the number of treated patients in order to avoid overestimating the number of eligible

patients. Nonetheless, across scenarios exploring this uncertainty, we still found net savings; this might be even truer in the context where it is expected that this technology can serve patients across Canada. These findings are believed to be robust enough, built with real data and using realistic assumptions.

The results presented by CADTH consider the option of constructing a proton therapy centre for Canada to be less expensive than continuing sending patients abroad in a time horizon of 10 years as by year 9 their model starts showing a positive return over the investment. However, these results cannot be extrapolated to the context of Quebec as our province seems to have a larger demand for this technology and is the one that sends the most patients to receive treatment in the US. Finally, the number of patients treated is forecast based only on the number of patients sent to the US, and does not take into consideration the number of eligible patients.

A limitation of our model is that it did not incorporate certain domains that could be relevant such as indirect costs (productivity and time losses) or the cost of managing side effects. It is perceived that the availability of a local treatment will bring additional benefits to these patients and allow the MUHC to treat all possible candidates from the province, and also attract more patients from across the country (or abroad) who could benefit from it. Additionally, besides the patient benefit, the presence of such a technology in the province is expected to have a positive impact on the economy of Quebec, due to creation of new employment it will generate and visitors it will attract. Also it will ensure the money expended remains in the province instead of being transferred abroad. Finally, there are also plans[13] for some associated academic and research activities that will bring added value to the scientific and academic community, besides public and patients in general.

Building a proton therapy centre is an expensive mid-term investment. However, the results obtained from our simulations seem to support pursuing this approach for its budgetary impact in the mid and long term.

7. RECOMMENDATIONS

No recommendation was issued to the MUHC administration as it was not the principal stakeholder. Nonetheless, the findings of this report are relevant to the MUHC administration. It provides information on the maximum and minimum possible values of the reimbursement to the MUHC that is necessary if proton therapy is offered on-site.

8. TABLES

Table 1. Number of patients from Quebec sent to the US for proton therapy since 2005 and corresponding cost.

Year	2005 - 2007[X]	2008- 2009[X]	2010	2011	2012*	2013*	2014	2015	2016*	2017[§]	2018[§]	2019[§]
Number of patients	21 accepted (11 treated)		8	3	7	13	7	16	23	10	28	33
Total Cost	$ 2,250,000.00		$ 1,341,000.00	$ 415,000.00	$ 1,430,000.00	$ 3,287,000.00	$ 1,717,000.00	$ 5,609,000.00	$ 2,660,000.00	$ 3,534,724.66	$ 9,312,230.22	$ 8,237,961.33
Cost per patient	$ 177,005.00	$ 252,826.00	$ 167,625.00	$ 138,333.33	$ 204,285.71	$ 252,846.15	$ 245,285.71	$ 350,562.50	$ 115,652.17	$ 353,472.47	$ 332,579.65	$ 249,635.19

[X] *Mean cost per patient presented.*

Estimated total cost until Dec 2019.	**$**	**39,793,916.21**

** Lacking some data cost.*

[§] *Cost per patient based on the number of patients reimbursed at the moment.*

Table 2. Estimation of the amount received by the MUHC per patient treated in the base case

Proposed Alternative	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Patients treated	40	47	56	66	77	91	100	109	118	129	141	153
Maintenance - service	$ -	$ -	$ -	$2,441,966.95	$2,490,806.29	$ 2,540,622.42	$ 2,591,434.87	$2,643,263.56	$2,696,128.83	$2,750,051.41	$2,805,052.44	$ 2,861,153.49
Electricity	$ -	$ -	$ 294,134.70	$ 300,017.40	$ 306,017.74	$ 312,138.10	$ 318,380.86	$ 324,748.48	$ 331,243.45	$ 337,868.32	$ 344,625.68	$ 351,518.20
Staff salaries	$ -	$ -	$ 585,164.66	$ 596,867.95	$ 608,805.31	$ 620,981.42	$ 633,401.04	$ 646,069.06	$ 658,990.45	$ 672,170.25	$ 685,613.66	$ 699,325.93
Loan			$4,837,718.19	$4,837,718.19	$4,837,718.19	$ 4,837,718.19	$ 4,837,718.19					
Total cost per year	$ -	$ -	$5,717,017.55	$8,176,570.49	$8,243,347.54	$ 8,311,460.12	$ 8,380,934.96	$3,614,081.11	$3,686,362.73	$3,760,089.98	$3,835,291.78	$ 3,911,997.62
	Total expended from 2019 until 2025						***$ 38,829,330.67***	***Total expended from 2019 until 2030***				***$ 57,637,153.89***
Reimbursement to the MUHC per patient treated	na	na	$ 102,826.77	$ 124,630.93	$ 106,482.02	$ 90,984.62	$ 84,169.86	$ 33,299.33	$ 31,160.84	$ 29,159.69	$ 27,287.05	$ 25,534.67

Table 3. Budget impact analysis

Base Case (U.S. Referral)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	36	43	51	60	70	83	91	99	108	117	128	139
Cost per patient treated	$ 321,378.91	$ 327,806.49	$ 334,362.62	$ 341,049.87	$ 347,870.87	$ 354,828.29	$ 361,924.85	$ 369,163.35	$ 376,546.62	$ 384,077.55	$ 391,759.10	$ 399,594.28
Total cost per year	$ 11,666,054.52	$ 14,041,263.22	$ 16,900,064.41	$ 20,340,917.52	$ 24,482,328.33	$ 29,466,930.37	$ 32,761,333.19	$ 36,424,050.24	$ 40,496,259.06	$ 45,023,740.82	$ 50,057,395.04	$ 55,653,811.81
	Total expended from 2019 until 2025						$ 149,658,891.54	Total expended from 2019 until 2030				$ 377,314,148.50
Proposed Alternative	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Targeted population	40	47	56	66	77	91	100	109	118	129	141	153
Reimbursement to the MUHC per patient treated	$ -	$ -	$ 102,826.77	$ 124,630.93	$ 106,482.02	$ 90,984.62	$ 84,169.86	$ 33,299.33	$ 31,160.84	$ 29,159.69	$ 27,287.05	$ 25,534.67
Loan to the MUHC	$ 12,094,295.48	$ 12,094,295.48										
Return of the loan (-)	$ -	$ -	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ -	$ -	$ -	$ -	$ -
Staff - MDs	$ -	$ -	$ 374,544.00	$ 382,034.88	$ 389,675.58	$ 397,469.09	$ 810,836.94	$ 827,053.68	$ 843,594.75	$ 860,466.65	$ 877,675.98	$ 895,229.50
Cost per patient treated	$ -	$ -	$ 22,551.73	$ 56,715.42	$ 49,025.20	$ 42,377.71	$ 43,727.83	$ 40,919.62	$ 38,291.76	$ 35,832.65	$ 33,531.47	$ 31,378.08
Total cost per year	$12,094,295.48	$ 12,094,295.48	$ 1,253,843.36	$ 3,720,887.18	$ 3,795,304.92	$ 3,871,211.02	$ 4,354,053.71	$ 4,441,134.79	$ 4,529,957.48	$ 4,620,556.63	$ 4,712,967.77	$ 4,807,227.12
	Total expended from 2019 until 2025						$ 41,183,891.16	Total expended from 2019 until 2030				$ 64,295,734.95
Budget impact per year	$ 23,760,350.00	$ 26,135,558.70	$ (15,646,221.05)	$ (16,620,030.34)	$ (20,687,023.40)	$ (25,595,719.35)	$ (28,407,279.47)	$ (31,982,915.45)	$ (35,966,301.57)	$ (40,403,184.18)	$ (45,344,427.28)	$ (50,846,584.69)
	Budgetary Impact at 7 years						$ (57,060,365)	Budgetary Impact at 12 years				$ (261,603,778)

Table 4. Input for the probabilistic sensitivity analysis: Number of patients treated in the US.

	U.S. patients 2020	U.S. patients 2021	U.S. patients 2022	U.S. patients 2023	U.S. patients 2024	U.S. patients 2025	U.S. patients 2026	U.S. patients 2027	U.S. patients 2028	U.S. patients 2029	U.S. patients 2030
2.5	38	40	42	44	46	48	51	53	56	58	61
AVG	42	48	56	65	76	80	85	90	96	101	107
97.5	48	64	85	112	149	161	174	188	204	220	238

2.5=2.5 percentile; AVG=average; 97.5=97.5 percentile

Table 5. Input for the probabilistic sensitivity analysis: Number of patients treated at the MUHC.

	MUHC patients 2021	MUHC patients 2022	MUHC patients 2023	MUHC patients 2024	MUHC patients 2025	MUHC patients 2026	MUHC patients 2027	MUHC patients 2028	MUHC patients 2029	MUHC patients 2030
2.5	45	47	50	52	55	58	61	64	67	70
AVG	56	65	75	88	93	98	104	110	117	124
97.5	76	100	132	177	192	207	223	240	258	278

2.5=2.5 percentile; AVG=average; 97.5=97.5 percentile

Table 6. Input for the probabilistic sensitivity analysis: Cost per patient treated in the US

	$ Pt sent US 2021	$ Pt sent US 2022	$ Pt sent US 2023	$ Pt sent US 2024	$ Pt sent US 2025	$ Pt sent US 2026	$ Pt sent US 2027	$ Pt sent US 2028	$ Pt sent US 2029	$ Pt sent US 2030
2.5	$ 302,909.18	$ 308,967.36	$ 315,146.71	$ 321,449.64	$ 327,878.63	$ 334,436.21	$ 341,124.93	$ 347,947.43	$ 354,906.38	$ 362,004.51
AVG	$ 324,467.32	$ 330,956.66	$ 337,575.80	$ 344,327.31	$ 351,213.86	$ 358,238.14	$ 365,402.90	$ 372,710.96	$ 380,165.18	$ 387,768.48
97.5	$ 347,668.62	$ 354,622.00	$ 361,714.44	$ 368,948.72	$ 376,327.70	$ 383,854.25	$ 391,531.34	$ 399,361.96	$ 407,349.20	$ 415,496.19

2.5=2.5 percentile; AVG=average; 97.5=97.5 percentile

Table 7. Input for the probabilistic sensitivity analysis: Amount transferred to the MUHC per patient treated

	CPPT 2021	CPPT 2022	CPPT 2023	CPPT 2024	CPPT 2025	CPPT 2026	CPPT 2027	CPPT 2028	CPPT 2029	CPPT 2030
2.5	$ 78,552.60	$ 86,827.92	$ 67,598.35	$ 51,798.35	$ 48,560.19	$ 19,483.46	$ 18,472.37	$ 17,507.90	$ 16,629.97	$ 15,744.93
AVG	$ 104,148.46	$ 130,516.92	$ 115,623.26	$ 102,721.48	$ 97,995.48	$ 39,990.12	$ 38,610.41	$ 37,287.67	$ 36,019.19	$ 34,802.39
97.5	$ 129,660.61	$ 176,110.25	$ 169,733.79	$ 163,255.56	$ 159,453.21	$ 65,878.33	$ 64,813.92	$ 63,161.28	$ 62,233.61	$ 61,631.20

2.5=2.5 percentile; AVG=average; 97.5=97.5 percentile

Table 8. Results of the probabilistic sensitivity analysis: Budget impact analysis results by year

	BIA 2019	BIA 2020	BIA 2021	BIA 2022	BIA 2023	BIA 2024	BIA 2025	BIA 2026	BIA 2027	BIA 2028	BIA 2029	BIA 2030
2.5	$ 22,662,925.90	$ 23,887,315.14	$ (18,763,737.01)	$ (22,637,837.88)	$ (31,326,058.24)	$ (42,868,065.33)	$ (46,912,498.01)	$ (51,724,453.41)	$ (57,002,819.56)	$ (62,823,048.57)	$ (69,238,544.93)	$ (76,113,190.53)
AVG	$ 23,415,098.65	$ 25,394,401.20	$ (14,421,675.29)	$ (14,815,146.95)	$ (18,197,408.66)	$ (22,313,430.87)	$ (23,912,119.58)	$ (26,078,318.53)	$ (28,429,246.21)	$ (30,980,900.45)	$ (33,750,710.51)	$ (36,757,669.81)
97.5	$ 24,224,602.10	$ 27,645,776.02	$ (11,202,024.05)	$ (9,567,385.72)	$ (10,354,558.80)	$ (11,141,219.08)	$ (11,635,686.45)	$ (12,580,615.23)	$ (13,574,886.69)	$ (14,487,071.33)	$ (15,608,317.63)	$ (16,667,258.21)

2.5=2.5 percentile; AVG=average; 97.5=97.5 percentile

APPENDICES

APPENDIX A: REQUIREMENTS TO BE CONSIDERED ELIGIBLE FOR PROTON RADIATION THERAPY ABROAD.

- To have a type of cancer for which proton radiation therapy confer to the patient a significant benefit over the latest PhT techniques available in Québec, such as image-guided radiotherapy (IGRT), volumetric-modulated arc therapy (VMAT), 4-dimensional radiotherapy or radiosurgery, namely:
    - Intraocular melanomas.
    - Skull base and spinal chordomas.
    - Skull base and spinal chondrosarcomas.
    - Meningiomas or intracranial tumours, spinal/paraspinal soft-tissue or bone sarcomas.
    - Pediatric tumours: ependymomas, craniopharyngiomas, pineal gland tumours, primitive neuroectodermal tumours, Ewing's sarcoma, lymphomas, rhabdomyosarcomas, retinoblastomas.

- Proton radiation therapy should be:
    - Curative in intent;
    - Patients should have a good performance score (0 to 2);
    - Patients should have a life expectancy greater than 5 years.

- The patient's should have the ability and willingness to travel.

- Potential patients should be discussed within a committee specializing in cancer diagnosis and treatment. This applies whether proton radiation therapy is to be used as first- or second-line treatment.

- The request for proton radiation therapy should be submitted to the Comité provincial de protonthérapie by a radiation oncologist who has evaluated the patient concerned.

APPENDIX B: SOURCES FOR COSTS AND PROBABILITIES USED IN COST AND SENSITIVITY ANALYSIS.

ITEM	VALUE	SOURCE
Quebec Target Population 2019 - epidemiologic scenario	100	Estimation from AETMIS 2010, MUHC Clinical Plan
Eligible patients to receive treatment in the U.S. in 2019 - base case	36	Estimation using RAMQ data
Annual Patient grow rate for the first 5 years	5%	Estimation using RAMQ data and CADTH
Annual Patient grow rate after 5 years	2.5%	Assumption
Annual growth rate patients sent to the U.S. 1 - 5 Yrs	18%	Estimation using RAMQ data
Annual growth rate patients sent to the U.S. >5 Yrs	9%	Assumption
Inflation rate	2.0%	Bank of Canada Nov 2019
Patient Referral to the US for 2019	$ 321,378.00	Estimation using RAMQ data
Total Construction Costs	$ 44,188,590.96	Plan Clinique, CADTH and Radiation Oncology
Interest free loan from Gouvernment at 5 Years	$ 24,088,590.96	Plan Clinique and Radiation Oncology MUHC
Interest free MUHC Foundation loan	$ 20,000,000.00	Plan Clinique and Radiation Oncology MUHC
Maintenance Service Fees (from 2022)	$ 2,441,966.95	MUHC Plan Clinique
Electricity (From 2021)	$ 294,134.70	MUHC Plan Clinique
$ Staff salaries MUHC (No Physicians salaries) (2021)	$ 585,164.66	Radiation Oncology MUHC
$ 1 Physician Salary Paid by RAMQ until 2025	$ 374,544.00	(Difference CADTH - MUHC)
$ 2 Physician Salary Paid by RAMQ (2 Physician) from 2025	$ 810,836.94	(Difference CADTH - MUHC)

AETMIS: Agence d'évaluation des technologies et des modes d'intervention en santé; MUHC: McGill University Health Centre;
RAMQ: Régie de l'Assurance Maladie du Québec; CADTH: Canadian Association of Drugs and Technologies in Health

APPENDIX C: INPUT FOR PROBABILISTIC SENSITIVITY ANALYSES

Item	Value in the model	Deterministic		Probabilistic			
		Mean Value	St Err	Value	Distribution	Alpha	Beta
Quebec Eligible Pop 2019	100.0				NA		
Annual patient growth rate for the first 5 years	5%	5%	22.5%	2%	Beta	3.242	71.085
Annual patient growth rate after 5 years	3%	2.5%	NA	2%	NA	NA	NA
Eligible patients to receive treatment in the U.S. in 2019	36	3%					
Annual growth rate patients sent to the U.S. 1 - 5 Yrs	18%	18%		14%	Beta	4.560	25.220
Annual growth rate patients sent to the U.S. >5 Yrs	9%	9%		5%			
Variability rate for eligible extra patients from baseline	10%	10%		6%	Beta	4.560	25.220
Inflation rate	2.0%		NA	NA	NA	NA	NA
Patient referral to the US for 2019	$ 321,378.91	$ 321,378.91	$ 58,194.74	$ 298,715.59	Gamma	881.3532	353.6080
Total Construction Costs 2020	$ 44,188,590.96						
Interest free loan from the government at 5 years	$ 24,188,590.96						
Construction costs assumed by the MUHC foundations	$ 20,000,000.00						
Maintenance Service Fees (from 2022)	$ 2,441,966.95						
Electricity (From 2021)	$ 294,134.70						
Approximate fees paid by RAMQ to MUHC (Year 2021)	$ 124,630.93						
Staff salaries MUHC (no physicians) (2021)	$ 585,164.66						
1 physician paid by RAMQ until 2025	$ 374,544.00						
2 physicians paid by RAMQ from 2025	$ 810,836.94						

In the sensitivity analysis the number of physicians was not increased in the lower limit case and increased up to 3 in the upper limit case.

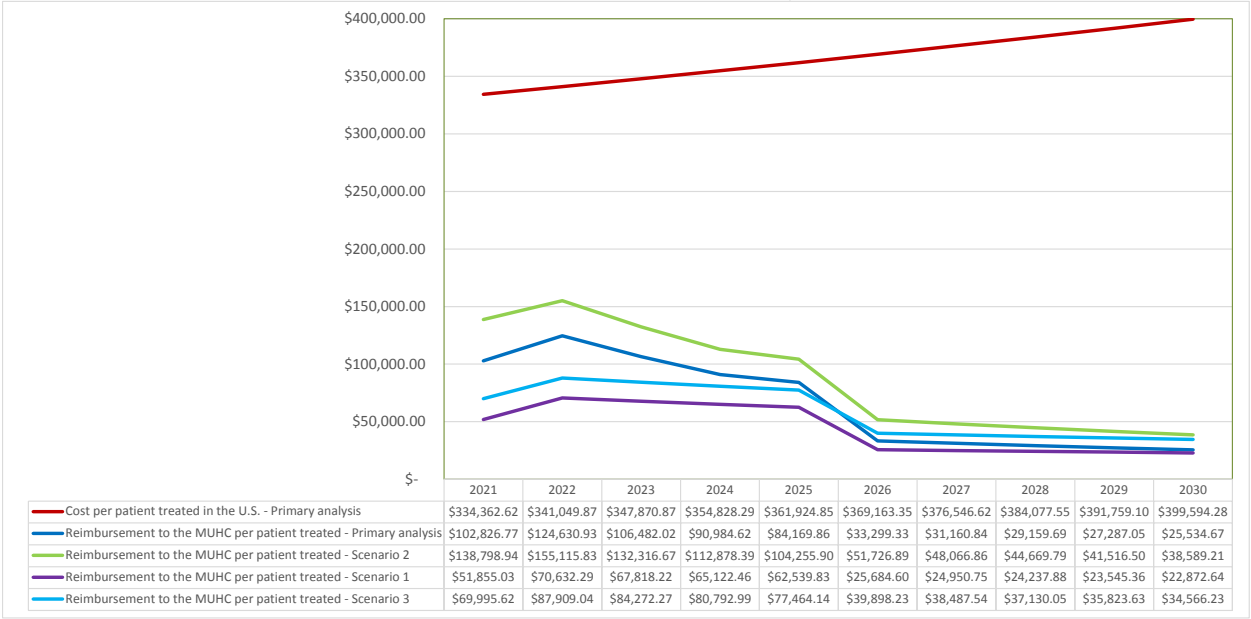
APPENDIX D: RAMQ DATA ON NUMBER OF PATIENTS TREATED IN THE US AND COSTS IN 2017-2019

Direction générale des programmes hors du Québec, des aides techniques et financières
Autorisations médicales hors Québec
Nombre et coûts pour des traitements de protonthérapie aux États-Unis
Pour les années 2017 à 2019

Année	Nombre de demandes d'autorisation			Montants payés
	Reçue	Acceptée	Remboursée	
2017	11	10	7	2,474,307 $
2018	31	28	27	8,979,651 $
2019	34	33	17	4,243,798 $
Total :	**76**	**71**	**51**	**15,697,756 $**

Note : Les résultats de l'année 2019 sont provisoires dû au délai de réception des services et au délai de facturation.

APPENDIX E: REIMBURSEMENT TO THE MUHC PER PATIENT TREATED IN EACH YEAR



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cost per patient treated in the U.S. - Primary analysis	$334,362.62	$341,049.87	$347,870.87	$354,828.29	$361,924.85	$369,163.35	$376,546.62	$384,077.55	$391,759.10	$399,594.28
Reimbursement to the MUHC per patient treated - Primary analysis	$102,826.77	$124,630.93	$106,482.02	$90,984.62	$84,169.86	$33,299.33	$31,160.84	$29,159.69	$27,287.05	$25,534.67
Reimbursement to the MUHC per patient treated - Scenario 2	$138,798.94	$155,115.83	$132,316.67	$112,878.39	$104,255.90	$51,726.89	$48,066.86	$44,669.79	$41,516.50	$38,589.21
Reimbursement to the MUHC per patient treated - Scenario 1	$51,855.03	$70,632.29	$67,818.22	$65,122.46	$62,539.83	$25,684.60	$24,950.75	$24,237.88	$23,545.36	$22,872.64
Reimbursement to the MUHC per patient treated - Scenario 3	$69,995.62	$87,909.04	$84,272.27	$80,792.99	$77,464.14	$39,898.23	$38,487.54	$37,130.05	$35,823.63	$34,566.23

APPENDIX F: RESULTS UNDER ALTERNATIVE SCENARIOS

Scenario 1: Higher number of patients treated

MUHC Perspective

Proposed Alternative	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	100	105	110	116	122	128	134	141	148	155	163	171
Maintenance - service	$ -	$ -	$ -	$2,441,966.95	$2,490,806.29	$ 2,540,622.42	$ 2,591,434.87	$2,643,263.56	$2,696,128.83	$2,750,051.41	$2,805,052.44	$ 2,861,153.49
Electricity	$ -	$ -	$ 294,134.70	$ 300,017.40	$ 306,017.74	$ 312,138.10	$ 318,380.86	$ 324,748.48	$ 331,243.45	$ 337,868.32	$ 344,625.68	$ 351,518.20
Staff salaries	$ -	$ -	$ 585,164.66	$ 596,867.95	$ 608,805.31	$ 620,981.42	$ 633,401.04	$ 646,069.06	$ 658,990.45	$ 672,170.25	$ 685,613.66	$ 699,325.93
Loan			$4,837,718.19	$4,837,718.19	$4,837,718.19	$ 4,837,718.19	$ 4,837,718.19					
Total cost per year	$ -	$ -	$5,717,017.55	$8,176,570.49	$8,243,347.54	$ 8,311,460.12	$ 8,380,934.96	$3,614,081.11	$3,686,362.73	$3,760,089.98	$3,835,291.78	$ 3,911,997.62
			Total expended from 2019 until 2025				$ 38,829,330.67		Total expended from 2019 until 2030			$ 57,637,153.89
Reimbursement to the MUHC per patient treated	na	na	$ 51,855.03	$ 70,632.29	$ 67,818.22	$ 65,122.46	$ 62,539.83	$ 25,684.60	$ 24,950.75	$ 24,237.88	$ 23,545.36	$ 22,872.64

Base Case and Proposed alternative. Budget Impact Analysis

Base Case (U.S. Referral)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	36	43	51	60	70	83	91	99	108	117	128	139
Cost per patient treated	$ 321,378.91	$ 327,806.49	$ 334,362.62	$ 341,049.87	$ 347,870.87	$ 354,828.29	$ 361,924.85	$ 369,163.35	$ 376,546.62	$ 384,077.55	$ 391,759.10	$ 399,594.28
Total cost per year	$ 11,666,054.52	$ 14,041,263.22	$ 16,900,064.41	$ 20,340,917.52	$ 24,482,328.33	$ 29,466,930.37	$ 32,761,333.19	$ 36,424,050.24	$ 40,496,259.06	$ 45,023,740.82	$ 50,057,395.04	$ 55,653,811.81
			Total expended from 2019 until 2025				$ 149,658,891.54		Total expended from 2019 until 2030			$ 377,314,148.50
Proposed Alternative	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Targeted population	100	105	110	116	122	128	134	141	148	155	163	171
Reimbursement to the MUHC per patient	$ -	$ -	$ 51,855.03	$ 70,632.29	$ 67,818.22	$ 65,122.46	$ 62,539.83	$ 25,684.60	$ 24,950.75	$ 24,237.88	$ 23,545.36	$ 22,872.64
Loan to the MUHC	$ 12,094,295.48	$ 12,094,295.48										
Return on the loan (-)	$ -	$ -	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ -	$ -	$ -	$ -	$ -
Staff - MDs	$ -	$ -	$ 374,544.00	$ 382,034.88	$ 389,675.58	$ 397,469.09	$ 810,836.94	$ 827,053.68	$ 843,594.75	$ 860,466.65	$ 877,675.98	$ 895,229.50
Cost per patient treated	$ -	$ -	$ 11,372.73	$ 32,142.42	$ 31,224.07	$ 30,331.95	$ 32,490.62	$ 31,562.32	$ 30,660.54	$ 29,784.52	$ 28,933.53	$ 28,106.86
Total cost per year	$12,094,295.48	$ 12,094,295.48	$ 1,253,843.36	$ 3,720,887.18	$ 3,795,304.92	$ 3,871,211.02	$ 4,354,053.71	$ 4,441,134.79	$ 4,529,957.48	$ 4,620,556.63	$ 4,712,967.77	$ 4,807,227.12
			Total expended from 2019 until 2025				$ 41,183,891.16		Total expended from 2019 until 2030			$ 64,295,734.95
Budget impact per year	$ 23,760,350.00	$ 26,135,558.70	$ (15,646,221.05)	$ (16,620,030.34)	$ (20,687,023.40)	$ (25,595,719.35)	$ (28,407,279.47)	$ (31,982,915.45)	$ (35,966,301.57)	$ (40,403,184.18)	$ (45,344,427.28)	$ (50,846,584.69)
			Budgetary Impact at 7 years				$ (57,060,365)		Budgetary Impact at 12 years			$ (261,603,778)

Scenario 2: MUHC Foundation contribution treated as a loan

MUHC Perspective

Proposed Alternative	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	40	47	56	66	77	91	100	109	118	129	141	153
Maintenance - service	$ -	$ -	$ -	$ 2,441,966.95	$ 2,490,806.29	$ 2,540,622.42	$ 2,591,434.87	$2,643,263.56	$2,696,128.83	$2,750,051.41	$2,805,052.44	$ 2,861,153.49
Electricity	$ -	$ -	$ 294,134.70	$ 300,017.40	$ 306,017.74	$ 312,138.10	$ 318,380.86	$ 324,748.48	$ 331,243.45	$ 337,868.32	$ 344,625.68	$ 351,518.20
Staff salaries	$ -	$ -	$ 585,164.66	$ 596,867.95	$ 608,805.31	$ 620,981.42	$ 633,401.04	$ 646,069.06	$ 658,990.45	$ 672,170.25	$ 685,613.66	$ 699,325.93
Loan			$4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19					
Loan MUHC Foundation			$2,000,000.00	$ 2,000,000.00	$ 2,000,000.00	$ 2,000,000.00	$ 2,000,000.00	$2,000,000.00	$2,000,000.00	$2,000,000.00	$2,000,000.00	$ 2,000,000.00
Total cost per year	$ -	$ -	$7,717,017.55	$10,176,570.49	$ 10,243,347.54	$ 10,311,460.12	$ 10,380,934.96	$5,614,081.11	$5,686,362.73	$5,760,089.98	$5,835,291.78	$ 5,911,997.62
			Total expended from 2019 until 2025				$ 48,829,330.67		Total expended from 2019 until 2030			$ 77,637,153.89
Reimbursement to the MUHC per patient treated	na	na	$ 138,798.94	$ 155,115.83	$ 132,316.67	$ 112,878.39	$ 104,255.90	$ 51,726.89	$ 48,066.86	$ 44,669.79	$ 41,516.50	$ 38,589.21

Base Case and Proposed alternative. Budget Impact Analysis

Base Case (U.S. Referral)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	36	43	51	60	70	83	91	99	108	117	128	139
Cost per patient treated	$ 321,378.91	$ 327,806.49	$ 334,362.62	$ 341,049.87	$ 347,870.87	$ 354,828.29	$ 361,924.85	$ 369,163.35	$ 376,546.62	$ 384,077.55	$ 391,759.10	$ 399,594.28
Total cost per year	$ 11,666,054.52	$ 14,041,263.22	$ 16,900,064.41	$ 20,340,917.52	$ 24,482,328.33	$ 29,466,930.37	$ 32,761,333.19	$ 36,424,050.24	$ 40,496,259.06	$ 45,023,740.82	$ 50,057,395.04	$ 55,653,811.81
	Total expended from 2019 until 2025						$ 149,658,891.54	Total expended from 2019 until 2030				$ 377,314,148.50
Proposed Alternative	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	40	47	56	66	77	91	100	109	118	129	141	153
Reimbursement to the MUHC per patient	$ -	$ -	$ 138,798.94	$ 155,115.83	$ 132,316.67	$ 112,878.39	$ 104,255.90	$ 51,726.89	$ 48,066.86	$ 44,669.79	$ 41,516.50	$ 38,589.21
Loan to the MUHC	$ 12,094,295.48	$ 12,094,295.48										
Return on the loan (-)	$ -	$ -	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ -	$ -	$ -	$ -	$ -
Staff - MDs	$ -	$ -	$ 374,544.00	$ 382,034.88	$ 389,675.58	$ 397,469.09	$ 810,836.94	$ 827,053.68	$ 843,594.75	$ 860,466.65	$ 877,675.98	$ 895,229.50
Cost per patient treated	$ -	$ -	$ 58,523.91	$ 87,200.31	$ 74,859.85	$ 64,271.49	$ 63,813.86	$ 59,347.17	$ 55,197.77	$ 51,342.75	$ 47,760.92	$ 44,432.62
Total cost per year	$12,094,295.48	$ 12,094,295.48	$ 3,253,843.36	$ 5,720,887.18	$ 5,795,304.92	$ 5,871,211.02	$ 6,354,053.71	$ 6,441,134.79	$ 6,529,957.48	$ 6,620,556.63	$ 6,712,967.77	$ 6,807,227.12
	Total expended from 2019 until 2025						$ 51,183,891.16	Total expended from 2019 until 2030				$ 84,295,734.95
Budget impact per year	$ 23,760,350.00	$ 26,135,558.70	$ (13,646,221.05)	$ (14,620,030.34)	$ (18,687,023.40)	$ (23,595,719.35)	$ (26,407,279.47)	$ (29,982,915.45)	$ (33,966,301.57)	$ (38,403,184.18)	$ (43,344,427.28)	$ (48,846,584.69)
Budgetary Impact at 7 years							$ (47,060,365)	Budgetary Impact at 12 years				$ (241,603,778)

Scenario 3: Higher number of patients treated + MUHC Foundation contribution treated as a loan

MUHC perspective

Proposed Alternative	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	100	105	110	116	122	128	134	141	148	155	163	171
Maintenance - service	$ -	$ -	$ -	$2,441,966.95	$2,490,806.29	$ 2,540,622.42	$ 2,591,434.87	$2,643,263.56	$2,696,128.83	$2,750,051.41	$2,805,052.44	$ 2,861,153.49
Electricity	$ -	$ -	$ 294,134.70	$ 300,017.40	$ 306,017.74	$ 312,138.10	$ 318,380.86	$ 324,748.48	$ 331,243.45	$ 337,868.32	$ 344,625.68	$ 351,518.20
Staff salaries	$ -	$ -	$ 585,164.66	$ 596,867.95	$ 608,805.31	$ 620,981.42	$ 633,401.04	$ 646,069.06	$ 658,990.45	$ 672,170.25	$ 685,613.66	$ 699,325.93
Loan			$4,837,718.19	$4,837,718.19	$4,837,718.19	$ 4,837,718.19	$ 4,837,718.19					
Loan MUHC foundation			$2,000,000.00	$2,000,000.00	$2,000,000.00	$ 2,000,000.00	$ 2,000,000.00	$2,000,000.00	$2,000,000.00	$2,000,000.00	$2,000,000.00	$ 2,000,000.00
Total cost per year	$ -	$ -	$7,717,017.55	###############	###############	$ 10,311,460.12	$ 10,380,934.96	$5,614,081.11	$5,686,362.73	$5,760,089.98	$5,835,291.78	$ 5,911,997.62
	Total expended from 2019 until 2025						$ 48,829,330.67	Total expended from 2019 until 2030				$ 77,637,153.89
Reimbursement to the MUHC per patient treated	na	na	$ 69,995.62	$ 87,909.04	$ 84,272.27	$ 80,792.99	$ 77,464.14	$ 39,898.23	$ 38,487.54	$ 37,130.05	$ 35,823.63	$ 34,566.23

Base Case and Proposed alternative. Budget Impact Analysis

Base Case (U.S. Referral)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	36	43	51	60	70	83	91	99	108	117	128	139
Cost per patient treated	$ 321,378.91	$ 327,806.49	$ 334,362.62	$ 341,049.87	$ 347,870.87	$ 354,828.29	$ 361,924.85	$ 369,163.35	$ 376,546.62	$ 384,077.55	$ 391,759.10	$ 399,594.28
Total cost per year	$ 11,666,054.52	$ 14,041,263.22	$ 16,900,064.41	$ 20,340,917.52	$ 24,482,328.33	$ 29,466,930.37	$ 32,761,333.19	$ 36,424,050.24	$ 40,496,259.06	$ 45,023,740.82	$ 50,057,395.04	$ 55,653,811.81
	Total expended from 2019 until 2025						$ 149,658,891.54	Total expended from 2019 until 2030				$ 377,314,148.50
Proposed Alternative	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Targeted population	100	105	110	116	122	128	134	141	148	155	163	171
Reimbursement to the MUHC per patient treated	$ -	$ -	$ 69,995.62	$ 87,909.04	$ 84,272.27	$ 80,792.99	$ 77,464.14	$ 39,898.23	$ 38,487.54	$ 37,130.05	$ 35,823.63	$ 34,566.23
Loan to the MUHC	$ 12,094,295.48	$ 12,094,295.48										
Return on the loan (-)	$ -	$ -	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ 4,837,718.19	$ -	$ -	$ -	$ -	$ -
Staff - MDs	$ -	$ -	$ 374,544.00	$ 382,034.88	$ 389,675.58	$ 397,469.09	$ 810,836.94	$ 827,053.68	$ 843,594.75	$ 860,466.65	$ 877,675.98	$ 895,229.50
Cost per patient treated	$ -	$ -	$ 29,513.32	$ 49,419.17	$ 47,678.12	$ 46,002.47	$ 47,414.93	$ 45,775.94	$ 44,197.32	$ 42,676.70	$ 41,211.80	$ 39,800.45
Total cost per year	$12,094,295.48	$ 12,094,295.48	$ 3,253,843.36	$ 5,720,887.18	$ 5,795,304.92	$ 5,871,211.02	$ 6,354,053.71	$ 6,441,134.79	$ 6,529,957.48	$ 6,620,556.63	$ 6,712,967.77	$ 6,807,227.12
	Total expended from 2019 until 2025						$ 51,183,891.16	Total expended from 2019 until 2030				$ 84,295,734.95
Budget impact per year	$ 23,760,350.00	$ 26,135,558.70	$ (13,646,221.05)	$ (14,620,030.34)	$ (18,687,023.40)	$ (23,595,719.35)	$ (26,407,279.47)	$ (29,982,915.45)	$ (33,966,301.57)	$ (38,403,184.18)	$ (43,344,427.28)	$ (48,846,584.69)
Budgetary Impact at 7 years							$ (47,060,365)	Budgetary Impact at 12 years				$ (241,603,778)

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