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Complete List of Authors:	Wong, William; University of Waterloo School of Pharmacy Lee, Linda; Centre for Family Medicine Family Health Team, ; McMaster University, Walker, Sasha ; Centre for Family Medicine Family Health Team Lee, Catherine; Centre for Family Medicine Family Health Team Patel, Tejal; University of Waterloo, School of Pharmacy; Centre for Family Medicine Family Health Team Hillier, Loretta; GERAS Centre for Aging Research Costa, Andrew P ; McMaster University, Sinha, Samir; University of Toronto, Departments of Medicine, Family and Community Medicine and the Institute of Health Policy, Management, and Evaluation; Toronto Metropolitan University, National Institute on Ageing
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Cost-utility analysis of a multispecialty interprofessional team dementia care model in Ontario, Canada

William W.L. Wong PhD,[1] Linda Lee, MD, MClSc(FM)[2,3] Sasha Walker BSc,[2] Catherine Lee BSc,[2] Tejal Patel PharmD,[1,2] Loretta M. Hillier MA,[4] Andrew Costa PhD,[5] and Samir K. Sinha MD, DPhil[6,7]

[1]School of Pharmacy, University of Waterloo, Waterloo, Ontario.

[2]Centre for Family Medicine Family Health Team, Kitchener, Ontario.

[3]Department of Family Medicine, McMaster University, Hamilton, Ontario.

[4]GERAS Centre for Aging Research, Hamilton, Ontario.

[5]Departments of Clinical Epidemiology & Biostatistics, and Medicine, McMaster University, Hamilton, Ontario.

[6]Departments of Medicine, Family and Community Medicine and the Institute of Health Policy, Management, and Evaluation, University of Toronto, Ontario

[7]National Institute on Ageing, Ryerson University, Toronto, Ontario

Corresponding Author: William W. L. Wong, PhD. School of Pharmacy, Faculty of Science, University of Waterloo, PHR4011, 10A Victoria Street S, Kitchener, N2G 1C5. Tel: 519-888-4567 ext. 21323; Fax: 519-883-7580; e-mail: wwlwong@uwaterloo.ca.

ABSTRACT

Objective Evaluative studies have demonstrated that Multi-specialty Interprofessional Team (MINT) Memory Clinics provide improved quality of dementia care within primary care, however there is limited economic evaluation data for this care model compared to usual care. The objective of this analysis was to examine the cost-effectiveness of MINT Memory Clinic care in comparison to the provision of usual care.

Methods We developed a Markov-based state transition model to perform a cost-utility (costs and quality-adjusted life years, QALYs) analysis of MINT Memory Clinic care and usual care not involving MINT Memory Clinics. Disease progression and cost data were obtained from published sources. Utility data were estimated based on patient-reported quality of life (EQ-5D-5L) survey results. We used a payer perspective, a lifetime time horizon and a 1.5% discount rate and conducted sensitivity analyses.

Results MINT Memory Clinics were found to be less expensive (CAD $51496) while slightly improving quality of life (+0.43QALY) compared to usual care. The probabilistic analysis showed that MINT Memory Clinics were the superior treatment compared to usual care 97.7% of the time. Variation in age was found to have the greatest impact on cost-effectiveness as patients may benefit from the MINT Memory Clinics more if they receive care beginning at a younger age.

Conclusion Multi-specialty interprofessional memory clinic care is less costly and more effective compared to usual care and early access to care significantly reduces care costs over time. The results of this economic evaluation can inform decision-making and improvements to health system design, resource allocation, and care experience for persons living with dementia. Specifically, widespread scaling of MINT Memory Clinics into existing primary care systems may assist with improving quality and access to memory care services while decreasing the growing economic and social burden of dementia.

Key words: dementia, primary care, cost-effectiveness, cost-utility analysis, memory clinics

Strengths and limitations of this study

- This study is an economic evaluation of a multispecialty interprofessional team model of dementia care in Canada for which there is limited economic evaluation data.
- This economic evaluation was conducted consistent with best practice methods and suggested that MINT Memory Clinic care is less costly and more effective compared to usual care in 97.7% of the time.
- The lack of existing research regarding a comparative usual care group for persons with dementia living in Canada limited us to using available data from different countries and healthcare systems thus comparability between MINT Memory Clinic care and usual care may be limited.

- As our data are most relevant to Canada, and in a particular to community care settings, it may be difficult to generalize to other jurisdictions due to differences in healthcare systems.

INTRODUCTION

Globally, dementia is one of the major causes of disability and dependency among older persons.[1] In addition to the significant impact on the quality of life for individuals diagnosed with dementia and their families, dementia also has significant economic implications for healthcare systems. In Canada, combined healthcare system and out of pocket caregiving costs totaled $10.4B in 2016 and is expected to increase to $16.6B by 2031.[2] In 2015, the total societal cost of dementia worldwide in terms of direct medical, social care and informal care costs was estimated to be USD $818 billion.[1]

Primary care clinicians are often the first point of contact for individuals experiencing memory concerns. Given the challenges experienced in diagnosing and managing this complex disorder within the time constraints in busy family practice, persons with memory concerns have historically been referred for specialist care.[3] There is increasing recognition of the need for primary care to take on greater responsibility for early diagnosis, management, and ongoing dementia care throughout the disease process.[4] There is particular interest in strengthening dementia care in primary care with the aim of supporting those with dementia to live at home for as long as possible and to avoid hospitalization and institutionalization.[4]

Collaborative, multidisciplinary team approaches to healthcare represent a significant opportunity to provide patient-centered care, improve health outcomes, and patients' experience with care.[5, 6] The Multi-specialty INterprofessional Team (MINT) Memory Clinic care model (formerly Primary Care Collaborative Memory Clinics) aims to improve assessment, diagnosis, and management of dementia in primary care.[7] Integrating specialist and community care for the most complex of cases, this model supports person-centred care that is experienced by patients

and caregivers as comprehensive, coordinated, timely, and accessible from one location, close to home.[8-10] Within this care model, patients with memory concerns are referred by their family physician to the MINT Memory Clinic, usually located within the same practice setting, for comprehensive assessment and care planning conducted by an interprofessional team consisting of specially trained family physicians, nurses, and other healthcare professionals (e.g., social workers, pharmacists, occupational therapists), and representatives from local community services (Alzheimer Society, home care, behavioural support services) as available.[11] Assessments are conducted with all team members working together in a coordinated and collaborative manner to complete the assessment at the same visit, formulate a diagnosis and develop an integrated, individualized care plan based on patient and caregiver preferences and needs. Using a shared care approach, MINT Memory Clinic team members work with the patient's own family physician to ensure that changes in care needs are identified and met, ensuring care continuity over time. Key model components include integration of geriatric specialists to provide consultative support, ongoing capacity building support, and team integration and coordination of community support services.[6]

The MINT Memory Clinic model exists in over 100 primary care settings across Ontario and is currently being expanded to other provinces across the country. Published evaluative studies have demonstrated improved clinical practice and quality of dementia care, improved access to health and social services, enhanced care experiences for persons with dementia and their caregivers, healthcare provider satisfaction with dementia care, and improved collaboration among health professionals.[6, 8-10] Using a chart audit tool developed by the Ontario of College of Physicians and Surgeons of Ontario, which assessed quality indictors related to diagnosis, investigations, treatment plan and follow-up,[12] two geriatricians independently reviewed 50

charts from five memory clinics.[10] This chart audit revealed a high level of agreement among the geriatricians (kappa coefficient = .86) with the diagnosis and management provided by the clinics, verifying the quality of care provided.[10] A significant healthcare system outcome associated with this care model has been the highly efficient use of limited available specialist resources with a less than 10% referral rate to specialists while maintaining high quality care based on geriatrician chart audit, reduced pressure on specialist wait lists, and delayed institutionalization.[7, 10, 13, 14] The purpose of this study was to examine the cost-effectiveness of the MINT Memory Clinic care model in comparison to the provision of usual dementia care.

METHODS

Study Design

We developed a Markov-based state-transition model to determine the cost-effectiveness of MINT Memory clinics from a public payer perspective (provincial Ministry of Health) for patients with cognitive impairment (CI) in Ontario, Canada using cost-utility analysis. We adopted a public payer perspective,[15] and used a lifetime time horizon and a 1.5% discount rate for our analysis based on Canadian economic evaluation guidelines.[15] An overview of our methodology is presented as follows and additional information can be found in online Supplemental Material.

Patient and public involvement

No patient involved.

Interventions

Two different care strategies were evaluated for their cost-effectiveness:

1) Usual (non-MINT Memory Clinic) care: Patients initially seen by their family physician for symptoms of cognitive impairment and then referred to a geriatric specialist to determine a formal diagnosis and a treatment plan.
2) MINT Memory Clinic: As described, this care model provides team-based interprofessional collaborative dementia care, in a shared care approach with patients' family physicians and with access to consultative specialist support for complex issues.[6, 7, 10] If a family physician has access to a MINT Memory Clinic, any adult with memory concerns can be referred. MINT Memory Clinics exist in a variety of primary care settings across Ontario in rural, urban, remote, and underserved communities. When there is no access to a MINT Memory Clinic, patients are likely to receive usual care.

Cohort

This study focused on older adults with memory concerns who were referred to receive usual care or MINT Memory Clinic care. Our cohort was based on data from a sample of 229 patients from the Centre for Family Medicine (CFFM) MINT Memory Clinic in Kitchener, Ontario. Patients were seen between January 2019 – January 2021. For inclusion, patients had to have had at least one clinic visit that documented standardized scale scores for cognition (Montreal Cognitive Assessment, MoCA)[16] and quality of life (EQ5D-5L, a preference-based health status

scale that is a valid and reliable measure of quality of life).[17] Patient characteristics are presented in Table 1. The mean age of the cohort was 80 years; 52% were female. A total of 376 MoCA scores were collected from the sample of 229 patients. To account for the varying level of care required for patients during their disease progression, patients were classified into four CI states based on their MoCA scores: Little to No CI (scores of 20-30); Mild CI (scores of 16-19); Moderate CI (scores of 11-15); and Moderate-Severe CI (scores of 2-10). The majority of patients (61%) had MoCA scores classified as Little to No CI state (in this group, the average MoCA score was 24/30). It is important to note that while all patients referred to Memory Clinics have some cognitive symptoms or concerns, some will have Subjective Cognitive Decline (SCD), which involves normal cognitive testing scores.[18] Like MCI, SCD is an at-risk state for future Alzheimer's disease and other dementias;[19] current Canadian Consensus guidelines recommend appropriate investigations and monitoring of persons with SCD because of risk of progression to dementia.[20] With cognitive test scores being within normal limits, persons with SCD were included in the "Little or no cognitive impairment" category. The identical cohort as described above was used for both the usual care intervention and the MINT Memory Clinic intervention in the cost-utility analysis.

Table 1. MINT Memory Clinic Patient Characteristics

Characteristics	n = 229
Sex, *n* (%)	
Male	111 (48.5)
Female	118 (51.5)

Age (years), mean (SD)	77.95 (9.83)
Age categories, *n (%)*	
≤50 years	2 (0.9)
51-60 years	11 (4.8)
61-70 years	34 (14.8)
71-80 years	84 (36.7)
81-90 years	79 (34.5)
≥91	19 (8.3)
First Language	
English	179 (78.2)
Non-English	50 (21.8)
Martial Status	
Married	143 (62.4)
Widowed	43 (18.8)
Divorced	25 (10.9)
Partner	7 (3.1)
Single	11 (4.8)
Education	
< 9th grade	33 (14.4)
Highschool	79 (34.5)
College or University	86 (37.6)
Professional Degree	31 (13.5)
Living Status	

Alone	49 (21.4)
With Caregiver	172 (75.1)
Institution	6 (2.6)
Other	2 (0.9)
Employment Status	
Employed	29 (12.7)
Unemployed	29 (12.7)
Retired	171 (74.6)
MoCA scores (N = 376)	
Little to No CI state (scores of 20 - 30)	230 (61.2)
Mild CI state (scores of 16 - 19)	56 (14.9)
Moderate CI state (scores of 11 - 15)	54 (14.4)
Moderate-severe CI state (scores of 2 - 10)	36 (9.6)

Notes: CI = cognitive impairment; MoCA = Montreal Cognitive Assessment

Model

A Markov-based state transition model was created to represent the progression of CI to dementia throughout a patient's care journey (Figure 1); a detailed model is presented in online Supplemental Figure 1. In our simulations, cohort members move between predefined health states in yearly cycles until all members die. In each yearly cycle, there are transition possibilities associated with a patient progressing to the next disease stage or remaining in their current health (CI) state. At each stage, changes in use of healthcare resources (emergency

department, hospital) were tracked. In our model, six main health states were: Little to No CI; Mild CI; Moderate CI; Moderate-Severe CI; long-term care (LTC) admission; and, death.

Data

Our model assumed that all patients started their journey within the little to no CI health state, and followed them over time until death. Transition probabilities related to disease progression, emergency department (ED) visits, hospitalization, and transition into nursing home, were either derived from the MINT Memory Clinic data, an independent provincial evaluation of the Memory Clinics commissioned by the Ministry of Health,[14] or other published literature as follows[21-24] (Table 2 and Table 3).

Table 2. Model Parameters: Transition Probabilities, Costs and Utility

Variable	Value	Range	Source
Transition Probabilities			
Probability of Group A[a] staying	0.842	0.6315 – 0.99	MINT Memory Clinic Data
Probability of Group A[a] to Group B[b]	0.111	0.0832 – 0.1387	MINT Memory Clinic Data
Probability of Group A[a] to Group C[c]	0.04	0.03-0.05	MINT Memory Clinic Data
Probability of Group A[a] to Group D[d]	0.007	0.00525-0.00875	MINT Memory Clinic Data
Probability of Group A[a] entering Emergency Department	0.262	0.225 - 0.297	Voisin, et al. 2009 [21]
Probability of Group A[a] entering Nursing Homes	0.01	0.005 – 0.015	MINT Memory Clinic Data
Probability of Group B[b] to Group A[a]	0.318	0.2385 – 0.3975	MINT Memory Clinic Data
Probability of Group B[b] staying	0.338	0.2535 – 0.4225	MINT Memory Clinic Data
Probability of Group B[b] to Group C[c]	0.255	0.1912 – 0.3187	MINT Memory Clinic Data
Probability of Group B[b] to Group D[d]	0.089	0.0667 – 0.1112	MINT Memory Clinic Data

Variable	Value	Range	Source
Probability of Group B[b] visiting the Emergency Department	0.262	0.225 - 0.297	Voisin, et al. 2009 [21]
Probability of Group A[a] entering Nursing Homes	0.012	0.0001 - 0.028	Spackman, et al. 2012 [22]
Probability of Group C[c] to Group A[a]	0.035	0.0262 – 0.0437	MINT Memory Clinic Data
Probability of Group C[c] to Group B[b]	0.175	0.1312 – 0.2187	MINT Memory Clinic Data
Probability of Group C[c] staying	0.518	0.3885– 0.6475	MINT Memory Clinic Data
Probability of Group C[c] to Group D[d]	0.272	0.204 – 0.34	MINT Memory Clinic Data
Probability of Group C[c] visiting the Emergency Department	0.261	0.225 - 0.297	Voisin, et al. 2009 [21]
Probability of Group C[c] entering Nursing Homes	0.034	0.000, 0.069	Spackman, et al. 2012 [22]
Probability of Group D[d] to Group B[b]	0.019	0.0142 – 0.0237	MINT Memory Clinic Data
Probability of Group D[d] to Group C[c]	0.094	0.0705 – 0.1175	MINT Memory Clinic Data
Probability of Group D[d] staying	0.887	0.66525 – 0.99	MINT Memory Clinic Data
Probability of Group D[d] visiting the Emergency Department	0.455	0.37 to 0.54	LaMantia, et al 2016 [23]
Probability of Group D[d] entering Nursing Homes	0.377	0.2827 – 0.4712	Mondor, et al. 2017 [24]
Probability of Short-Term Hospital Stay (MINT Memory Clinics)	0.65	0.4875 – 0.8125	Provincial Evaluation [14]
Probability of Short-Term Hospital Stay (Usual Care)	0.61	0.4575 – 0.7625	Provincial Evaluation [14]
Probability of Entering Long Term Care from Hospital for Group A[a] to C[c]	0.012	0.009 – 0.0015	Spackman, et al. 2012 [22]
Probability of Entering Nursing Home from Hospital for Group D[d]	0.299	0.262 – 0.33	Mondor, et al. 2017 [24]
Probability of Death during Hospital Care	0.002	0.0015 – 0.0025	Provincial Evaluation [14]
Probability of Death in Nursing Home	0.30	0.262 – 0.33	Xiong, et al. 2019 [25]

LTC = Long-term care.
[a] Group A, Little to No Cognitive Impairment (MoCA Score 20-30)
[b] Group B, Mild Degree of Cognitive Impairment (MoCA Score 16-19)
[c] Group C, Moderate Degree of Cognitive Impairment (MoCA Score 11-15)
[d] Group D, Moderate-Severe Degree of Cognitive Impairment (MoCA Score 2-10)

Table 3. Model Parameters: Costs and Utility

Costs			
MINT Memory Clinics			
Annual cost of group A[a]	$14,724	$11,043 – 18,407	Provincial Evaluation [14]
Annual cost of group B[b]	$14,857	$11,142 – 18,571	Provincial Evaluation [14]
Annual cost of group C[c]	$14,894	$11,170 – 18,618	Provincial Evaluation [14]
Annual cost of group D[d]	$14,986	$11,240-18,733	Provincial Evaluation [14]
Annual cost of emergency department visit	$941	$706-1,177	Provincial Evaluation [14]
Annual cost of hospitalization	$416	$312-520	Provincial Evaluation [14]
Annual cost of nursing home care	$9,902	$7426-12,378	Provincial Evaluation [14]
One-time Training cost	$23,000	$17,250-$28,750	MINT Memory Clinic Data
Usual Care			
Annual cost of group A[a]	$21,020	$15,765 – 26,275	Provincial Evaluation [14]
Annual cost of group B[b]	$21,020	$15,765 – 26,275	Provincial Evaluation [14]
Annual cost of group C[c]	$21,020	$15,765 – 26,275	Provincial Evaluation [14]
Annual cost of group D[d]	$21,020	$15,765 – 26,275	Provincial Evaluation [14]
Annual cost of emergency department visit	$1,912	$14,34 – 2,390	Provincial Evaluation [14]
Annual cost of hospitalization	$876	$657 – 1,095	Provincial Evaluation [14]

Annual cost of nursing home care	$12,212	$9,159 – 15,266	Provincial Evaluation [14]
Health State Utilities			
MINT Memory Clinics			
Utility for group A[a]	0.8288	0.697-0.961	MINT Memory Clinic Data
Utility for group B[b]	0.8461	0.739-0.953	MINT Memory Clinic Data
Utility for group C[c]	0.8502	0.721-0.979	MINT Memory Clinic Data
Utility for group D[d]	0.8222	0.675-0.970	MINT Memory Clinic Data
Utility for LTC	0.52	0.28-0.76	Brandauer, et al. 2020 [26]
Usual Care			
Utility for group A[a]	0.8276	0.621-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019 [27]
Utility for group B[b]	0.8449	0.634-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019 [27]
Utility for group C[c]	0.8490	0.635-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019 [27]
Utility for group D[d]	0.8211	0.616-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019 [27]
Utility for LTC	0.52	0.28-0.76	Brandauer, et al. 2020 [26]

LTC = Long-term care.
[a] Group A, Little to No Cognitive Impairment (MoCA Score 20-30)
[b] Group B, Mild Degree of Cognitive Impairment (MoCA Score 16-19)
[c] Group C, Moderate Degree of Cognitive Impairment (MoCA Score 11-15)
[d] Group D, Moderate-Severe Degree of Cognitive Impairment (MoCA Score 2-10)

Disease Progression Probabilities

To calculate the annual disease transition probabilities, we used medical record data from the MINT Memory Clinic to build a disease history for each patient that began at their first assessment visit. The transition probability of patients moving between CI state groups within the next year was calculated using only data from patients who had at least two visits. Transition probabilities for disease progression are presented in Table 2. Identical transition probabilities were used for both the usual care and Memory Clinic patients since we conservatively assumed that Memory Clinic care will not affect the progression of CI.

Emergency Department Visit Probabilities, Hospitalization Probabilities and Frequency of Visits

The annual probability of a person in the Little to No CI, Mild CI and Moderate CI states who have at least one ED visit is 26.2%.[21] For the Moderate-Severe CI person, an annual probability of 45.5% was used.[23] Among those who have had at least one ED visit, our model assumed that 22% of individuals visited the ED once, 24% visited twice and 54% visited three times based on published data.[28] According to the provincial evaluation, 65% of MINT Memory Clinic patients returned to the community after a short-term hospital stay, compared to 61% of usual care patients.[14]

Transition into LTC Homes

The probabilities of entering nursing homes were 1.2% for patients in the Mild CI state and 3.5% for patients in the Moderate CI state.[22] For patients in the Moderate-Severe CI state, the

transition probability was reported as 37.7%.[24] Since patients in the Little to No CI group were mostly younger and did not show many symptoms of cognitive impairment, the model assumed no transition into LTC homes.

Mortality

All-cause mortality was calculated using life tables developed by Statistics Canada.[29] Dementia-related mortality for both Memory Clinic and usual care patients in the hospital was 0.2% based on the provincial evaluation.[14] Once patients were admitted to LTC, the annual mortality was assumed to be 30% based on the literature.[25, 30]

Cost

Cost values in this model were derived primarily from the provincial memory clinic evaluation reported in 2017, in which a retrospective costing analysis based on health administrative data was conducted between patients receiving MINT Memory Clinic care and usual care from 2006-2015.[14] Online Supplemental Table 1 presents a detailed summary of the daily costs of healthcare services for Memory Clinic and usual care patients. The cost of Memory Clinics was based on the conservative assumption that clinics operate one day a month and see four patients per day. The daily costs of healthcare services involved in both interventions were converted to yearly costs in order to determine the annual health state cost for both interventions. The total annual health state cost for Memory Clinics was calculated to be CAD $14438 and CAD $21020 for usual care. The one-time training cost involved in setting up the Memory Clinics was

estimated at CAD $23000 per clinic. Using the same assumption as in the provincial evaluation,[14] with each Memory Clinic operating once per month with minimum 4 of patients per clinic day, the one-time training cost is estimated to be CAD $479 per patient for the first year of operation.

For hospitalization costs, inpatient hospital stays and mental health hospital stays costs reported in the provincial evaluation were combined, using an average length of hospitalization stay of 10 days.[31] The overall annual cost of hospitalization was estimated at CAD $877 for usual care patients and CAD $416 for Memory Clinic patients. Similarly, the annual nursing home costs were estimated at CAD $12213 for usual care patients and CAD $9902 for MINT Memory Clinic patients. Table 3 provides an overview of all cost values utilized in our model.

Utility

Effectiveness was measured in quality adjusted life years (QALYs), calculated based on the quality of life of patients in given CI states. Utility scores were obtained from EQ-5D-5L surveys that were completed by 229 Memory Clinic patients, and a published study for purposes of comparative effectiveness for the usual care.[27] A detailed summary of the utility values utilized for both intervention groups is presented in Table 3. The total effectiveness of care is presented as a sum of the quality adjusted life year (QALY) throughout the patient transition.

Analyses

A base-case analysis was conducted first to estimate the incremental cost-effectiveness ratio (ICER) between the Memory Clinics and usual care based on a probabilistic analysis using Monte Carlo simulation for 5000 iterations. A full deterministic one-way sensitivity analysis was then run on all model parameters over the plausible ranges using the reported 95% confidence interval if available or ±25% of the reference value, for parameters where estimates of uncertainty were not available. Further, a scenario analysis was conducted by assuming the utility scores in each CI state remain the same for both the Memory Clinic patients and the usual care patients. All analyses were conducted using TreeAge Pro 2021 (TreeAge Software, Williamstown, MA).

RESULTS

Base Case Analysis

The cost-effectiveness results between MINT Memory Clinics and usual care are presented in Table 4 and online Supplemental Figure 2. The total average cost for a patient receiving MINT Memory Clinic care and usual care in MINT Memory Clinics is CAD $145805 and CAD $197301, throughout their entire care journey, respectively. The cost difference between Memory Clinic and usual care is CAD $51496, indicating that MINT Memory Care is cost-

saving in comparison to usual care. In addition, MINT Memory Clinics care is a more effective intervention in terms of total QALY (7.86 QALY), in comparison with the usual care (7.43 QALY), which translates to a gain of 0.43 QALYs for MINT Memory Clinic care over usual care. In this probabilistic analysis (online Supplemental Figure 2), MINT Memory clinics were the superior option (less costly and more effective) in 97.7% of the 5000 Monte Carlo simulations.

Table 4. Cost Effectiveness of MINT Memory Clinics versus Usual Care: Base case analysis and scenario analysis results

Analysis	Total Cost ($)	Incremental Cost	Effectiveness (QALY)	Incremental Effectiveness	ICER ($/QALY)
Base Case Analysis MINT Memory Clinics	$145805	0	7.86	0	0

Usual Care	$197301	$51496	7.43	-0.43	Dominated
Scenario Analysis[a] MINT Memory Clinics	$145805	0	7.86	0	0
Usual Care	$197301	$51496	7.44	-0.42	Dominated

Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality Adjusted Life Year. All costs are in Canadian dollars.

[a] Scenario Analysis in which the utility scores in each CI state were assumed to be the same for both the Memory Clinic patients and the usual care patients.

Scenario Analysis and Sensitivity Analysis Results

When we assumed the utility scores in each CI state remain the same for both the Memory Clinic patients and the usual care patients in the analysis, the conclusion remained unchanged and MINT Memory Clinic care remained to be a cost-saving option in comparison with usual care (Table 4). One way sensitivity analysis results (online Supplemental Figure 3) indicate that

patients' intervention starting age had the largest effect on the results. Patients with a lower starting age provided further cost-saving than the base-case. Patients with a lower starting age showed improved quality of life compared to patients who entered usual care at the same age. Level of cost-saving was affected by the lower health service utilization in MINT Memory Clinic care compared to usual care and the lower utility values for the usual care CI states, which created a greater difference in utility values between the intervention groups and affected the level of cost-saving. Further, the cost of care for Memory Clinic patients in the Little to No CI state group also affected the level of cost-saving. However, the conclusion remains favourable for MINT Memory Clinics when such uncertainty is considered.

DISCUSSION

This study demonstrated that MINT Memory Clinic care is cost saving compared to the provision of usual dementia care in Ontario. Despite the minimal difference in utility values, MINT Memory Clinics greatly reduce overall healthcare costs as demonstrated in the lower costs for system resources such as nursing home care and ED visits.[14] Variation in intervention starting

age was found to have the greatest impact on ICER; patients may benefit from MINT Memory Clinic care more if they began care at a younger age. When patients were identified with CI at a younger age and underwent usual dementia care services, they utilized more resources, which increased overall costs significantly. Even when considering the variation of all factors and a deviance in the normal values in our model, MINT Memory Clinic care was still shown to be cost saving. Moreover, as demonstrated in the probabilistic analysis, MINT Memory Clinics provided superior treatment over usual dementia care 97.7% of the time.

Although no other studies have compared care models similar to MINT Memory Clinic care to usual dementia care services, cost-effectiveness of other dementia care interventions have been studied with positive results.[27,32-34] A community health intervention that supported informal caregivers with systematic collection and sharing of patient health data with medical providers, was reported to be cost-effective under three of the four scenarios presented.[34434433333] The cost-effectiveness of a community-based, nurse-led collaborative dementia care management intervention that aimed to support persons with dementia and their caregivers through coordination of optimal care with their family physician was found to be a potentially cost-effective strategy for treating dementia due to improving quality of life (+0.05 QALY) at

lower costs (-569€) compared to usual care services.[27] Based on main cost-per-QALY analysis, care provided by an integrated multidisciplinary diagnostic facility was deemed cost-effective.[32] Lastly, an economic evaluation comparing the cost-effectiveness of one year dementia follow-up care by specialist-led memory clinics versus general practitioners showed that memory clinics were on average €1024 cheaper but had a decrease of 0.025 QALY compared to usual care,[33] which may be attributable to the short follow-up time period. A one-year follow-up period may not be sufficient to capture the effects of living with a progressive illness with significant sequalae that can negatively impact quality of life. A strength of our economic analysis is our larger sample size and longer EQ-5D-5L data collection time period.

The positive outcomes in this economic analysis are likely attributable to the unique features of the MINT Memory Clinic model, which differentiates it from other dementia care models and usual care. The MINT Memory Clinic model is effective, not just because dementia care is provided at a primary care level, but that there is enhanced and ongoing nationally accredited training for the multi-disciplinary team members, true coordination and collaboration between primary care, specialist, and community care, and ongoing access to full dementia care service from one location that facilitates the comprehensive care needed to support healthy and

safe living within the community as the disease progresses. Moreover, the standardized nationally accredited memory clinic training program was created and delivered by primary care-based clinicians, making it highly relevant to primary care practice, and involves best teaching practices.[11, 35] Timely diagnosis, person-centered care, and early access to support and coordinated care for each patient and caregiver dyad compared to patients receiving usual care may reduce healthcare costs in the long term by decreasing frequency of ED visits and delaying institutionalization. The fact that MINT Memory Clinic care demonstrated a slight increase in QALY in face of a progressive neurodegenerative condition can be viewed as positive as it may reflect the positive impact that early support can have on helping persons with dementia live fulfilling and independent lives for as long as possible. Current evidence demonstrates the potential of interventions focused on earlier management of cognitive impairment and/or dementia in yielding economic benefits.[36]

Similar to all studies that use convenience sampling, our results may have under- or over-estimated the cost-effectiveness of MINT Memory Clinic care due to selection bias associated with this sampling method and a relatively small sample size.[37] The lack of existing research regarding a comparative usual care group for persons with dementia living in Canada limited us

to using available data from different countries and healthcare systems. As such, the comparability between MINT Memory Clinic care and usual care may be limited since all of the data used was not collected from within the Canadian healthcare system. Despite this limitation, key values such as transition probabilities and cost values were taken directly from the MINT Memory Clinic patient database and Canadian administrative databases (IC/ES). Further research is needed to collect utility values for persons living with dementia in Canada in the usual care setting. This data would play a key role in future economic analyses of dementia care programs in Canada. In addition, we conducted our analysis using a health system perspective rather than a societal perspective, thus we may have underestimated or overestimated the benefit of MINT Memory Clinics as costs associated with patient and caregiver time and out-of-pocket expenses were not included in our analysis.[38, 39]

Another limitation was the exclusion of costs of space and administration costs in the calculation costs for MINT Memory Clinics. As MINT Memory Clinics are often operated within existing family practice sites, there is no additional cost for space in most cases. We conservatively estimated new MINT Memory Clinic capacity at four newly-diagnosed patients with dementia per month amongst the patients with other cognitive diagnoses being made. As

more mature clinics may have greater capacity, our results may underestimate cost-efficiency for some clinics. The estimated cost for salaries utilized in our study is a gross over-estimation as most health professionals are already employed within the primary care site and their work in the clinic is infrequent, in some cases just one day per month, given the efficiencies of a shared care model with the patients' own family physicians. Lastly, as our data are most relevant to Canada, and in a particular to community care settings, it may be difficult to generalize to other jurisdictions due to differences in healthcare systems.

CONCLUSION

As there is a growing need for high quality, cost effective, dementia care within the context of limited healthcare resources, information about the economic impact of the MINT Memory Clinics can inform health service design and resource allocation. Our study adds to the growing body of literature demonstrating that dementia care interventions in primary care can have significant positive impacts on healthcare system resource use.[40] Our study showed that as compared to usual care, patients receiving MINT Memory Clinic care had much lower healthcare costs and modestly improved quality of life. Based on the results of this study, the MINT

Memory Clinic model has a very high likelihood (97.7%) of reducing healthcare costs and improving healthcare over usual care. Implementation of this care model across primary care systems may assist with improving quality and access to memory care while decreasing the growing economic and social burden of dementia.

Word Count: 3737

Author Contributions LL and WW were involved in study conceptualization, and implementation; LL, WW, SW, CL and TP were involved in study design; WW, SW and CL completed the data collection, and analysis; all authors were involved in data interpretation and manuscript preparation and final approval.

Funding This work was supported by the Centre for Family Medicine Family Health Team. The funding had no role in the design, conduct, or reporting of the analysis.

Competing Interests Sasha Walker and Catherine Lee are employed by the Centre for Family Medicine Family Health Team. The remaining authors have no conflicts to declare.

Patient consent for publication Not required.

Ethics Approval Ethics approval was obtained for the collection of MINT Memory Clinic patient data. Approval was granted by the Hamilton Integrated Research Ethics Board, McMaster University (#13-266).

Data availability statement Data are available upon reasonable request. The data that support the findings of this study are not publicly available due to them containing information that could compromise participant privacy. Deidentified, limited data will be shared by the corresponding author upon request.

Supplemental Material

Supplemental Material 1. Detailed Methodology

Supplemental Table 1. Cost of healthcare services by MINT Memory Clinic patients and usual care patients.

Supplemental Figure 1. Detailed Markov-based State Transition Model for Usual Care and MINT Memory Clinics.

Supplemental Figure 2. Results of Probabilistic Sensitivity Analysis: Incremental Cost-Effectiveness of MINT Memory Clinics versus Usual Care.

Supplemental Figure 3. Tornado Diagram; One-Way Sensitivity analysis of MINT Memory Clinics versus Usual Care.

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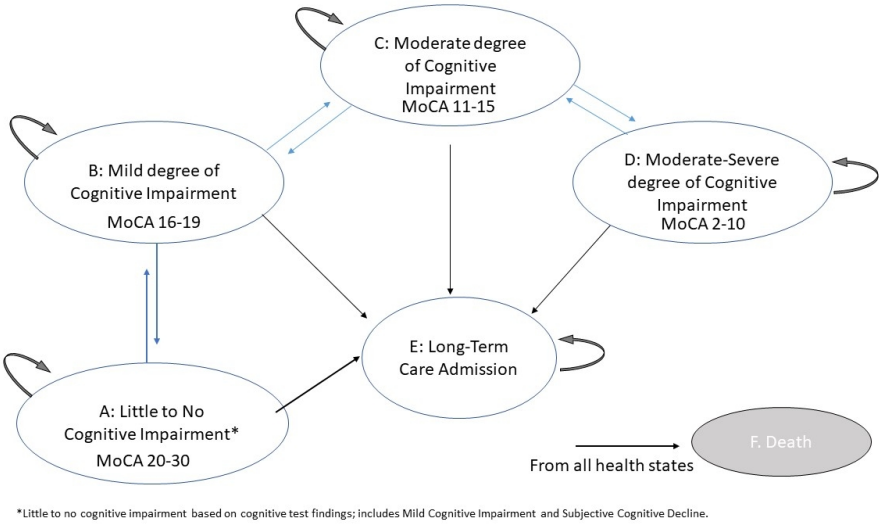
Figure Legend

Figure 1 Markov-based State Transition Model for Usual Care and MINT Memory Clinics



Markov-based State Transition Model for Usual Care and MINT Memory Clinics

338x190mm (96 x 96 DPI)

Online Supplemental Materials (Text, Tables, and Figures)

Supplemental Text: Detailed Methodology

Detailed Cost Calculation

Cost values (all in Canadian dollars) in our model were derived primarily from the provincial Memory Clinic evaluation.[1] In the provincial evaluation, a retrospective costing analysis based on health administrative data was conducted between patients in MINT Memory Clinics and usual care from 2006-2015.[1] Daily operating costs for Memory Clinics were reported to be $287.72 per patient, based on the cost of employing each healthcare professional once a month and seeing a minimum of four patients per day.[1] We estimated the yearly operating cost for each health state by multiplying the daily operating cost per patient by the average number of yearly visits for each health state. The average number of yearly visits for each cognitive impairment (CI) health state was calculated based on a 5-year history for each patient. The yearly costs per health state are as follows, Little to No CI: $241.69 based on an average of 0.84 visits per year; Mild CI: $374.04 based on an average number of 1.3 visits per year; Moderate CI: $411.44 based on an average of 1.43 visits per year; and, Moderate-Severe CI: $503.51 based on an average number of 1.75 visits per year.

The total annual health state cost of each Memory Clinic CI state group was calculated based on the sum of the yearly cost of Memory Clinic services as detailed above and the yearly cost of other associated healthcare services utilized by patients with dementia (e.g., Fee-for-Service and Non-Fee-for-Service visits, home care services, Complex Continuing Care). For each usual care CI state group, the annual cost was calculated based only on the yearly cost of

other associated healthcare services utilized by patients with dementia. Supplementary Table S1 presents a detailed summary of the daily costs of healthcare services for Memory Clinic and usual care patients. Some of these costs (inpatient hospital stays, inpatient mental health stays, Emergency Department, ED, visits, nursing home) were excluded from the annual health state costs for both Memory Clinic and usual care since these costs were accounted for separately when these events occurred during the simulation. The daily costs of all other healthcare services were converted to yearly costs in order to determine the annual health state cost for both interventions. The total annual health state cost for Memory Clinics was calculated to be $14,438.20 and $21,020.35 for usual care.

For hospitalization costs, inpatient hospital stays and mental health hospital stay costs reported in the provincial evaluation were combined, leading to a total of $87.66 daily per patient in usual care and $41.65 daily per Memory Clinic patient.[1] Based on data from the Canadian Institute for Health Information (CIHI), adults aged 60 years and older diagnosed with dementia have an average length of hospitalization stay of 10 days.[2] Accordingly, the overall annual cost of hospitalization was estimated at $876.60 for usual care patients and $416.50 for Memory Clinic patients. Annual ED and nursing home costs were calculated based on the cost per day values provided in the provincial evaluation multiplied by 365 days.[1] The annual ED costs were estimated at $1,912.60 for usual care patients and $941.70 for Memory Clinic patients. Similarly, the annual nursing home costs were estimated at $12,212.90 for usual care patients and $9,902.45 for MINT Memory Clinic patients. Table 2 in the main text provides an overview of all cost values utilized in our model.

Utility

EQ-5D-5L is a preference-based health status measure that is a valid and reliable measurement tool for quality of life utilized worldwide.[3] Patients score their health state (no, slight, moderate, severe, or extreme problems) across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. EQ-5D-5L surveys were completed by Memory Clinic patients and averaged for each health state group. Generally, patients are asked to complete the EQ-5D-5L survey independently but sometimes, in advanced stages, their caregivers assisted them to complete the survey to provide an accurate estimate.[4] A total of 376 EQ-5D-5L and Montreal Cognitive Assessment (MoCA) scores were collected from 229 patient records. Average utility values for Memory Clinic patients in each CI state are as follows, Little to No CI group: 0.83; Mild CI group: 0.85; Moderate CI group: 0.85; and, Moderate-Severe CI group: 0.82.

Utility scores were obtained from a published study for purposes of comparative effectiveness.[5] In this study, it was reported that a collaborative dementia care program had a 0.0012 quality-adjusted-life-year (QALY) increase compared to the usual care group.[5] Thus, the following utility values for the usual care CI state were utilized, Little to No CI: 0.82; Mild CI:, 0.83; Moderate CI: 0.84; and, Moderate-Severe CI: 0.81. A detailed summary of the utility values utilized for both intervention groups is presented in Table 2 in the main text.

Assumptions

As we conservatively assumed that the Memory Clinic intervention does not alter progression of cognitive impairment, the same transition probabilities were utilized for both groups. The cost of

the Memory Clinics was based on the conservative assumption that clinics operate one day a month and see four patients per day.

Analyses

A base-case analysis was conducted first to estimate the incremental cost-effectiveness ratio (ICER) between the Memory Clinics and usual care deterministically. A full deterministic one-way sensitivity analysis was then run on all model parameters over the plausible ranges using the reported 95% confidence interval if available or ±25% of the reference value. A tornado diagram was used to summarize the results of the one-way sensitivity analysis of memory clinic versus usual care. Finally, we conducted probabilistic sensitivity analysis (PSA) using the Monte Carlo simulation for 5,000 iterations. The willingness to pay was set at zero for this simulation and for intervention starting age, normal distribution was used (77.95 ± 9.84). All probabilistic parameters and utilities used in the model are represented by beta distributions formed by the corresponding ranges, and all cost parameters are represented by gamma distributions formed by the corresponding ranges as presented in Table 2 in the main text. All analyses were conducted using TreeAge Pro 2021 (TreeAge Software, Williamstown, MA).

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Supplemental Table 1. Cost of healthcare services by MINT Memory Clinic patients and usual care patients.

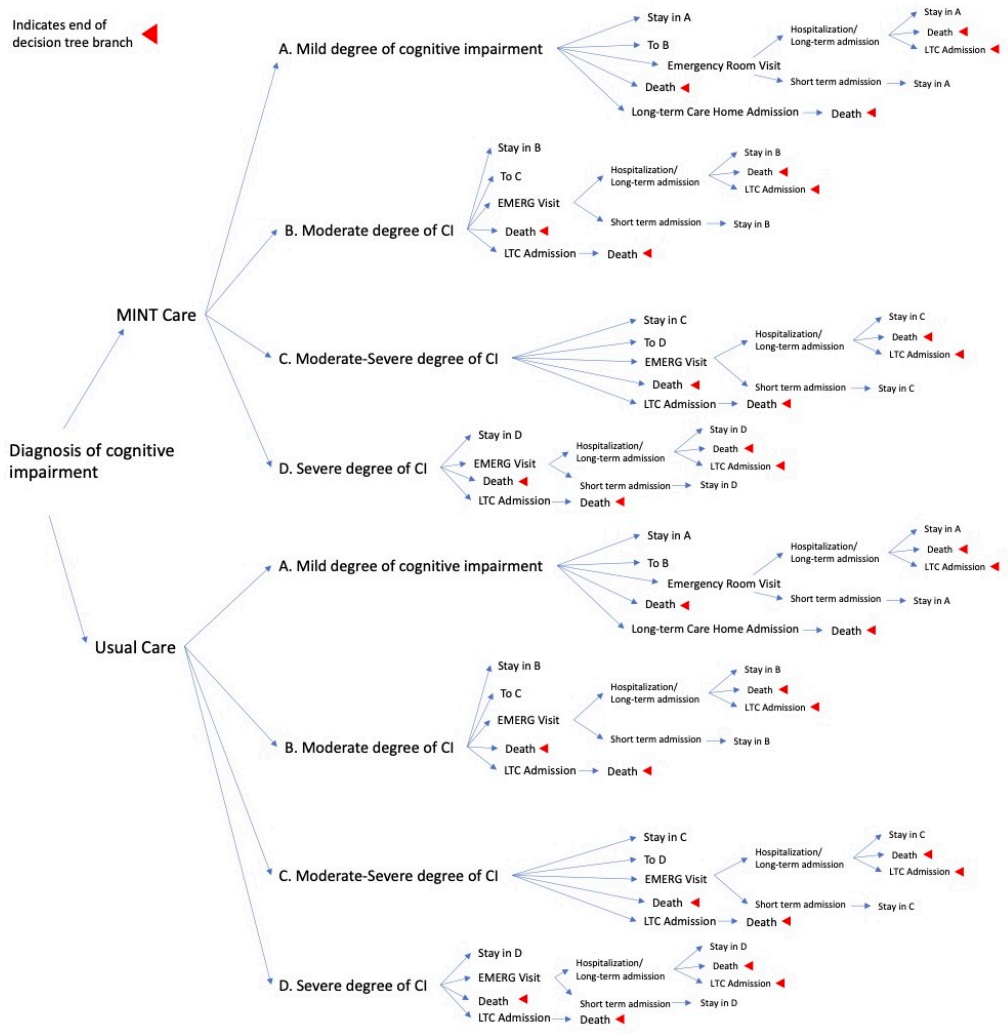
Cost Per Day After Index Date, Including Index Date (Data Source)	Non-MINT MC care	MINT-MC care	Significant (s) / Not Significant (ns)
Inpatient hospital admission (DAD)	86.53	39.38	s
Emergency Department visits (NACRS)	5.24	2.58	s
Medications (ODB, all ages)	8.38	8.17	ns
Rehabilitation (NRS)	2.49	2.19	ns
Complex Continuing Care (CCRS)	10.68	8.99	s
Nursing home care (total)	33.46	27.13	s
Nursing home care (OHIP/ODB)	5.19	0.5	s
Long Term Care (using CCRS)	28.27	26.62	s
Home Care Services	9.19	8.4	s
Total Visits	17.10	9.66	s
Total Fee-for-Service visits	15.23	8.16	s
Other non-Fee-for-Service visits	0.75	0.72	ns
Non-Fee-for-Service primary care physician visits	0.03	0.05	s
Inpatient Mental Health	2.13	2.27	ns
Total Cost Per Day	184.95	114.18	s

Adapted from: Health Innovations Group, 2019.[1]

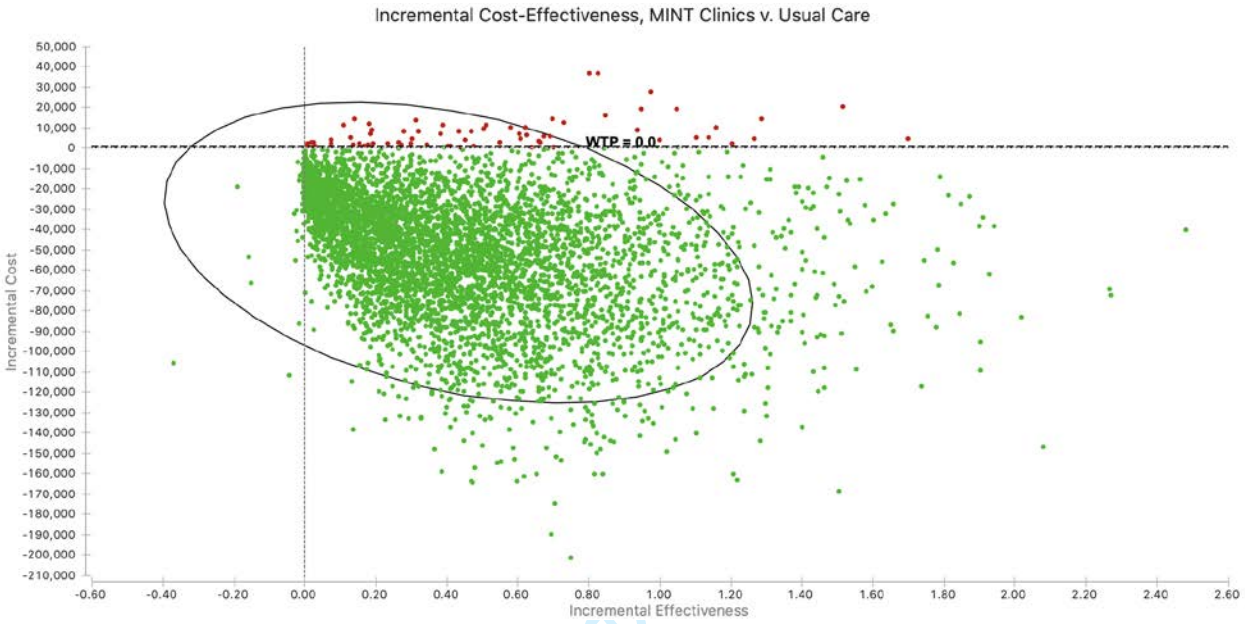
CCRS = Continuing Care Reporting System (contains data on all patients receiving continuing care services in hospitals or nursing homes across Canada); DAD = Discharge Abstract Database (contains data regarding each

inpatient hospital stay); MINT MC = Multispecialty Interprofessional Team Memory Clinic; NACRS = National Ambulatory Care Reporting System (contains data on each Emergency Department visit); NRS = National Rehabilitation Reporting System (contains data on all inpatient rehabilitation facilities and programs across Canada); ODB = Ontario Drug Benefit (formulary of prescription medications paid for by the Ministry of Health);OHIP = Ontario Health Insurance Plan (publicly funded healthcare plan).

Supplemental Figure 1. Detailed Markov-based State Transition Model for Usual Care and MINT Memory Clinics

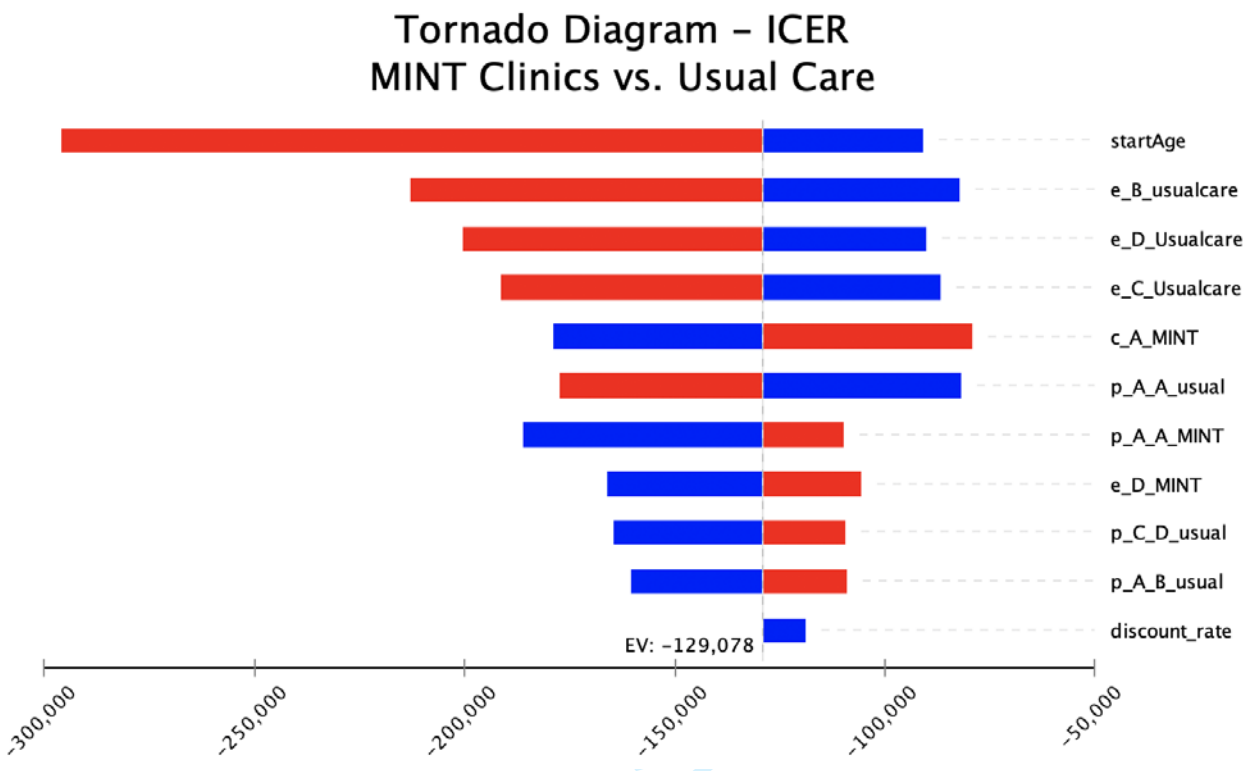


Supplemental Figure 2. Results of Probabilistic Sensitivity Analysis: Incremental Cost-Effectiveness of MINT Memory Clinics versus Usual Care



MINT Memory clinics were cost saving in 97.7% of the 5000 Monte Carlo simulations.

Supplemental Figure 3. Tornado Diagram; One-Way Sensitivity analysis of MINT Memory Clinics versus Usual Care.



startAge = The age at which patients start to receive dementia/MCI related care in MINT Memory Clinics or usual care; e_B_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 16-19 (Group B); e_D_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 2-10 (Group D);E_C_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 11-15 (Group C); c_A_MINT = The cost of patients in MINT Memory Clinics per year who have MoCA scores of 20-30 (Group A); p_A_A_usual = The probability of usual care patients remaining in MoCA Group A (MoCA Score of 20-30) after one year; p_A_A_MINT = The probability of MINT Memory clinic patients remaining in MoCA Group A (MoCA Score of 20-30) after one year; e_D_MINT = The effectiveness and quality of life of patients in MINT Memory Clinics who have MoCA scores of 2-10 (Group D); p_C_D_usual = The probability of usual care patients transitioning from MoCA Group C (11-15) to MoCA Group D (2-10) within a year; p_A_B_usual = The probability of usual care patients transitioning from MoCA Group A (20-30) to MoCA Group B (16-19) within a year.

CHEERS 2022 Checklist

Topic	No.	Item	Location where item is reported
Title			
	1	Identify the study as an economic evaluation and specify the interventions being compared.	Page 1
Abstract			
	2	Provide a structured summary that highlights context, key methods, results, and alternative analyses.	Page 2
Introduction			
Background and objectives	3	Give the context for the study, the study question, and its practical relevance for decision making in policy or practice.	Page 4-5
Methods			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	Page 6
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	Page 7
Setting and location	6	Provide relevant contextual information that may influence findings.	Page 6
Comparators	7	Describe the interventions or strategies being compared and why chosen.	Page 7
Perspective	8	State the perspective(s) adopted by the study and why chosen.	Page 6
Time horizon	9	State the time horizon for the study and why appropriate.	Page 6
Discount rate	10	Report the discount rate(s) and reason chosen.	Page 6
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	Page 12
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	Page 12
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	Table 1, page 12
Measurement and valuation of resources and costs	14	Describe how costs were valued.	Page 11
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	Page 11, Supplementary File Page 1

Topic	No.	Item	Location where item is reported
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	Page 8
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	Supplementary File Page 4
Characterising heterogeneity	18	Describe any methods used for estimating how the results of the study vary for subgroups.	N/A
Characterising distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	N/A
Characterising uncertainty	20	Describe methods to characterise any sources of uncertainty in the analysis.	Page 12
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (such as clinicians or payers) in the design of the study.	N/A
Results			
Study parameters	22	Report all analytic inputs (such as values, ranges, references) including uncertainty or distributional assumptions.	Table 2
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	Page 13 and Table 3
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	Page 13-14
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	NA
Discussion			
Study findings, limitations, generalisability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could affect patients, policy, or practice.	Page 14-18
Other relevant information			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	Page 19
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	Page 20

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Cost-utility analysis of a multispecialty interprofessional team dementia care model in Ontario, Canada

William W.L. Wong PhD,[1] Linda Lee, MD, MClSc(FM)[2,3] Sasha Walker BSc,[2] Catherine Lee BSc,[2] Tejal Patel PharmD,[1,2] Loretta M. Hillier MA,[4] Andrew Costa PhD,[5] and Samir K. Sinha MD, DPhil[6,7]

[1]School of Pharmacy, University of Waterloo, Waterloo, Ontario.

[2]Centre for Family Medicine Family Health Team, Kitchener, Ontario.

[3]Department of Family Medicine, McMaster University, Hamilton, Ontario.

[4]GERAS Centre for Aging Research, Hamilton, Ontario.

[5]Departments of Clinical Epidemiology & Biostatistics, and Medicine, McMaster University, Hamilton, Ontario.

[6]Departments of Medicine, Family and Community Medicine and the Institute of Health Policy, Management, and Evaluation, University of Toronto, Ontario

[7]National Institute on Ageing, Ryerson University, Toronto, Ontario

Corresponding Author: William W. L. Wong, PhD. School of Pharmacy, Faculty of Science, University of Waterloo, PHR4011, 10A Victoria Street S, Kitchener, N2G 1C5. Tel: 519-888-4567 ext. 21323; Fax: 519-883-7580; e-mail: wwlwong@uwaterloo.ca.

ABSTRACT

Objective Evaluative studies have demonstrated that Multi-specialty Interprofessional Team (MINT) Memory Clinics provide improved quality of dementia care within primary care, however there is limited economic evaluation data for this care model compared to usual care. The objective of this analysis was to examine the cost-effectiveness of MINT Memory Clinic care in comparison to the provision of usual care.

Methods We developed a Markov-based state transition model to perform a cost-utility (costs and quality-adjusted life years, QALYs) analysis of MINT Memory Clinic care and usual care not involving MINT Memory Clinics. Disease progression and cost data were obtained from published sources. Utility data were estimated based on patient-reported quality of life (EQ-5D-5L) survey results. We used a payer perspective, a lifetime time horizon and a 1.5% discount rate and conducted sensitivity analyses.

Results MINT Memory Clinics were found to be less expensive (CAD $51496 (95% Crl, $4806-$119367)) while slightly improving quality of life (+0.43 (95 Crl, 0.01-1.24) QALY) compared to usual care. The probabilistic analysis showed that MINT Memory Clinics were the superior treatment compared to usual care 97.7% of the time. Variation in age was found to have the greatest impact on cost-effectiveness as patients may benefit from the MINT Memory Clinics more if they receive care beginning at a younger age.

Conclusion Multi-specialty interprofessional memory clinic care is less costly and more effective compared to usual care and early access to care significantly reduces care costs over time. The results of this economic evaluation can inform decision-making and improvements to health system design, resource allocation, and care experience for persons living with dementia. Specifically, widespread scaling of MINT Memory Clinics into existing primary care systems may assist with improving quality and access to memory care services while decreasing the growing economic and social burden of dementia.

Key words: dementia, primary care, cost-effectiveness, cost-utility analysis, memory clinics

Strengths and limitations of this study

- This study is an economic evaluation of a multispecialty interprofessional team model of dementia care in Canada for which there is limited economic evaluation data.
- This economic evaluation was conducted consistent with best practice methods and suggested that MINT Memory Clinic care is less costly and more effective compared to usual care in 97.7% of the time.
- The lack of existing research regarding a comparative usual care group for persons with dementia living in Canada limited us to using available data from different countries and healthcare systems thus comparability between MINT Memory Clinic care and usual care may be limited.

- As our data are most relevant to Canada, and in a particular to community care settings, it may be difficult to generalize to other jurisdictions due to differences in healthcare systems.

INTRODUCTION

Globally, dementia is one of the major causes of disability and dependency among older persons.[1] In addition to the significant impact on the quality of life for individuals diagnosed with dementia and their families, dementia also has significant economic implications for healthcare systems. In Canada, combined healthcare system and out of pocket caregiving costs totaled $10.4B in 2016 and is expected to increase to $16.6B by 2031.[2] In 2015, the total societal cost of dementia worldwide in terms of direct medical, social care and informal care costs was estimated to be USD $818 billion.[1]

Primary care clinicians are often the first point of contact for individuals experiencing memory concerns. Given the challenges experienced in diagnosing and managing this complex disorder within the time constraints in busy family practice, persons with memory concerns have historically been referred for specialist care.[3] There is increasing recognition of the need for primary care to take on greater responsibility for early diagnosis, management, and ongoing dementia care throughout the disease process.[4] There is particular interest in strengthening dementia care in primary care with the aim of supporting those with dementia to live at home for as long as possible and to avoid hospitalization and institutionalization.[4]

Collaborative, multidisciplinary team approaches to healthcare represent a significant opportunity to provide patient-centered care, improve health outcomes, and patients' experience with care.[5, 6] The Multi-specialty INterprofessional Team (MINT) Memory Clinic care model (formerly Primary Care Collaborative Memory Clinics) aims to improve assessment, diagnosis, and management of dementia in primary care.[7] Integrating specialist and community care for the most complex of cases, this model supports person-centred care that is experienced by patients

and caregivers as comprehensive, coordinated, timely, and accessible from one location, close to home.[7-10] Within this care model, patients with memory concerns are referred by their family physician to the MINT Memory Clinic, usually located within the same practice setting, for comprehensive assessment and care planning conducted by an interprofessional team consisting of specially trained family physicians, nurses, and other healthcare professionals (e.g., social workers, pharmacists, occupational therapists), and representatives from local community services (Alzheimer Society, home care, behavioural support services) as available.[11] Assessments are conducted with all team members working together in a coordinated and collaborative manner to complete the assessment at the same visit, formulate a diagnosis and develop an integrated, individualized care plan based on patient and caregiver preferences and needs. Using a shared care approach, MINT Memory Clinic team members work with the patient's own family physician to ensure that changes in care needs are identified and met, ensuring care continuity over time. Key model components include integration of geriatric specialists to provide consultative support, ongoing capacity building support, and team integration and coordination of community support services.[6]

The MINT Memory Clinic model exists in over 100 primary care settings across Ontario and is currently being expanded to other provinces across the country. Published evaluative studies have demonstrated improved clinical practice and quality of dementia care, improved access to health and social services, enhanced care experiences for persons with dementia and their caregivers, healthcare provider satisfaction with dementia care, and improved collaboration among health professionals.[6, 8-10] Using a chart audit tool developed by the Ontario of College of Physicians and Surgeons of Ontario, which assessed quality indictors related to diagnosis, investigations, treatment plan and follow-up,[12] two geriatricians independently reviewed 50

charts from five memory clinics.[10] This chart audit revealed a high level of agreement among the geriatricians (kappa coefficient = .86) with the diagnosis and management provided by the clinics, verifying the quality of care provided.[10] A significant healthcare system outcome associated with this care model has been the highly efficient use of limited available specialist resources with a less than 10% referral rate to specialists while maintaining high quality care based on geriatrician chart audit, reduced pressure on specialist wait lists, and delayed institutionalization.[7, 10, 13, 14] The purpose of this study was to examine the cost-effectiveness of the MINT Memory Clinic care model in comparison to the provision of usual dementia care.

METHODS

Study Design

We developed a Markov-based state-transition model to determine the cost-effectiveness of MINT Memory clinics from a public payer perspective (provincial Ministry of Health) for patients with cognitive impairment (CI) in Ontario, Canada using cost-utility analysis. We adopted a public payer perspective, and used a lifetime time horizon and a 1.5% discount rate for our analysis based on Canadian economic evaluation guidelines.[15] An overview of our methodology is presented as follows and additional information can be found in online Supplemental Material.

Patient and public involvement

No patient involvement.

Interventions

Two different care strategies were evaluated for their cost-effectiveness:

1) Usual (non-MINT Memory Clinic) care: Patients initially seen by their family physician for symptoms of cognitive impairment and then referred to a geriatric specialist to determine a formal diagnosis and a treatment plan.
2) MINT Memory Clinic: As described, this care model provides team-based interprofessional collaborative dementia care, in a shared care approach with patients' family physicians and with access to consultative specialist support for complex issues.[6, 7, 10] If a family physician has access to a MINT Memory Clinic, any adult with memory concerns can be referred. MINT Memory Clinics exist in a variety of primary care settings across Ontario in rural, urban, remote, and underserved communities. When there is no access to a MINT Memory Clinic, patients are likely to receive usual care.

Cohort

This study focused on older adults with memory concerns who were referred to receive usual care or MINT Memory Clinic care. Our cohort was based on data from a sample of 229 patients from the Centre for Family Medicine (CFFM) MINT Memory Clinic in Kitchener, Ontario. Patients were seen between January 2019 – January 2021. For inclusion, patients had to have had at least one clinic visit that documented standardized scale scores for cognition (Montreal Cognitive Assessment, MoCA)[16] and quality of life (EQ5D-5L, a preference-based health status

scale that is a valid and reliable measure of quality of life).[17] The EQ5D-5L is administered to patients as part of the Memory Clinic's comprehensive assessment. We excluded patients who were unable or unwilling to provide consent or lack of capacity (as judged by patient's physician). The EQ5D-5L is administered to patients as part of the Memory Clinic's comprehensive assessment. We excluded patients who were unable or unwilling to provide consent or lack of capacity (as judged by patient's physician). Patient characteristics are presented in Table 1. The mean age of the cohort was 80 years; 52% were female. A total of 376 MoCA scores were collected from the sample of 229 patients. To account for the varying level of care required for patients during their disease progression, patients were classified into four CI states based on their MoCA scores: Little to No CI (scores of 20-30); Mild CI (scores of 16-19); Moderate CI (scores of 11-15); and Moderate-Severe CI (scores of 2-10). The majority of patients (61%) had MoCA scores classified as Little to No CI state (in this group, the average MoCA score was 24/30). It is important to note that while all patients referred to Memory Clinics have some cognitive symptoms or concerns, some will have Subjective Cognitive Decline (SCD), which involves normal cognitive testing scores.[18] Like MCI, SCD is an at-risk state for future Alzheimer's disease and other dementias;[19] current Canadian Consensus guidelines recommend appropriate investigations and monitoring of persons with SCD because of risk of progression to dementia.[20] With cognitive test scores being within normal limits, persons with SCD were included in the "Little or no cognitive impairment" category. The identical cohort as described above was used for both the usual care intervention and the MINT Memory Clinic intervention in the cost-utility analysis.

Table 1. MINT Memory Clinic Patient Characteristics

Characteristics	n = 229
Sex, *n* (%)	
Male	111 (48.5)
Female	118 (51.5)
Age (years), mean (SD)	77.95 (9.83)
Age categories, *n (%)*	
≤50 years	2 (0.9)
51-60 years	11 (4.8)
61-70 years	34 (14.8)
71-80 years	84 (36.7)
81-90 years	79 (34.5)
≥91	19 (8.3)
First Language	
English	179 (78.2)
Non-English	50 (21.8)
Martial Status	
Married	143 (62.4)
Widowed	43 (18.8)
Divorced	25 (10.9)
Partner	7 (3.1)
Single	11 (4.8)
Education	

< 9th grade	33 (14.4)
Highschool	79 (34.5)
College or University	86 (37.6)
Professional Degree	31 (13.5)
Living Status	
Alone	49 (21.4)
With Caregiver	172 (75.1)
Institution	6 (2.6)
Other	2 (0.9)
Employment Status	
Employed	29 (12.7)
Unemployed	29 (12.7)
Retired	171 (74.6)
MoCA scores (N = 376)	
Little to No CI state (scores of 20 - 30)	230 (61.2)
Mild CI state (scores of 16 - 19)	56 (14.9)
Moderate CI state (scores of 11 - 15)	54 (14.4)
Moderate-severe CI state (scores of 2 - 10)	36 (9.6)

Notes: CI = cognitive impairment; MoCA = Montreal Cognitive Assessment

Model

A Markov-based state transition model was created to represent the progression of CI to dementia throughout a patient's care journey (Figure 1); a detailed model is presented in online

Supplemental Figure 1. In our simulations, cohort members move between predefined health states in yearly cycles until all members die. In each yearly cycle, there are transition possibilities associated with a patient progressing to the next disease stage or remaining in their current health (CI) state. At each stage, changes in use of healthcare resources (emergency department, hospital) were tracked. In our model, six main health states were: Little to No CI; Mild CI; Moderate CI; Moderate-Severe CI; long-term care (LTC) admission; and, death.

Data

Our model assumed that all patients started their journey within the little to no CI health state, and followed them over time until death. Transition probabilities related to disease progression, emergency department (ED) visits, hospitalization, and transition into nursing home, were either derived from the MINT Memory Clinic data, an independent provincial evaluation of the Memory Clinics commissioned by the Ministry of Health,[14] or other published literature as follows[21-24] (Table 2).

Table 2. Model Parameters: Transition Probabilities, Costs and Utility

Variable	Value	Range	Source
Transition Probabilities			
Probability of Group A[a] staying	0.842	0.6315 – 0.99	MINT Memory Clinic Data
Probability of Group A[a] to Group B[b]	0.111	0.0832 – 0.1387	MINT Memory Clinic Data
Probability of Group A[a] to Group C[c]	0.04	0.03-0.05	MINT Memory Clinic Data
Probability of Group A[a] to Group D[d]	0.007	0.00525-0.00875	MINT Memory Clinic Data

Variable	Value	Range	Source
Probability of Group A[a] entering Emergency Department	0.262	0.225 - 0.297	Voisin, et al. 2009[21]
Probability of Group A[a] entering Nursing Homes	0.01	0.005 – 0.015	MINT Memory Clinic Data
Probability of Group B[b] to Group A[a]	0.318	0.2385 – 0.3975	MINT Memory Clinic Data
Probability of Group B[b] staying	0.338	0.2535 – 0.4225	MINT Memory Clinic Data
Probability of Group B[b] to Group C[c]	0.255	0.1912 – 0.3187	MINT Memory Clinic Data
Probability of Group B[b] to Group D[d]	0.089	0.0667 – 0.1112	MINT Memory Clinic Data
Probability of Group B[b] visiting the Emergency Department	0.262	0.225 - 0.297	Voisin, et al. 2009[21]
Probability of Group A[a] entering Nursing Homes	0.012	0.0001 - 0.028	Spackman, et al. 2012[22]
Probability of Group C[c] to Group A[a]	0.035	0.0262 – 0.0437	MINT Memory Clinic Data
Probability of Group C[c] to Group B[b]	0.175	0.1312 – 0.2187	MINT Memory Clinic Data
Probability of Group C[c] staying	0.518	0.3885– 0.6475	MINT Memory Clinic Data
Probability of Group C[c] to Group D[d]	0.272	0.204 – 0.34	MINT Memory Clinic Data
Probability of Group C[c] visiting the Emergency Department	0.261	0.225 - 0.297	Voisin, et al. 2009[21]
Probability of Group C[c] entering Nursing Homes	0.034	0.000, 0.069	Spackman, et al. 2012[22]
Probability of Group D[d] to Group B[b]	0.019	0.0142 – 0.0237	MINT Memory Clinic Data
Probability of Group D[d] to Group C[c]	0.094	0.0705 – 0.1175	MINT Memory Clinic Data

Variable	Value	Range	Source
Probability of Group D[d] staying	0.887	0.66525 – 0.99	MINT Memory Clinic Data
Probability of Group D[d] visiting the Emergency Department	0.455	0.37 to 0.54	LaMantia, et al 2016[23]
Probability of Group D[d] entering Nursing Homes	0.377	0.2827 – 0.4712	Mondor, et al. 2017[24]
Probability of Short-Term Hospital Stay (MINT Memory Clinics)	0.65	0.4875 – 0.8125	Provincial Evaluation[14]
Probability of Short-Term Hospital Stay (Usual Care)	0.61	0.4575 – 0.7625	Provincial Evaluation[14]
Probability of Entering Long Term Care from Hospital for Group A[a] to C[c]	0.012	0.009 – 0.0015	Spackman, et al. 2012[22]
Probability of Entering Nursing Home from Hospital for Group D[d]	0.299	0.262 – 0.33	Mondor, et al. 2017[24]
Probability of Death during Hospital Care	0.002	0.0015 – 0.0025	Provincial Evaluation[14]
Probability of Death in Nursing Home	0.30	0.262 – 0.33	Xiong, et al. 2019[25]
Costs			
MINT Memory Clinics			
Annual cost of group A[a]	$14,724	$11,043 – 18,407	Provincial Evaluation[14]
Annual cost of group B[b]	$14,857	$11,142 – 18,571	Provincial Evaluation[14]

Variable	Value	Range	Source
Annual cost of group C[c]	$14,894	$11,170 – 18,618	Provincial Evaluation[14]
Annual cost of group D[d]	$14,986	$11,240-18,733	Provincial Evaluation[14]
Annual cost of emergency department visit	$941	$706-1,177	Provincial Evaluation[14]
Annual cost of hospitalization	$416	$312-520	Provincial Evaluation[14]
Annual cost of nursing home care	$9,902	$7426-12,378	Provincial Evaluation[14]
One-time Training cost	$23,000	$17,250-$28,750	MINT Memory Clinic Data
Usual Care			
Annual cost of group A[a]	$21,020	$15,765 – 26,275	Provincial Evaluation[14]
Annual cost of group B[b]	$21,020	$15,765 – 26,275	Provincial Evaluation[14]
Annual cost of group C[c]	$21,020	$15,765 – 26,275	Provincial Evaluation[14]
Annual cost of group D[d]	$21,020	$15,765 – 26,275	Provincial Evaluation[14]
Annual cost of emergency department visit	$1,912	$14,34 – 2,390	Provincial Evaluation[14]
Annual cost of hospitalization	$876	$657 – 1,095	Provincial Evaluation[14]
Annual cost of nursing home care	$12,212	$9,159 – 15,266	Provincial Evaluation[14]
Health State Utilities			
MINT Memory Clinics			
Utility for group A[a]	0.8288	0.697-0.961	MINT Memory Clinic Data
Utility for group B[b]	0.8461	0.739-0.953	MINT Memory Clinic Data
Utility for group C[c]	0.8502	0.721-0.979	MINT Memory Clinic Data
Utility for group D[d]	0.8222	0.675-0.970	MINT Memory Clinic Data

Variable	Value	Range	Source
Utility for LTC	0.52	0.28-0.76	Brandauer, et al. 2020[26]
Usual Care			
Utility for group A[a]	0.8276	0.621-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019[27]
Utility for group B[b]	0.8449	0.634-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019[27]
Utility for group C[c]	0.8490	0.635-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019[27]
Utility for group D[d]	0.8211	0.616-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019[27]
Utility for LTC	0.52	0.28-0.76	Brandauer, et al. 2020[26]

LTC = Long-term care.
[a] Group A, Little to No Cognitive Impairment (MoCA Score 20-30)
[b] Group B, Mild Degree of Cognitive Impairment (MoCA Score 16-19)
[c] Group C, Moderate Degree of Cognitive Impairment (MoCA Score 11-15)
[d] Group D, Moderate-Severe Degree of Cognitive Impairment (MoCA Score 2-10)

Disease Progression Probabilities

To calculate the annual disease transition probabilities, we used medical record data from the MINT Memory Clinic to build a disease history for each patient that began at their first assessment visit. The transition probability of patients moving between CI state groups within the next year was calculated using only data from patients who had at least two visits. Transition probabilities for disease progression are presented in Table 2. Identical transition probabilities

were used for both the usual care and Memory Clinic patients since we conservatively assumed that Memory Clinic care will not affect the progression of CI.

Emergency Department Visit Probabilities, Hospitalization Probabilities and Frequency of Visits

The annual probability of a person in the Little to No CI, Mild CI and Moderate CI states who have at least one ED visit is 26.2%.[21] For the Moderate-Severe CI person, an annual probability of 45.5% was used.[23] Among those who have had at least one ED visit, our model assumed that 22% of individuals visited the ED once, 24% visited twice and 54% visited three times based on published data.[28] According to the provincial evaluation, 65% of MINT Memory Clinic patients returned to the community after a short-term hospital stay, compared to 61% of usual care patients.[14]

Transition into LTC Homes

The probabilities of entering nursing homes were 1.2% for patients in the Mild CI state and 3.5% for patients in the Moderate CI state.[22] For patients in the Moderate-Severe CI state, the transition probability was reported as 37.7%.[24] Since patients in the Little to No CI group were mostly younger and did not show many symptoms of cognitive impairment, the model assumed no transition into LTC homes.

Mortality

All-cause mortality was calculated using life tables developed by Statistics Canada.[29] Dementia-related mortality for both Memory Clinic and usual care patients in the hospital was 0.2% based on the provincial evaluation.[14] Once patients were admitted to LTC, the annual mortality was assumed to be 30% based on the literature.[25, 30]

Cost

Cost values in this model were derived primarily from the provincial memory clinic evaluation reported in 2017, in which a retrospective costing analysis based on health administrative data was conducted between patients receiving MINT Memory Clinic care and usual care from 2006-2015.[14] Online Supplemental Table 1 presents a detailed summary of the daily costs of healthcare services for Memory Clinic and usual care patients. The cost of Memory Clinics was based on the conservative assumption that clinics operate one day a month and see four patients per day. The daily costs of healthcare services involved in both interventions were converted to yearly costs in order to determine the annual health state cost for both interventions. The total annual health state cost for Memory Clinics was calculated to be CAD $14438 and CAD $21020 for usual care. The one-time direct training cost involved in setting up the Memory Clinics was estimated at CAD $23000 per clinic, implementation cost paid by the Ministry. Using the same assumption as in the provincial evaluation,[14] with each Memory Clinic operating once per month with minimum 4 of patients per clinic day, the one-time training cost is estimated to be CAD $479 per patient ($23,000 / 12 months /4 patients) for the first year of operation.

For hospitalization costs, inpatient hospital stays and mental health hospital stays costs reported in the provincial evaluation were combined, using an average length of hospitalization

stay of 10 days.[31] The overall annual cost of hospitalization was estimated at CAD $877 for usual care patients and CAD $416 for Memory Clinic patients. Similarly, the annual nursing home costs were estimated at CAD $12213 for usual care patients and CAD $9902 for MINT Memory Clinic patients. Table 2 provides an overview of all cost values utilized in our model.

Utility

Effectiveness was measured in quality adjusted life years (QALYs), calculated based on the quality of life of patients in given CI states. Utility scores were obtained from EQ-5D-5L surveys that were completed by 229 Memory Clinic patients, and a published study for purposes of comparative effectiveness for the usual care.[27] A detailed summary of the utility values utilized for both intervention groups is presented in Table 2. The total effectiveness of care is presented as a sum of the quality adjusted life year (QALY) throughout the patient transition.

Analyses

A base-case analysis was conducted first to estimate the incremental cost-effectiveness ratio (ICER) between the Memory Clinics and usual care based on a probabilistic analysis using Monte Carlo simulation for 5000 iterations. A full deterministic one-way sensitivity analysis was then run on all model parameters over the plausible ranges using the reported 95% confidence interval if available or ±25% of the reference value, for parameters where estimates of uncertainty were not available. Further, two scenario analyses were conducted by 1) assuming

the utility scores in each CI state remain the same for both the Memory Clinic patients and the usual care patients; and 2) using the utility scores in each CI state from a published study (mild CI:0.9; moderate CI:0.68; serve CI:0.45).[32] All analyses were conducted using TreeAge Pro 2021 (TreeAge Software, Williamstown, MA).

RESULTS

Base Case Analysis

The cost-effectiveness results between MINT Memory Clinics and usual care are presented in Table 3 and online Supplemental Figure 2. The total average cost for a patient receiving MINT Memory Clinic care and usual care in MINT Memory Clinics is CAD $145805 (95% CrI, $42594-$244574) and CAD $197301(95% CrI, $59539-$331406), throughout their entire care journey, respectively. The cost difference between Memory Clinic and usual care is CAD $51496 (95% CrI, $4806-$119367), indicating that MINT Memory Care is cost-saving in comparison to usual care. In addition, MINT Memory Clinics care is a more effective intervention in terms of total QALY (7.86 (95% CrI, 2.34-12.86) QALY), in comparison with the usual care (7.43 (95% CrI, 2.31-7.56) QALY), which translates to a gain of 0.43 (95% CrI,

0.01-1.24) QALYs for MINT Memory Clinic care over usual care. In this probabilistic analysis (online Supplemental Figure 2), MINT Memory clinics were the superior option (less costly and more effective) in 97.7% of the 5000 Monte Carlo simulations.

Table 3. Cost Effectiveness of MINT Memory Clinics versus Usual Care: Base case analysis and scenario analysis results

Analysis	Total Cost ($) Mean (95% Crl)	Incremental Cost Mean (95% Crl)	Effectiveness (QALY) Mean (95% Crl)	Incremental Effectiveness Mean (95% Crl)	ICER ($/QALY)
Base Case Analysis MINT Memory Clinics	$145805 ($42594-$244574)	0	7.86 (2.34-12.86)	0	0

Usual Care	$197301 ($59539-331406)	$51496 (4806-119367)	7.43 (2.31-7.56)	-0.43 (-0.01--1.24)	Dominated
Scenario Analysis[a] MINT Memory Clinics	$145805 ($42594-$244574)	0	7.86 (2.34-12.86)	0	0
Usual Care	$197301 ($59539-331406)	$51496 (4806-119367)	7.44 (2.33-11.97)	-0.42 (-0.01 – - 1.23)	Dominated

Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality Adjusted Life Year. All costs are in Canadian dollars. Crl = credible interval

[a] Scenario Analysis in which the utility scores in each CI state were assumed to be the same for both the Memory Clinic patients and the usual care patients.

Scenario Analysis and Sensitivity Analysis Results

When we assumed the utility scores in each CI state remain the same for both the Memory Clinic patients and the usual care patients in the analysis, the conclusion remained unchanged and MINT Memory Clinic care remained to be a cost-saving option in comparison with usual care (Table 3). Similarly, when we used the utility scores in each CI state from a published study[32] in the analysis, the conclusion remained unchanged (Supplemental Table 2). One way sensitivity analysis results (online Supplemental Figure 3) indicate that patients' intervention starting age had the largest effect on the results. Patients with a lower starting age provided further cost-saving than the base-case. Patients with a lower starting age showed improved quality of life compared to patients who entered usual care at the same age. Level of cost-saving was affected by the lower health service utilization in MINT Memory Clinic care compared to usual care and the lower utility values for the usual care CI states, which created a greater difference in utility values between the intervention groups and affected the level of cost-saving. Further, the cost of care for Memory Clinic patients in the Little to No CI state group also affected the level of cost-saving. However, the conclusion remains favourable for MINT Memory Clinics when such uncertainty is considered.

DISCUSSION

This study demonstrated that MINT Memory Clinic care is cost saving compared to the provision of usual dementia care in Ontario. Despite the minimal difference in utility values, MINT Memory Clinics greatly reduce overall healthcare costs as demonstrated in the lower costs for system resources such as nursing home care and ED visits.[14] Variation in intervention starting age was found to have the greatest impact on ICER; patients may benefit from MINT Memory Clinic care more if they began care at a younger age. When patients were identified with CI at a younger age and underwent usual dementia care services, they utilized more resources, which increased overall costs significantly. Even when considering the variation of all factors and a deviance in the normal values in our model, MINT Memory Clinic care was still shown to be cost saving. Moreover, as demonstrated in the probabilistic analysis, MINT Memory Clinics provided superior treatment over usual dementia care 97.7% of the time.

We have used a model-based approach to conduct the cost-effectiveness analysis for MINT Memory Clinic; this similar approach has also been used to evaluate the cost of illness associated with dementia,[33, 34] and the cost effectiveness of health interventions for people with

dementia.[32] Although no other studies have compared care models similar to MINT Memory Clinic care to usual dementia care services, cost-effectiveness of other dementia care interventions have been studied with positive results.[27, 32, 35, 36] A community health intervention that supported informal caregivers with systematic collection and sharing of patient health data with medical providers, was reported to be cost-effective under three of the four scenarios presented.[32] The cost-effectiveness of a community-based, nurse-led collaborative dementia care management intervention that aimed to support persons with dementia and their caregivers through coordination of optimal care with their family physician was found to be a potentially cost-effective strategy for treating dementia due to improving quality of life (+0.05 QALY) at lower costs (-569€) compared to usual care services.[27] Based on main cost-per-QALY analysis, care provided by an integrated multidisciplinary diagnostic facility was deemed cost-effective.[35] Lastly, an economic evaluation comparing the cost-effectiveness of one year dementia follow-up care by specialist-led memory clinics versus general practitioners showed that memory clinics were on average €1024 cheaper but had a decrease of 0.025 QALY compared to usual care,[36] which may be attributable to the short follow-up time period. A one-year follow-up period may not be sufficient to capture the effects of living with a progressive illness with significant

sequalae that can negatively impact quality of life. A strength of our economic analysis is our larger sample size and longer EQ-5D-5L data collection time period.

The positive outcomes in this economic analysis are likely attributable to the unique features of the MINT Memory Clinic model, which differentiates it from other dementia care models and usual care. The MINT Memory Clinic model is effective, not just because dementia care is provided at a primary care level, but that there is enhanced and ongoing nationally accredited training for the multi-disciplinary team members, true coordination and collaboration between primary care, specialist, and community care, and ongoing access to full dementia care service from one location that facilitates the comprehensive care needed to support healthy and safe living within the community as the disease progresses. Moreover, the standardized nationally accredited memory clinic training program was created and delivered by primary care-based clinicians, making it highly relevant to primary care practice, and involves best teaching practices.[11, 37] Timely diagnosis, person-centered care, and early access to support and coordinated care for each patient and caregiver dyad compared to patients receiving usual care may reduce healthcare costs in the long term by decreasing frequency of ED visits and delaying institutionalization. The fact that MINT Memory Clinic care demonstrated a slight increase in

QALY in face of a progressive neurodegenerative condition can be viewed as positive as it may reflect the positive impact that early support can have on helping persons with dementia live fulfilling and independent lives for as long as possible. Current evidence demonstrates the potential of interventions focused on earlier management of cognitive impairment and/or dementia in yielding economic benefits.[38]

Similar to all studies that use convenience sampling, our results may have under- or over-estimated the cost-effectiveness of MINT Memory Clinic care due to selection bias associated with this sampling method and a relatively small sample size.[39] The lack of existing research regarding a comparative usual care group for persons with dementia living in Canada limited us to using available data from different countries and healthcare systems. As such, the comparability between MINT Memory Clinic care and usual care may be limited since all of the data used was not collected from within the Canadian healthcare system. Despite this limitation, key values such as transition probabilities and cost values were taken directly from the MINT Memory Clinic patient database and Canadian administrative databases (IC/ES). Further research is needed to collect utility values for persons living with dementia in Canada in the usual care setting. This data would play a key role in future economic analyses of dementia care programs

in Canada. Further, we are not able to investigate the impact of the type of dementia in relationship to our results due to existing data limitation. In addition, we conducted our analysis using a health system perspective rather than a societal perspective, thus we may have underestimated or overestimated the benefit of MINT Memory Clinics as costs associated with patient and caregiver time and out-of-pocket expenses were not included in our analysis.[40, 41]

Another limitation was the exclusion of costs of space and administration costs in the calculation costs for MINT Memory Clinics. As MINT Memory Clinics are often operated within existing family practice sites, there is no additional cost for space in most cases. We conservatively estimated new MINT Memory Clinic capacity at four newly-diagnosed patients with dementia per month amongst the patients with other cognitive diagnoses being made. As more mature clinics may have greater capacity, our results may underestimate cost-efficiency for some clinics. The estimated cost for salaries utilized in our study is a gross over-estimation as most health professionals are already employed within the primary care site and their work in the clinic is infrequent, in some cases just one day per month, given the efficiencies of a shared care model with the patients' own family physicians. Lastly, as our data are most relevant to Canada, and in a particular to community care settings, it may be difficult to generalize to other jurisdictions due to differences in healthcare systems.

CONCLUSION

As there is a growing need for high quality, cost effective, dementia care within the context of limited healthcare resources, information about the economic impact of the MINT Memory Clinics can inform health service design and resource allocation. Our study adds to the growing body of literature demonstrating that dementia care interventions in primary care can have significant positive impacts on healthcare system resource use.[42] Our study showed that as compared to usual care, patients receiving MINT Memory Clinic care had much lower healthcare costs and modestly improved quality of life. Based on the results of this study, the MINT Memory Clinic model has a very high likelihood (97.7%) of reducing healthcare costs and improving healthcare over usual care. Implementation of this care model across primary care systems may assist with improving quality and access to memory care while decreasing the growing economic and social burden of dementia.

Word Count: 3931

Author Contributions LL and WW were involved in study conceptualization, and implementation; LL, WW, SW, CL and TP were involved in study design; WW, SW and CL completed the data collection, and analysis; all authors (WW, LL, SW, CL, LMH, AC, SKS) were involved in data interpretation and manuscript preparation and final approval.

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Competing Interests Sasha Walker and Catherine Lee are employed by the Centre for Family Medicine Family Health Team. The remaining authors have no conflicts to declare.

Patient consent for publication Not required.

Ethics Approval Ethics approval was obtained for the collection of MINT Memory Clinic patient data. Approval was granted by the Hamilton Integrated Research Ethics Board, McMaster University (#13-266).

Data availability statement Data are available upon reasonable request. The data that support the findings of this study are not publicly available due to them containing information that could compromise participant privacy. Deidentified, limited data will be shared by the corresponding author upon request.

Supplemental Material

Supplemental Material 1. Detailed Methodology

Supplemental Table 1. Cost of healthcare services by MINT Memory Clinic patients and usual care patients.

Supplemental Table 2. Scenario Analysis Results

Supplemental Figure 1. Detailed Markov-based State Transition Model for Usual Care and MINT Memory Clinics.

Supplemental Figure 2. Results of Probabilistic Sensitivity Analysis: Incremental Cost-Effectiveness of MINT Memory Clinics versus Usual Care.

Supplemental Figure 3. Tornado Diagram; One-Way Sensitivity analysis of MINT Memory Clinics versus Usual Care.

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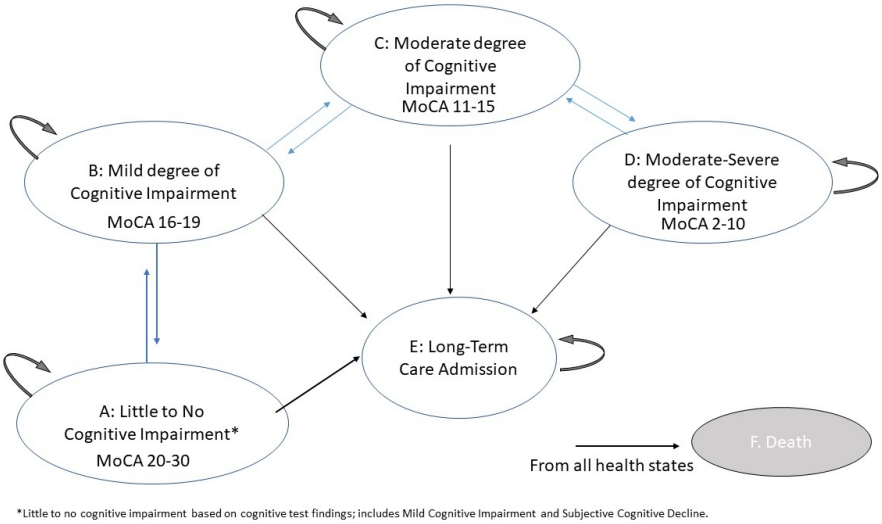
Figure Legend

Figure 1 Markov-based State Transition Model for Usual Care and MINT Memory Clinics



Markov-based State Transition Model for Usual Care and MINT Memory Clinics

338x190mm (96 x 96 DPI)

Online Supplemental Materials (Text, Tables, and Figures)

Supplemental Text: Detailed Methodology

Detailed Cost Calculation

Cost values (all in Canadian dollars) in our model were derived primarily from the provincial Memory Clinic evaluation.[1] In the provincial evaluation, a retrospective costing analysis based on health administrative data was conducted between patients in MINT Memory Clinics and usual care from 2006-2015.[1] Daily operating costs for Memory Clinics were reported to be $287.72 per patient, based on the cost of employing each healthcare professional once a month and seeing a minimum of four patients per day.[1] We estimated the yearly operating cost for each health state by multiplying the daily operating cost per patient by the average number of yearly visits for each health state. The average number of yearly visits for each cognitive impairment (CI) health state was calculated based on a 5-year history for each patient. The yearly costs per health state are as follows, Little to No CI: $241.69 based on an average of 0.84 visits per year; Mild CI: $374.04 based on an average number of 1.3 visits per year; Moderate CI: $411.44 based on an average of 1.43 visits per year; and, Moderate-Severe CI: $503.51 based on an average number of 1.75 visits per year.

The total annual health state cost of each Memory Clinic CI state group was calculated based on the sum of the yearly cost of Memory Clinic services as detailed above and the yearly cost of other associated healthcare services utilized by patients with dementia (e.g., Fee-for-Service and Non-Fee-for-Service visits, home care services, Complex Continuing Care). For each usual care CI state group, the annual cost was calculated based only on the yearly cost of

other associated healthcare services utilized by patients with dementia. Supplementary Table S1 presents a detailed summary of the daily costs of healthcare services for Memory Clinic and usual care patients. Some of these costs (inpatient hospital stays, inpatient mental health stays, Emergency Department, ED, visits, nursing home) were excluded from the annual health state costs for both Memory Clinic and usual care since these costs were accounted for separately when these events occurred during the simulation. The daily costs of all other healthcare services were converted to yearly costs in order to determine the annual health state cost for both interventions. The total annual health state cost for Memory Clinics was calculated to be $14,438.20 and $21,020.35 for usual care.

For hospitalization costs, inpatient hospital stays and mental health hospital stay costs reported in the provincial evaluation were combined, leading to a total of $87.66 daily per patient in usual care and $41.65 daily per Memory Clinic patient.[1] Based on data from the Canadian Institute for Health Information (CIHI), adults aged 60 years and older diagnosed with dementia have an average length of hospitalization stay of 10 days.[2] Accordingly, the overall annual cost of hospitalization was estimated at $876.60 for usual care patients and $416.50 for Memory Clinic patients. Annual ED and nursing home costs were calculated based on the cost per day values provided in the provincial evaluation multiplied by 365 days.[1] The annual ED costs were estimated at $1,912.60 for usual care patients and $941.70 for Memory Clinic patients. Similarly, the annual nursing home costs were estimated at $12,212.90 for usual care patients and $9,902.45 for MINT Memory Clinic patients. Table 2 in the main text provides an overview of all cost values utilized in our model.

Utility

EQ-5D-5L is a preference-based health status measure that is a valid and reliable measurement tool for quality of life utilized worldwide.[3] Patients score their health state (no, slight, moderate, severe, or extreme problems) across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. EQ-5D-5L surveys were completed by Memory Clinic patients and averaged for each health state group. Generally, patients are asked to complete the EQ-5D-5L survey independently but sometimes, in advanced stages, their caregivers assisted them to complete the survey to provide an accurate estimate.[4] A total of 376 EQ-5D-5L and Montreal Cognitive Assessment (MoCA) scores were collected from 229 patient records. Average utility values for Memory Clinic patients in each CI state are as follows, Little to No CI group: 0.83; Mild CI group: 0.85; Moderate CI group: 0.85; and, Moderate-Severe CI group: 0.82.

Utility scores were obtained from a published study for purposes of comparative effectiveness.[5] In this study, it was reported that a collaborative dementia care program had a 0.0012 quality-adjusted-life-year (QALY) increase compared to the usual care group.[5] Thus, the following utility values for the usual care CI state were utilized, Little to No CI: 0.82; Mild CI:, 0.83; Moderate CI: 0.84; and, Moderate-Severe CI: 0.81. A detailed summary of the utility values utilized for both intervention groups is presented in Table 2 in the main text.

Assumptions

As we conservatively assumed that the Memory Clinic intervention does not alter progression of cognitive impairment, the same transition probabilities were utilized for both groups. The cost of

the Memory Clinics was based on the conservative assumption that clinics operate one day a month and see four patients per day.

Analyses

A base-case analysis was conducted first to estimate the incremental cost-effectiveness ratio (ICER) between the Memory Clinics and usual care deterministically. A full deterministic one-way sensitivity analysis was then run on all model parameters over the plausible ranges using the reported 95% confidence interval if available or ±25% of the reference value. A tornado diagram was used to summarize the results of the one-way sensitivity analysis of memory clinic versus usual care. Finally, we conducted probabilistic sensitivity analysis (PSA) using the Monte Carlo simulation for 5,000 iterations. The willingness to pay was set at zero for this simulation and for intervention starting age, normal distribution was used (77.95 ± 9.84). All probabilistic parameters and utilities used in the model are represented by beta distributions formed by the corresponding ranges, and all cost parameters are represented by gamma distributions formed by the corresponding ranges as presented in Table 2 in the main text. All analyses were conducted using TreeAge Pro 2021 (TreeAge Software, Williamstown, MA).

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Supplemental Table 1. Cost of healthcare services by MINT Memory Clinic patients and usual care patients.

Cost Per Day After Index Date, Including Index Date (Data Source)	**Non-MINT MC care**	**MINT-MC care**	**Significant (s) / Not Significant (ns)**
Inpatient hospital admission (DAD)	86.53	39.38	s
Emergency Department visits (NACRS)	5.24	2.58	s
Medications (ODB, all ages)	8.38	8.17	ns
Rehabilitation (NRS)	2.49	2.19	ns
Complex Continuing Care (CCRS)	10.68	8.99	s
Nursing home care (total)	33.46	27.13	s
Nursing home care (OHIP/ODB)	5.19	0.5	s
Long Term Care (using CCRS)	28.27	26.62	s
Home Care Services	9.19	8.4	s
Total Visits	17.10	9.66	s
Total Fee-for-Service visits	15.23	8.16	s
Other non-Fee-for-Service visits	0.75	0.72	ns
Non-Fee-for-Service primary care physician visits	0.03	0.05	s
Inpatient Mental Health	2.13	2.27	ns
Total Cost Per Day	184.95	114.18	s

Adapted from: Health Innovations Group, 2019.[1]

CCRS = Continuing Care Reporting System (contains data on all patients receiving continuing care services in hospitals or nursing homes across Canada); DAD = Discharge Abstract Database (contains data regarding each

inpatient hospital stay); MINT MC = Multispecialty Interprofessional Team Memory Clinic; NACRS = National Ambulatory Care Reporting System (contains data on each Emergency Department visit); NRS = National Rehabilitation Reporting System (contains data on all inpatient rehabilitation facilities and programs across Canada); ODB = Ontario Drug Benefit (formulary of prescription medications paid for by the Ministry of Health);OHIP = Ontario Health Insurance Plan (publicly funded healthcare plan).

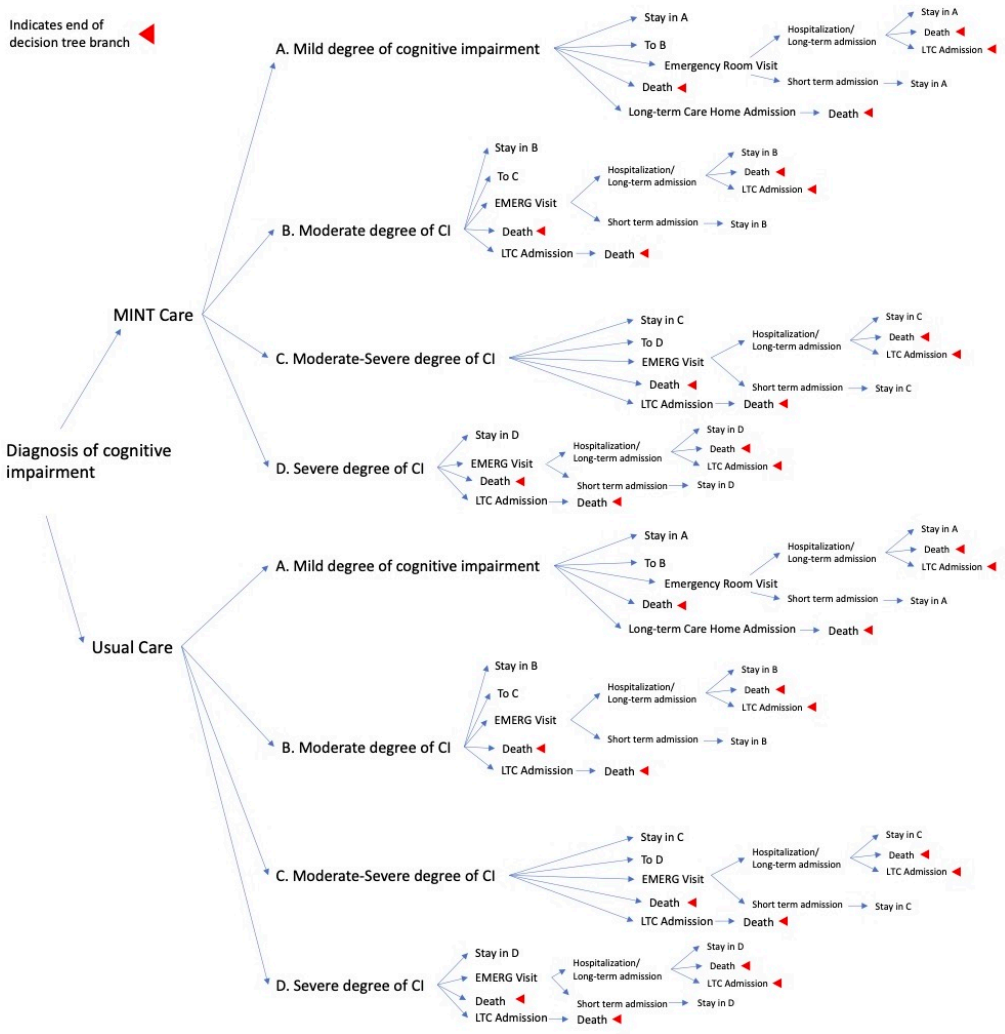
Supplemental Table 2. Scenario Analysis Results

Analysis	Total Cost ($) Mean (95% Crl)	Incremental Cost Mean (95% Crl)	Effectiveness (QALY) Mean (95% Crl)	Incremental Effectiveness Mean (95% Crl)	ICER ($/QALY)
Scenario Analysis[a] MINT Memory Clinics	$145805 ($42594-$244574)	0	7.35 (2.36-11.74)	0	0
Usual Care	$197301 ($59539-331406)	$51496 (4806-119367)	6.93 (2.33-10.91)	-0.42 (0.03 – - 1.35)	Dominated

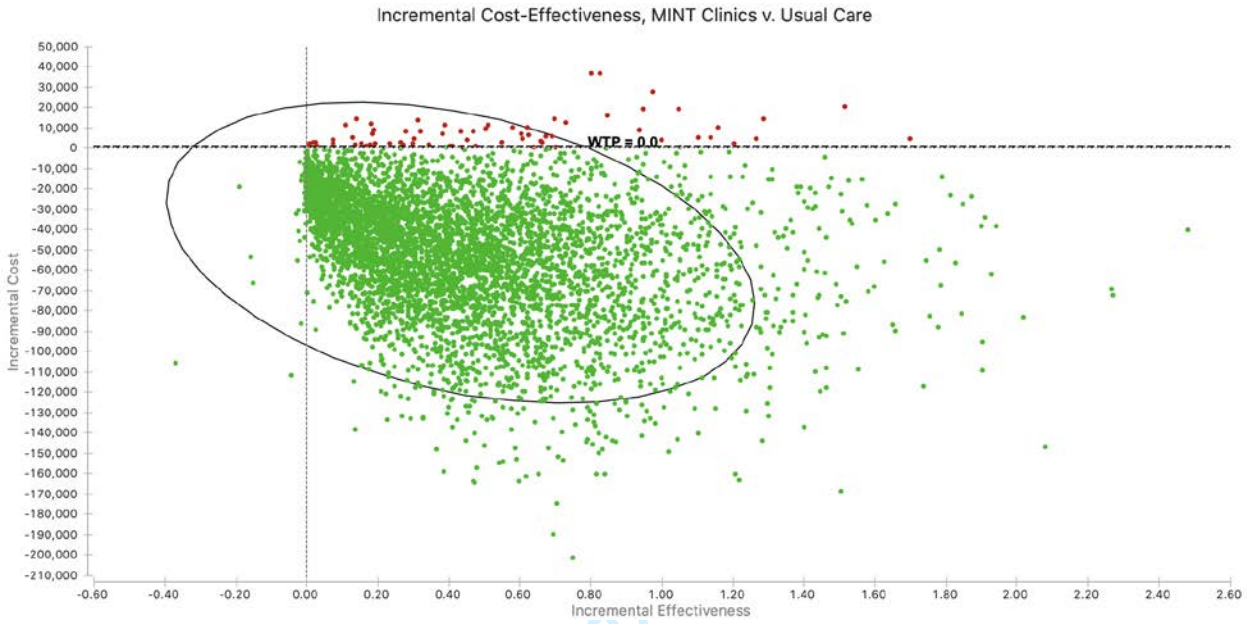
Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality Adjusted Life Year. All costs are in Canadian dollars. Crl = credible interval

[a] Scenario Analysis in which the utility scores in each CI state were based on a published study (mild CI:0.9; moderate CI:0.68; serve CI:0.45).

Supplemental Figure 1. Detailed Markov-based State Transition Model for Usual Care and MINT Memory Clinics

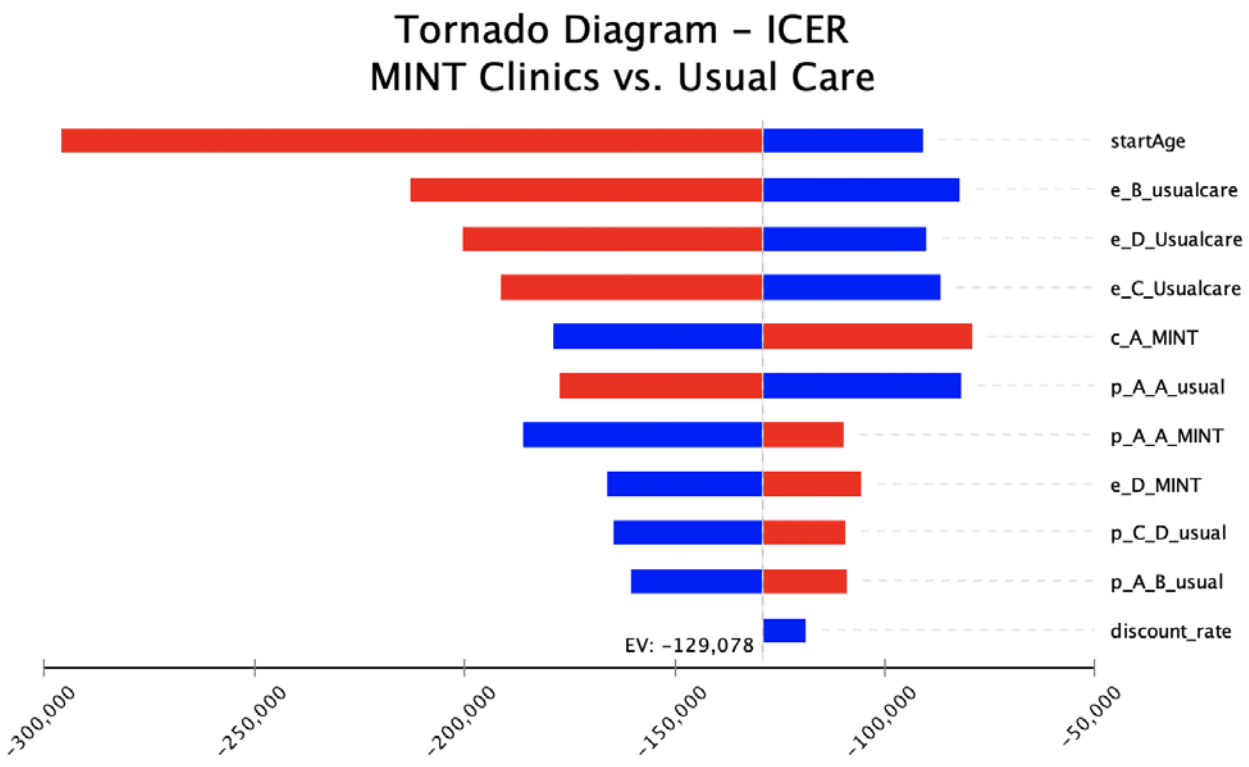


Supplemental Figure 2. Results of Probabilistic Sensitivity Analysis: Incremental Cost-Effectiveness of MINT Memory Clinics versus Usual Care



MINT Memory clinics were cost saving in 97.7% of the 5000 Monte Carlo simulations.

Supplemental Figure 3. Tornado Diagram; One-Way Sensitivity analysis of MINT Memory Clinics versus Usual Care.



startAge = The age at which patients start to receive dementia/MCI related care in MINT Memory Clinics or usual care; e_B_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 16-19 (Group B); e_D_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 2-10 (Group D);E_C_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 11-15 (Group C); c_A_MINT = The cost of patients in MINT Memory Clinics per year who have MoCA scores of 20-30 (Group A); p_A_A_usual = The probability of usual care patients remaining in MoCA Group A (MoCA Score of 20-30) after one year; p_A_A_MINT = The probability of MINT Memory clinic patients remaining in MoCA Group A (MoCA Score of 20-30) after one year; e_D_MINT = The effectiveness and quality of life of patients in MINT Memory Clinics who have MoCA scores of 2-10 (Group D); p_C_D_usual = The probability of usual care patients transitioning from MoCA Group C (11-15) to MoCA Group D (2-10) within a year; p_A_B_usual = The probability of usual care patients transitioning from MoCA Group A (20-30) to MoCA Group B (16-19) within a year.

CHEERS 2022 Checklist

Topic	No.	Item	Location where item is reported
Title			
	1	Identify the study as an economic evaluation and specify the interventions being compared.	Page 1
Abstract			
	2	Provide a structured summary that highlights context, key methods, results, and alternative analyses.	Page 2
Introduction			
Background and objectives	3	Give the context for the study, the study question, and its practical relevance for decision making in policy or practice.	Page 4-5
Methods			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	Page 6
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	Page 7
Setting and location	6	Provide relevant contextual information that may influence findings.	Page 6
Comparators	7	Describe the interventions or strategies being compared and why chosen.	Page 7
Perspective	8	State the perspective(s) adopted by the study and why chosen.	Page 6
Time horizon	9	State the time horizon for the study and why appropriate.	Page 6
Discount rate	10	Report the discount rate(s) and reason chosen.	Page 6
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	Page 12
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	Page 12
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	Table 1, page 12
Measurement and valuation of resources and costs	14	Describe how costs were valued.	Page 11
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	Page 11, Supplementary File Page 1

Topic	No.	Item	Location where item is reported
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	Page 8
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	Supplementary File Page 4
Characterising heterogeneity	18	Describe any methods used for estimating how the results of the study vary for subgroups.	N/A
Characterising distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	N/A
Characterising uncertainty	20	Describe methods to characterise any sources of uncertainty in the analysis.	Page 12
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (such as clinicians or payers) in the design of the study.	N/A
Results			
Study parameters	22	Report all analytic inputs (such as values, ranges, references) including uncertainty or distributional assumptions.	Table 2
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	Page 13 and Table 3
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	Page 13-14
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	NA
Discussion			
Study findings, limitations, generalisability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could affect patients, policy, or practice.	Page 14-18
Other relevant information			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	Page 19
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	Page 20

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Cost-utility analysis of a multispecialty interprofessional team dementia care model in Ontario, Canada

William W.L. Wong PhD,[1] Linda Lee, MD, MClSc(FM)[2,3] Sasha Walker BSc,[2] Catherine Lee BSc,[2] Tejal Patel PharmD,[1,2] Loretta M. Hillier MA,[4] Andrew Costa PhD,[5] and Samir K. Sinha MD, DPhil[6,7]

[1]School of Pharmacy, University of Waterloo, Waterloo, Ontario.

[2]Centre for Family Medicine Family Health Team, Kitchener, Ontario.

[3]Department of Family Medicine, McMaster University, Hamilton, Ontario.

[4]GERAS Centre for Aging Research, Hamilton, Ontario.

[5]Departments of Clinical Epidemiology & Biostatistics, and Medicine, McMaster University, Hamilton, Ontario.

[6]Departments of Medicine, Family and Community Medicine and the Institute of Health Policy, Management, and Evaluation, University of Toronto, Ontario

[7]National Institute on Ageing, Ryerson University, Toronto, Ontario

Corresponding Author: William W. L. Wong, PhD. School of Pharmacy, Faculty of Science, University of Waterloo, PHR4011, 10A Victoria Street S, Kitchener, N2G 1C5. Tel: 519-888-4567 ext. 21323; Fax: 519-883-7580; e-mail: wwlwong@uwaterloo.ca.

ABSTRACT

Objectives To examine the cost-effectiveness of Multi-specialty Interprofessional Team (MINT) Memory Clinic care in comparison to the provision of usual care.

Design Using a Markov-based state transition model, we performed a cost-utility (costs and quality-adjusted life years, QALY) analysis of MINT Memory Clinic care and usual care not involving MINT Memory Clinics.

Setting A primary care-based Memory Clinic in Ontario, Canada

Participants The analysis included data from a sample of 229 patients assessed in the MINT Memory Clinic between January 2019 – January 2021.

Primary Outcome Measures Effectiveness as measured in quality-adjusted life years, QALY, costs (in Canadian dollars), and the incremental cost-effectiveness ratio, ICER, calculated as the incremental cost per QALY gained between MINT Memory Clinics versus usual care.

Results MINT Memory Clinics were found to be less expensive (CAD $51496 (95% Crl, $4806 - $119367) while slightly improving quality of life (+0.43 (95 Crl, 0.01 - 1.24) QALY) compared to usual care. The probabilistic analysis showed that MINT Memory Clinics were the superior treatment compared to usual care 98% of the time. Variation in age was found to have the greatest impact on cost-effectiveness as patients may benefit from the MINT Memory Clinics more if they receive care beginning at a younger age.

Conclusion Multi-specialty interprofessional memory clinic care is less costly and more effective compared to usual care and early access to care significantly reduces care costs over time. The results of this economic evaluation can inform decision-making and improvements to health system design, resource allocation, and care experience for persons living with dementia. Specifically, widespread scaling of MINT Memory Clinics into existing primary care systems may assist with improving quality and access to memory care services while decreasing the growing economic and social burden of dementia.

Key words: dementia, primary care, cost-effectiveness, cost-utility analysis, memory clinics

Strengths and limitations of this study

- This study is an economic evaluation of a multispecialty interprofessional team model of dementia care in Canada for which there is limited economic evaluation data.
- This economic evaluation was conducted consistent with best practice methods and suggested that MINT Memory Clinic care is less costly and more effective compared to usual care in 98% of the time.
- The lack of existing research regarding a comparative usual care group for persons with dementia living in Canada limited us to using available data from different countries and healthcare systems thus comparability between MINT Memory Clinic care and usual care may be limited.

- As our data are most relevant to Canada, and in a particular to community care settings, it may be difficult to generalize to other jurisdictions due to differences in healthcare systems.

INTRODUCTION

Globally, dementia is one of the major causes of disability and dependency among older persons.[1] In addition to the significant impact on the quality of life for individuals diagnosed with dementia and their families, dementia also has significant economic implications for healthcare systems. In Canada, combined healthcare system and out of pocket caregiving costs totaled $10.4B in 2016 and is expected to increase to $16.6B by 2031.[2] In 2015, the total societal cost of dementia worldwide in terms of direct medical, social care and informal care costs was estimated to be USD $818 billion.[1]

Primary care clinicians are often the first point of contact for individuals experiencing memory concerns. Given the challenges experienced in diagnosing and managing this complex disorder within the time constraints in busy family practice, persons with memory concerns have historically been referred for specialist care.[3] There is increasing recognition of the need for primary care to take on greater responsibility for early diagnosis, management, and ongoing dementia care throughout the disease process.[4] There is particular interest in strengthening dementia care in primary care with the aim of supporting those with dementia to live at home for as long as possible and to avoid hospitalization and institutionalization.[4]

Collaborative, multidisciplinary team approaches to healthcare represent a significant opportunity to provide patient-centered care, improve health outcomes, and patients' experience

with care.[5, 6] The Multi-specialty INterprofessional Team (MINT) Memory Clinic care model (formerly Primary Care Collaborative Memory Clinics) aims to improve assessment, diagnosis, and management of dementia in primary care.[7] Integrating specialist and community care for the most complex of cases, this model supports person-centred care that is experienced by patients and caregivers as comprehensive, coordinated, timely, and accessible from one location, close to home.[7-10] Memory clinics are usually located within the same location as their family physician. Within this care model, patients with memory concerns are referred by their family physician to the MINT Memory Clinic for comprehensive assessment and care planning conducted by an interprofessional team consisting of specially trained family physicians, nurses, and other healthcare professionals (e.g., social workers, pharmacists, occupational therapists), and representatives from local community services (Alzheimer Society, home care, behavioural support services) as available.[11] Assessments are conducted with all team members working together in a coordinated and collaborative manner to complete the assessment at the same visit, formulate a diagnosis and develop an integrated, individualized care plan based on patient and caregiver preferences and needs. Using a shared care approach, MINT Memory Clinic team members work with the patient's own family physician over the course of the disease to ensure that changes in care needs are identified and met. Key model components include integration of geriatric specialists to provide consultative support, ongoing capacity building support, and team integration and coordination of community support services.[6]

The MINT Memory Clinic model exists in over 100 primary care settings across Ontario and is currently being expanded to other provinces across the country. Published evaluative studies have demonstrated improved clinical practice and quality of dementia care, improved access to health and social services, enhanced care experiences for patients and their caregivers,

healthcare provider satisfaction with dementia care, and improved collaboration among health professionals.[6, 8-10] To assess the quality of care provided in MINT Memory Clinics, two geriatricians independently reviewed 50 medical chart from five Memory Clinics using a chart audit tool developed by the Ontario of College of Physicians and Surgeons of Ontario[12] This chart audit revealed a high level of agreement among the geriatricians (kappa coefficient = .86) with the diagnosis and management provided by the clinics, verifying the quality of care provided.[10] A significant healthcare system outcome associated with this care model has been the highly efficient use of limited available specialist resources with a less than 10% referral rate to specialists, reduced pressure on specialist wait lists, and delayed institutionalization.[7, 10, 13, 14] The purpose of this study was to examine the cost-effectiveness of the MINT Memory Clinic care model in comparison to the provision of usual dementia care in Ontario, Canada.

METHODS

Study Design

We developed a Markov-based state-transition model to determine the cost-effectiveness of MINT Memory clinics for patients with cognitive impairment (CI) in Ontario, Canada using cost-utility analysis. We adopted a public payer perspective (provincial Ministry of Health), used a lifetime time horizon, and a 1.5% discount rate for our analysis based on Canadian economic evaluation guidelines.[15] An overview of our methodology is presented as follows and additional information can be found in online Supplemental Material.

Patient and public involvement

None

Interventions

Two different care strategies were evaluated for their cost-effectiveness:

1) Usual (non-MINT Memory Clinic) care: Patients initially seen by their family physician for symptoms of cognitive impairment and then referred to a geriatric specialist to determine a formal diagnosis and a treatment plan.
2) MINT Memory Clinic care: As described above, this care model provides team-based interprofessional collaborative dementia care, in a shared care approach with patients' family physicians and with access to consultative specialist support for complex issues.[6, 7, 10] If a family physician has access to a MINT Memory Clinic, any adult with memory concerns can be referred. MINT Memory Clinics exist in a variety of primary care settings across Ontario in rural, urban, remote, and underserved communities. When there is no access to a MINT Memory Clinic, patients are likely to receive usual care.

Cohort

This study focused on older adults with memory concerns who were referred to receive usual care or MINT Memory Clinic care. Our cohort was based on data from a sample of 229 patients from the Centre for Family Medicine MINT Memory Clinic in Kitchener, Ontario. Patients were

seen between January 2019 – January 2021. For inclusion, patients had to have had at least one clinic visit that documented standardized scale scores for cognition (Montreal Cognitive Assessment, MoCA)[16] and quality of life (EQ5D-5L, a preference-based health status scale that is a valid and reliable measure of quality of life).[17] The MoCA and EQ5D-5L are administered to patients as part of the Memory Clinic's comprehensive assessment. We excluded patients who were unable or unwilling to provide consent or lack of capacity (as judged by patient's physician). Patient characteristics are presented in Table 1. The mean age of the cohort was 80 years; 52% were female. A total of 376 MoCA scores were collected from the sample of 229 patients. To account for the varying level of care required for patients during their disease progression, patients were classified into four CI states based on their MoCA scores: Little to No CI (scores of 20-30); Mild CI (scores of 16-19); Moderate CI (scores of 11-15); and Moderate-Severe CI (scores of 2-10). The majority of patients (61%) had MoCA scores classified as Little to No CI state (in this group, the average MoCA score was 24/30). It is important to note that while all patients referred to Memory Clinics have some cognitive symptoms or concerns, some will have Subjective Cognitive Decline (SCD), which involves normal cognitive testing scores.[18] Like MCI, SCD is an at-risk state for future Alzheimer's disease and other dementias;[19] current Canadian Consensus guidelines recommend appropriate investigations and monitoring of persons with SCD because of risk of progression to dementia.[20] With cognitive test scores being within normal limits, persons with SCD were included in the Little or No CI state. The identical cohort as described above was used for both the usual care intervention and the MINT Memory Clinic intervention in the cost-utility analysis.

Model

A Markov-based state transition model was created to represent the progression of CI to dementia throughout a patient's care journey (Figure 1); a detailed model is presented in online Supplemental Figure 1. In our simulations, cohort members move between predefined health states in yearly cycles until all members die. In each yearly cycle, there are transition possibilities associated with a patient progressing to the next disease stage or remaining in their current health (CI) state. At each stage, changes in use of healthcare resources (emergency department, hospital) were tracked. In our model, six main health states were: Little to No CI; Mild CI; Moderate CI; Moderate-Severe CI; long-term care (LTC) admission; and, death.

Data

Our model assumed that all patients started their journey within the little to no CI health state, and followed them over time until death. Transition probabilities related to disease progression, emergency department (ED) visits, hospitalization, and transition into LTC, were either derived from the MINT Memory Clinic data, an independent provincial evaluation of the Memory Clinics commissioned by the Ontario Ministry of Health,[14] or other published literature as follows (Table 2).[21-24]

Disease Progression Probabilities

To calculate the annual disease transition probabilities, we used medical record data from the MINT Memory Clinic to build a disease history for each patient that began at their first

assessment visit. The transition probability of patients moving between CI state groups within the next year was calculated using only data from patients who had at least two visits. Transition probabilities for disease progression are presented in Table 2. Identical transition probabilities were used for both the usual care and Memory Clinic patients since we conservatively assumed that Memory Clinic care will not affect the progression of CI.

Emergency Department Visit Probabilities, Hospitalization Probabilities and Frequency of Visits

The annual probability of a person in the Little to No CI, Mild CI and Moderate CI states who have at least one ED visit is 26.2%.[21] For the Moderate-Severe CI person, an annual probability of 45.5% was used.[23] Among those who have had at least one ED visit, our model assumed that 22% of individuals visited the ED once, 24% visited twice and 54% visited three times based on published data.[25] According to the provincial evaluation, 65% of MINT Memory Clinic patients returned to the community after a short-term hospital stay, compared to 61% of usual care patients.[14]

Transition into LTC Homes

The probabilities of entering nursing homes were 1.2% for patients in the Mild CI state and 3.5% for patients in the Moderate CI state.[22] For patients in the Moderate-Severe CI state, the transition probability was reported as 37.7%.[24] Since patients in the Little to No CI group were mostly younger and did not show many symptoms of cognitive impairment, the model assumed no transition into LTC homes.

Mortality

All-cause mortality was calculated using life tables developed by Statistics Canada.[26] Dementia-related mortality for both Memory Clinic and usual care patients in the hospital was 0.2% based on the provincial evaluation.[14] Once patients were admitted to LTC, the annual mortality was assumed to be 30% based on the literature.[27, 28]

Cost

Cost values in this model were derived primarily from the provincial memory clinic evaluation reported in 2017, in which a retrospective costing analysis based on health administrative data was conducted between patients receiving MINT Memory Clinic care and usual care from 2006-2015.[14] Online Supplemental Table 1 presents a detailed summary of the daily costs of healthcare services for Memory Clinic and usual care patients. The cost of Memory Clinics was based on the conservative assumption that clinics operate one day a month and see four patients per day. The daily costs of healthcare services involved in both interventions were converted to yearly costs in order to determine the annual health state cost for both interventions. The total annual health state cost for Memory Clinics was calculated to be CAD $14438 and CAD $21020 for usual care. The one-time direct training cost involved in setting up the Memory Clinics was estimated at CAD $23000 per clinic; this implementation cost is paid by the Ministry of Health. Using the same assumption as in the provincial evaluation,[14] with each Memory Clinic operating once per month with minimum 4 of patients per clinic day, the one-time training cost is

estimated to be CAD $479 per patient ($23,000 / 12 months /4 patients) for the first year of operation.

For hospitalization costs, inpatient hospital stays and mental health hospital stays costs reported in the provincial evaluation were combined, using an average length of hospitalization stay of 10 days.[29] The overall annual cost of hospitalization was estimated at CAD $877 for usual care patients and CAD $416 for Memory Clinic patients. Similarly, annual nursing home costs were estimated at CAD $12213 for usual care patients and CAD $9902 for MINT Memory Clinic patients. Table 2 provides an overview of all cost values utilized in our model.

Utility

Effectiveness was measured in quality adjusted life years (QALY), calculated based on the quality of life of patients in given CI states. Utility scores were obtained from EQ-5D-5L surveys completed by 229 Memory Clinic patients, and a published study for purposes of comparative effectiveness for the usual care cohort.[30] A detailed summary of the utility values utilized for both intervention groups is presented in Table 2. The total effectiveness of care is presented as a sum of the quality adjusted life years (QALY) throughout the patient transition.

Analyses

A base-case analysis was conducted first to estimate the incremental cost-effectiveness ratio (ICER) between the Memory Clinics and usual care based on a probabilistic analysis using Monte Carlo simulation for 5000 iterations. A full deterministic one-way sensitivity analysis was

then performed on all model parameters over the plausible ranges using the reported 95% confidence interval, if available, or ±25% of the reference value, for parameters where estimates of uncertainty were not available. Further, two scenario analyses were conducted by 1) assuming the utility scores in each CI state remain the same for both the Memory Clinic patients and the usual care patients; and 2) using the utility scores in each CI state from a published study (mild CI: 0.9; moderate CI: 0.68; severe CI: 0.45).[31] All analyses were conducted using TreeAge Pro 2021 (TreeAge Software, Williamstown, MA).

RESULTS

Base Case Analysis

The cost-effectiveness results between MINT Memory Clinics and usual care are presented in Table 3 and online Supplemental Figure 2. The total average cost for a patient receiving MINT Memory Clinic care and usual care in MINT Memory Clinics is CAD $145805 (95% CrI, $42594 - $244574) and CAD $197301(95% CrI, $59539 - $331406), throughout their entire care journey, respectively. The cost difference between Memory Clinic and usual care is CAD $51496 (95% CrI, $4806 - $119367), indicating that MINT Memory Care is cost-saving in comparison to usual care. In addition, MINT Memory Clinics care is a more effective

intervention in terms of total QALY [7.86 (95% CrI, 2.34 - 12.86) QALY], in comparison with usual care [7.43 (95% CrI, 2.31-7.56) QALY], which translates to a gain of 0.43 (95% CrI, 0.01 - 1.24) QALY for MINT Memory Clinic care over usual care. In this probabilistic analysis (online Supplemental Figure 2), MINT Memory clinics were the superior option (less costly and more effective) in 97.7% of the 5000 Monte Carlo simulations.

Scenario Analysis and Sensitivity Analysis Results

When we assumed the utility scores in each CI state remain the same for both the Memory Clinic patients and the usual care patients in the analysis, MINT Memory Clinic care remained to be a cost-saving option in comparison with usual care (Table 3). Similarly, when we used the utility scores in each CI state from a published study[31] in the analysis, the conclusion remained unchanged (Supplemental Table 2). One way sensitivity analysis (online Supplemental Figure 3) revealed that patients' intervention starting age had the largest effect on the results. Patients with a lower starting age provided further cost-saving than the base-case and showed improved quality of life compared to patients who entered usual care at the same age. Level of cost-saving

was affected by the lower health service utilization in MINT Memory Clinic care compared to usual care and the lower utility values for the usual care CI states, which created a greater difference in utility values between the groups and affected the level of cost-saving. Further, the cost of care for Memory Clinic patients in the Little to No CI state group also affected the level of cost-saving. However, the conclusion remains favourable for MINT Memory Clinics when such uncertainty is considered.

DISCUSSION

This study demonstrated that MINT Memory Clinic care is cost saving compared to the provision of usual dementia care in Ontario. Despite the minimal difference in utility values, MINT Memory Clinics greatly reduce overall healthcare costs as demonstrated in the lower costs for system resources such as LTC and ED visits.[14] Variation in intervention starting age was found to have the greatest impact on ICER; patients may benefit from MINT Memory Clinic care more if they begin care at a younger age. When patients were identified with CI at a younger age and underwent usual dementia care services, they utilized more resources, which

increased overall costs significantly. Even when considering the variation of all factors and a deviance in the normal values in our model, MINT Memory Clinic care was still shown to be cost saving. Moreover, as demonstrated in the probabilistic analysis, MINT Memory Clinics provided superior treatment over usual dementia care 98% of the time.

We have used a model-based approach to conduct the cost-effectiveness analysis for MINT Memory Clinic; a similar approach has also been used to evaluate the cost of illness associated with dementia,[32, 33] and the cost effectiveness of health interventions for people with dementia.[31] Although no other studies have compared care models similar to MINT Memory Clinic care to usual dementia care services, cost-effectiveness of other dementia care interventions have been studied with positive results.[30, 31, 34, 35] A community health intervention that supported informal caregivers with systematic collection and sharing of patient health data with medical providers, was reported to be cost-effective under three of the four scenarios presented.[31] The cost-effectiveness of a community-based, nurse-led collaborative dementia care management intervention that aimed to support persons with dementia and their caregivers through coordination of optimal care with their family physician was found to be a potentially cost-effective strategy for treating dementia due to improving quality of life (+0.05 QALY) at

lower costs (-569€) compared to usual care services.[30] Based on main cost-per-QALY analysis, care provided by an integrated multidisciplinary diagnostic facility was deemed cost-effective.[34] Lastly, an economic evaluation comparing the cost-effectiveness of one year dementia follow-up care by specialist-led memory clinics versus usual care provided by general practitioners showed that memory clinics were on average €1024 cheaper but had a decrease of 0.025 QALY compared to usual care,[35] which may be attributable to the short follow-up time period. A one-year follow-up period may not be sufficient to capture the effects of living with a progressive illness with significant sequalae that can negatively impact quality of life. A strength of our economic analysis is our larger sample size and longer EQ-5D-5L data collection time period.

The positive outcomes in this economic analysis are likely attributable to the unique features of the MINT Memory Clinic model, which differentiates it from other dementia care models and usual care. The MINT Memory Clinic model is effective because dementia care is provided at a primary care level, , true coordination and collaboration between primary care, specialist, and community care, and ongoing access to full dementia care service from one location that facilitates the comprehensive care needed to support healthy and safe living within the community as the disease progresses. Moreover, there is enhanced and ongoing nationally

accredited training for the multi-disciplinary team members that was created and delivered by primary care-based clinicians, making it highly relevant to primary care practice, and involves best teaching practices.[11, 36] Timely diagnosis, person-centered care, and early access to support and coordinated care for each patient and caregiver dyad compared to patients receiving usual care may reduce healthcare costs in the long term by decreasing frequency of ED visits and delaying institutionalization. The fact that MINT Memory Clinic care demonstrated a slight increase in QALY in the face of a progressive neurodegenerative condition can be viewed as positive as it may reflect the significant impact that early support can have on helping persons with dementia live fulfilling and independent lives for as long as possible. Current evidence demonstrates the potential of interventions focused on earlier management of cognitive impairment and/or dementia in yielding economic benefits.[37]

Similar to all studies that use convenience sampling, our results may have under- or over-estimated the cost-effectiveness of MINT Memory Clinic care due to selection bias associated with our sampling method and a relatively small sample size.[38] The lack of existing research regarding a comparative usual care group for persons with dementia living in Canada limited us to using available data from different countries and healthcare systems. As such, the

comparability between MINT Memory Clinic care and usual care may be limited since all of the data used was not collected from within the Canadian healthcare system. Despite this limitation, key values such as transition probabilities and cost values were taken directly from the MINT Memory Clinic patient database and Canadian administrative databases (ICES). Further research is needed to collect utility values for persons living with dementia in Canada in the usual care setting. This data would play a key role in future economic analyses of dementia care programs in Canada. Further, we are not able to investigate the impact of the type of dementia in relationship to our results due to existing data limitations. In addition, we conducted our analysis using a health system perspective rather than a societal perspective, thus we may have underestimated or overestimated the benefit of MINT Memory Clinics as costs associated with patient and caregiver time and out-of-pocket expenses were not included in our analysis.[39, 40]

Another limitation was the exclusion of costs of space and administration costs in the calculation costs for MINT Memory Clinics. As MINT Memory Clinics are often operated within existing family practice sites, there is no additional cost for space in most cases. We conservatively estimated new MINT Memory Clinic capacity at four newly-diagnosed patients with dementia per month amongst the patients with other cognitive diagnoses being made. As

more mature clinics may have greater capacity, our results may underestimate cost-efficiency for some clinics. The estimated cost for salaries utilized in our study is a gross over-estimation as most health professionals are already employed within the primary care site and their work in the clinic is infrequent, in some cases just one day per month, given the efficiencies of a shared care model with the patients' own family physicians. Lastly, as our data are most relevant to Canada, and in a particular to community care settings, it may be difficult to generalize to other jurisdictions due to differences in healthcare systems.

CONCLUSION

As there is a growing need for high quality, cost effective, dementia care within the context of limited healthcare resources, information about the economic impact of the MINT Memory Clinic care can inform health service design and resource allocation. Our study adds to the growing body of literature demonstrating that dementia care interventions in primary care can have significant positive impacts on healthcare system resource use.[41] Our study showed that as compared to usual care, patients receiving MINT Memory Clinic care had much lower healthcare costs and modestly improved quality of life. Based on the results of this study, the MINT

Memory Clinic model has a very high likelihood (98%) of reducing healthcare costs and improving healthcare over usual care. Implementation of this care model across primary care systems may assist with improving quality and access to memory care while decreasing the growing economic and social burden of dementia.

Word Count: 3906

Author Contributions LL and WW were involved in study conceptualization, and implementation; LL, WW, SW, CL and TP were involved in study design; WW, SW and CL completed the data collection, and analysis; all authors (WW, LL, SW, CL, LMH, AC, SKS) were involved in data interpretation and manuscript preparation and final approval.

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Competing Interests Sasha Walker and Catherine Lee are employed by the Centre for Family Medicine Family Health Team. The remaining authors have no conflicts to declare.

Patient consent for publication Not required.

Ethics Approval Ethics approval was obtained for the collection of MINT Memory Clinic patient data. Approval was granted by the Hamilton Integrated Research Ethics Board, McMaster University (#13-266).

Data availability statement Data are available upon reasonable request. The data that support the findings of this study are not publicly available due to them containing information that could compromise participant privacy. Deidentified, limited data will be shared by the corresponding author upon request.

Supplemental Material

Supplemental Material 1. Detailed Methodology

Supplemental Table 1. Cost of healthcare services by MINT Memory Clinic patients and usual care patients.

Supplemental Table 2. Scenario Analysis Results

Supplemental Figure 1. Detailed Markov-based State Transition Model for Usual Care and MINT Memory Clinics.

Supplemental Figure 2. Results of Probabilistic Sensitivity Analysis: Incremental Cost-Effectiveness of MINT Memory Clinics versus Usual Care.

Supplemental Figure 3. Tornado Diagram; One-Way Sensitivity analysis of MINT Memory Clinics versus Usual Care.

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Figure Legend

Figure 1 Markov-based State Transition Model for Usual Care and MINT Memory Clinics

Table 1. MINT Memory Clinic Patient Characteristics

Characteristics	n = 229
Sex, *n* (%)	
Male	111 (48.5)
Female	118 (51.5)
Age (years), mean (SD)	77.95 (9.83)
Age categories, *n (%)*	
≤50 years	2 (0.9)
51-60 years	11 (4.8)
61-70 years	34 (14.8)
71-80 years	84 (36.7)
81-90 years	79 (34.5)

≥91	19 (8.3)
First Language	
English	179 (78.2)
Non-English	50 (21.8)
Martial Status	
Married	143 (62.4)
Widowed	43 (18.8)
Divorced	25 (10.9)
Partner	7 (3.1)
Single	11 (4.8)
Education	
< 9th grade	33 (14.4)
Highschool	79 (34.5)
College or University	86 (37.6)
Professional Degree	31 (13.5)
Living Status	
Alone	49 (21.4)
With Caregiver	172 (75.1)
Institution	6 (2.6)
Other	2 (0.9)
Employment Status	
Employed	29 (12.7)
Unemployed	29 (12.7)

Retired	171 (74.6)
MoCA scores (N = 376)	
Little to No CI state (scores of 20 - 30)	230 (61.2)
Mild CI state (scores of 16 - 19)	56 (14.9)
Moderate CI state (scores of 11 - 15)	54 (14.4)
Moderate-severe CI state (scores of 2 - 10)	36 (9.6)

Notes: CI = cognitive impairment; MoCA = Montreal Cognitive Assessment

Table 2. Model Parameters: Transition Probabilities, Costs and Utility

Variable	Value	Range	Source
Transition Probabilities			
Probability of Group A[a] staying	0.842	0.6315 – 0.99	MINT Memory Clinic Data
Probability of Group A[a] to Group B[b]	0.111	0.0832 – 0.1387	MINT Memory Clinic Data
Probability of Group A[a] to Group C[c]	0.04	0.03-0.05	MINT Memory Clinic Data
Probability of Group A[a] to Group D[d]	0.007	0.00525-0.00875	MINT Memory Clinic Data
Probability of Group A[a] entering Emergency Department	0.262	0.225 - 0.297	Voisin, et al. 2009[21]
Probability of Group A[a] entering Nursing Homes	0.01	0.005 – 0.015	MINT Memory Clinic Data

Variable	Value	Range	Source
Probability of Group B[b] to Group A[a]	0.318	0.2385 – 0.3975	MINT Memory Clinic Data
Probability of Group B[b] staying	0.338	0.2535 – 0.4225	MINT Memory Clinic Data
Probability of Group B[b] to Group C[c]	0.255	0.1912 – 0.3187	MINT Memory Clinic Data
Probability of Group B[b] to Group D[d]	0.089	0.0667 – 0.1112	MINT Memory Clinic Data
Probability of Group B[b] visiting the Emergency Department	0.262	0.225 - 0.297	Voisin, et al. 2009[21]
Probability of Group A[a] entering Nursing Homes	0.012	0.0001 - 0.028	Spackman, et al. 2012[22]
Probability of Group C[c] to Group A[a]	0.035	0.0262 – 0.0437	MINT Memory Clinic Data
Probability of Group C[c] to Group B[b]	0.175	0.1312 – 0.2187	MINT Memory Clinic Data
Probability of Group C[c] staying	0.518	0.3885– 0.6475	MINT Memory Clinic Data
Probability of Group C[c] to Group D[d]	0.272	0.204 – 0.34	MINT Memory Clinic Data
Probability of Group C[c] visiting the Emergency Department	0.261	0.225 - 0.297	Voisin, et al. 2009[21]
Probability of Group C[c] entering Nursing Homes	0.034	0.000, 0.069	Spackman, et al. 2012[22]
Probability of Group D[d] to Group B[b]	0.019	0.0142 – 0.0237	MINT Memory Clinic Data
Probability of Group D[d] to Group C[c]	0.094	0.0705 – 0.1175	MINT Memory Clinic Data
Probability of Group D[d] staying	0.887	0.66525 – 0.99	MINT Memory Clinic Data
Probability of Group D[d] visiting the Emergency Department	0.455	0.37 to 0.54	LaMantia, et al 2016[23]

Variable	Value	Range	Source
Probability of Group D[d] entering Nursing Homes	0.377	0.2827 – 0.4712	Mondor, et al. 2017[24]
Probability of Short-Term Hospital Stay (MINT Memory Clinics)	0.65	0.4875 – 0.8125	Provincial Evaluation[14]
Probability of Short-Term Hospital Stay (Usual Care)	0.61	0.4575 – 0.7625	Provincial Evaluation[14]
Probability of Entering Long Term Care from Hospital for Group A[a] to C[c]	0.012	0.009 – 0.0015	Spackman, et al. 2012[22]
Probability of Entering Nursing Home from Hospital for Group D[d]	0.299	0.262 – 0.33	Mondor, et al. 2017[24]
Probability of Death during Hospital Care	0.002	0.0015 – 0.0025	Provincial Evaluation[14]
Probability of Death in Nursing Home	0.30	0.262 – 0.33	Xiong, et al. 2019[27]
Costs			
MINT Memory Clinics			
Annual cost of group A[a]	$14,724	$11,043 – 18,407	Provincial Evaluation[14]
Annual cost of group B[b]	$14,857	$11,142 – 18,571	Provincial Evaluation[14]
Annual cost of group C[c]	$14,894	$11,170 – 18,618	Provincial Evaluation[14]
Annual cost of group D[d]	$14,986	$11,240-18,733	Provincial Evaluation[14]

Variable	Value	Range	Source
Annual cost of emergency department visit	$941	$706-1,177	Provincial Evaluation[14]
Annual cost of hospitalization	$416	$312-520	Provincial Evaluation[14]
Annual cost of nursing home care	$9,902	$7426-12,378	Provincial Evaluation[14]
One-time Training cost	$23,000	$17,250-$28,750	MINT Memory Clinic Data
Usual Care			
Annual cost of group A[a]	$21,020	$15,765 – 26,275	Provincial Evaluation[14]
Annual cost of group B[b]	$21,020	$15,765 – 26,275	Provincial Evaluation[14]
Annual cost of group C[c]	$21,020	$15,765 – 26,275	Provincial Evaluation[14]
Annual cost of group D[d]	$21,020	$15,765 – 26,275	Provincial Evaluation[14]
Annual cost of emergency department visit	$1,912	$14,34 – 2,390	Provincial Evaluation[14]
Annual cost of hospitalization	$876	$657 – 1,095	Provincial Evaluation[14]
Annual cost of nursing home care	$12,212	$9,159 – 15,266	Provincial Evaluation[14]
Health State Utilities			
MINT Memory Clinics			
Utility for group A[a]	0.8288	0.697-0.961	MINT Memory Clinic Data
Utility for group B[b]	0.8461	0.739-0.953	MINT Memory Clinic Data
Utility for group C[c]	0.8502	0.721-0.979	MINT Memory Clinic Data
Utility for group D[d]	0.8222	0.675-0.970	MINT Memory Clinic Data
Utility for LTC	0.52	0.28-0.76	Brandauer, et al. 2020[42]
Usual Care			

Variable	Value	Range	Source
Utility for group A[a]	0.8276	0.621-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019[30]
Utility for group B[b]	0.8449	0.634-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019[30]
Utility for group C[c]	0.8490	0.635-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019[30]
Utility for group D[d]	0.8211	0.616-0.99	MINT Memory Clinic Data, Michalowsky, et al. 2019[30]
Utility for LTC	0.52	0.28-0.76	Brandauer, et al. 2020[42]

LTC = Long-term care.

[a] Group A, Little to No Cognitive Impairment (MoCA Score 20-30)

[b] Group B, Mild Degree of Cognitive Impairment (MoCA Score 16-19)

[c] Group C, Moderate Degree of Cognitive Impairment (MoCA Score 11-15)

[d] Group D, Moderate-Severe Degree of Cognitive Impairment (MoCA Score 2-10)

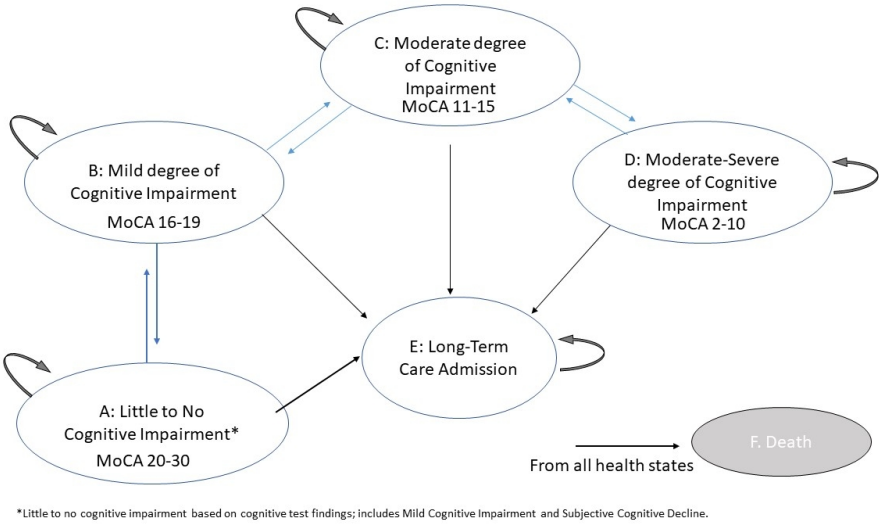
Table 3. Cost Effectiveness of MINT Memory Clinics versus Usual Care: Base case analysis and scenario analysis results

Analysis	Total Cost ($)	Incremental Cost	Effectiveness (QALY)	Incremental Effectiveness	ICER ($/QALY)

	Mean (95% Crl)	Mean (95% Crl)	Mean (95% Crl)	Mean (95% Crl)	
Base Case Analysis MINT Memory Clinics	$145805 ($42594-$244574)	0	7.86 (2.34-12.86)	0	0
Usual Care	$197301 ($59539-331406)	$51496 (4806-119367)	7.43 (2.31-7.56)	-0.43 (-0.01--1.24)	Dominated
Scenario Analysis[a] MINT Memory Clinics	$145805 ($42594-$244574)	0	7.86 (2.34-12.86)	0	0
Usual Care	$197301 ($59539-331406)	$51496 (4806-119367)	7.44 (2.33-11.97)	-0.42 (-0.01 – - 1.23)	Dominated

Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality Adjusted Life Years. All costs are in Canadian dollars. Crl = credible interval

[a] Scenario Analysis in which the utility scores in each CI state were assumed to be the same for both the Memory Clinic patients and the usual care patients.



Markov-based State Transition Model for Usual Care and MINT Memory Clinics

338x190mm (96 x 96 DPI)

Online Supplemental Materials (Text, Tables, and Figures)

Supplemental Text: Detailed Methodology

Detailed Cost Calculation

Cost values (all in Canadian dollars) in our model were derived primarily from the provincial Memory Clinic evaluation.[1] In the provincial evaluation, a retrospective costing analysis based on health administrative data was conducted between patients in MINT Memory Clinics and usual care from 2006-2015.[1] Daily operating costs for Memory Clinics were reported to be $287.72 per patient, based on the cost of employing each healthcare professional once a month and seeing a minimum of four patients per day.[1] We estimated the yearly operating cost for each health state by multiplying the daily operating cost per patient by the average number of yearly visits for each health state. The average number of yearly visits for each cognitive impairment (CI) health state was calculated based on a 5-year history for each patient. The yearly costs per health state are as follows, Little to No CI: $241.69 based on an average of 0.84 visits per year; Mild CI: $374.04 based on an average number of 1.3 visits per year; Moderate CI: $411.44 based on an average of 1.43 visits per year; and, Moderate-Severe CI: $503.51 based on an average number of 1.75 visits per year.

The total annual health state cost of each Memory Clinic CI state group was calculated based on the sum of the yearly cost of Memory Clinic services as detailed above and the yearly cost of other associated healthcare services utilized by patients with dementia (e.g., Fee-for-Service and Non-Fee-for-Service visits, home care services, Complex Continuing Care). For each usual care CI state group, the annual cost was calculated based only on the yearly cost of

other associated healthcare services utilized by patients with dementia. Supplementary Table S1 presents a detailed summary of the daily costs of healthcare services for Memory Clinic and usual care patients. Some of these costs (inpatient hospital stays, inpatient mental health stays, Emergency Department, ED, visits, nursing home) were excluded from the annual health state costs for both Memory Clinic and usual care since these costs were accounted for separately when these events occurred during the simulation. The daily costs of all other healthcare services were converted to yearly costs in order to determine the annual health state cost for both interventions. The total annual health state cost for Memory Clinics was calculated to be $14,438.20 and $21,020.35 for usual care.

For hospitalization costs, inpatient hospital stays and mental health hospital stay costs reported in the provincial evaluation were combined, leading to a total of $87.66 daily per patient in usual care and $41.65 daily per Memory Clinic patient.[1] Based on data from the Canadian Institute for Health Information (CIHI), adults aged 60 years and older diagnosed with dementia have an average length of hospitalization stay of 10 days.[2] Accordingly, the overall annual cost of hospitalization was estimated at $876.60 for usual care patients and $416.50 for Memory Clinic patients. Annual ED and nursing home costs were calculated based on the cost per day values provided in the provincial evaluation multiplied by 365 days.[1] The annual ED costs were estimated at $1,912.60 for usual care patients and $941.70 for Memory Clinic patients. Similarly, the annual nursing home costs were estimated at $12,212.90 for usual care patients and $9,902.45 for MINT Memory Clinic patients. Table 2 in the main text provides an overview of all cost values utilized in our model.

Utility

EQ-5D-5L is a preference-based health status measure that is a valid and reliable measurement tool for quality of life utilized worldwide.[3] Patients score their health state (no, slight, moderate, severe, or extreme problems) across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. EQ-5D-5L surveys were completed by Memory Clinic patients and averaged for each health state group. Generally, patients are asked to complete the EQ-5D-5L survey independently but sometimes, in advanced stages, their caregivers assisted them to complete the survey to provide an accurate estimate.[4] A total of 376 EQ-5D-5L and Montreal Cognitive Assessment (MoCA) scores were collected from 229 patient records. Average utility values for Memory Clinic patients in each CI state are as follows, Little to No CI group: 0.83; Mild CI group: 0.85; Moderate CI group: 0.85; and, Moderate-Severe CI group: 0.82.

Utility scores were obtained from a published study for purposes of comparative effectiveness.[5] In this study, it was reported that a collaborative dementia care program had a 0.0012 quality-adjusted-life-year (QALY) increase compared to the usual care group.[5] Thus, the following utility values for the usual care CI state were utilized, Little to No CI: 0.82; Mild CI:, 0.83; Moderate CI: 0.84; and, Moderate-Severe CI: 0.81. A detailed summary of the utility values utilized for both intervention groups is presented in Table 2 in the main text.

Assumptions

As we conservatively assumed that the Memory Clinic intervention does not alter progression of cognitive impairment, the same transition probabilities were utilized for both groups. The cost of

the Memory Clinics was based on the conservative assumption that clinics operate one day a month and see four patients per day.

Analyses

A base-case analysis was conducted first to estimate the incremental cost-effectiveness ratio (ICER) between the Memory Clinics and usual care deterministically. A full deterministic one-way sensitivity analysis was then run on all model parameters over the plausible ranges using the reported 95% confidence interval if available or ±25% of the reference value. A tornado diagram was used to summarize the results of the one-way sensitivity analysis of memory clinic versus usual care. Finally, we conducted probabilistic sensitivity analysis (PSA) using the Monte Carlo simulation for 5,000 iterations. The willingness to pay was set at zero for this simulation and for intervention starting age, normal distribution was used (77.95 ± 9.84). All probabilistic parameters and utilities used in the model are represented by beta distributions formed by the corresponding ranges, and all cost parameters are represented by gamma distributions formed by the corresponding ranges as presented in Table 2 in the main text. All analyses were conducted using TreeAge Pro 2021 (TreeAge Software, Williamstown, MA).

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Supplemental Table 1. Cost of healthcare services by MINT Memory Clinic patients and usual care patients.

Cost Per Day After Index Date, Including Index Date (Data Source)	**Non-MINT MC care**	**MINT-MC care**	**Significant (s) / Not Significant (ns)**
Inpatient hospital admission (DAD)	86.53	39.38	s
Emergency Department visits (NACRS)	5.24	2.58	s
Medications (ODB, all ages)	8.38	8.17	ns
Rehabilitation (NRS)	2.49	2.19	ns
Complex Continuing Care (CCRS)	10.68	8.99	s
Nursing home care (total)	33.46	27.13	s
Nursing home care (OHIP/ODB)	5.19	0.5	s
Long Term Care (using CCRS)	28.27	26.62	s
Home Care Services	9.19	8.4	s
Total Visits	17.10	9.66	s
Total Fee-for-Service visits	15.23	8.16	s
Other non-Fee-for-Service visits	0.75	0.72	ns
Non-Fee-for-Service primary care physician visits	0.03	0.05	s
Inpatient Mental Health	2.13	2.27	ns
Total Cost Per Day	184.95	114.18	s

Adapted from: Health Innovations Group, 2019.[1]

CCRS = Continuing Care Reporting System (contains data on all patients receiving continuing care services in hospitals or nursing homes across Canada); DAD = Discharge Abstract Database (contains data regarding each

inpatient hospital stay); MINT MC = Multispecialty Interprofessional Team Memory Clinic; NACRS = National Ambulatory Care Reporting System (contains data on each Emergency Department visit); NRS = National Rehabilitation Reporting System (contains data on all inpatient rehabilitation facilities and programs across Canada); ODB = Ontario Drug Benefit (formulary of prescription medications paid for by the Ministry of Health);OHIP = Ontario Health Insurance Plan (publicly funded healthcare plan).

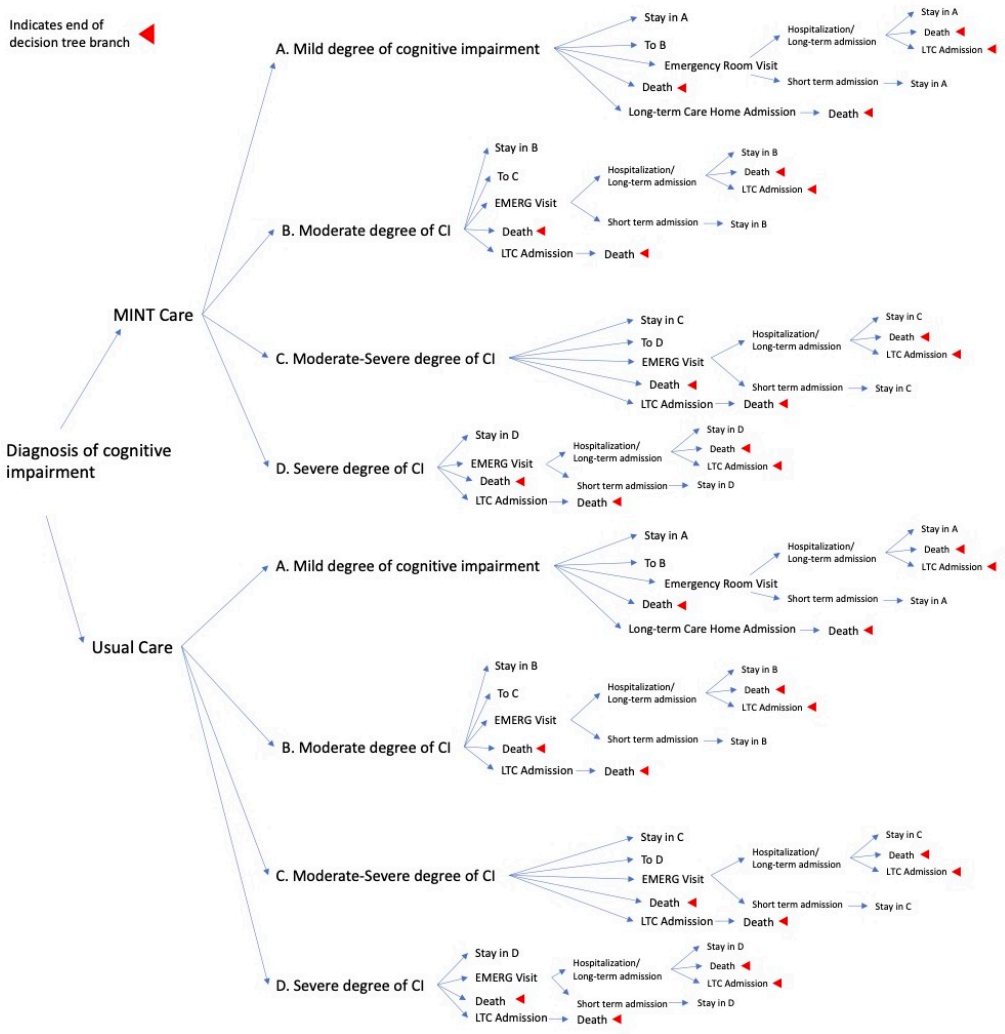
Supplemental Table 2. Scenario Analysis Results

Analysis	Total Cost ($) Mean (95% Crl)	Incremental Cost Mean (95% Crl)	Effectiveness (QALY) Mean (95% Crl)	Incremental Effectiveness Mean (95% Crl)	ICER ($/QALY)
Scenario Analysis[a] MINT Memory Clinics	$145805 ($42594-$244574)	0	7.35 (2.36-11.74)	0	0
Usual Care	$197301 ($59539-331406)	$51496 (4806-119367)	6.93 (2.33-10.91)	-0.42 (0.03 – - 1.35)	Dominated

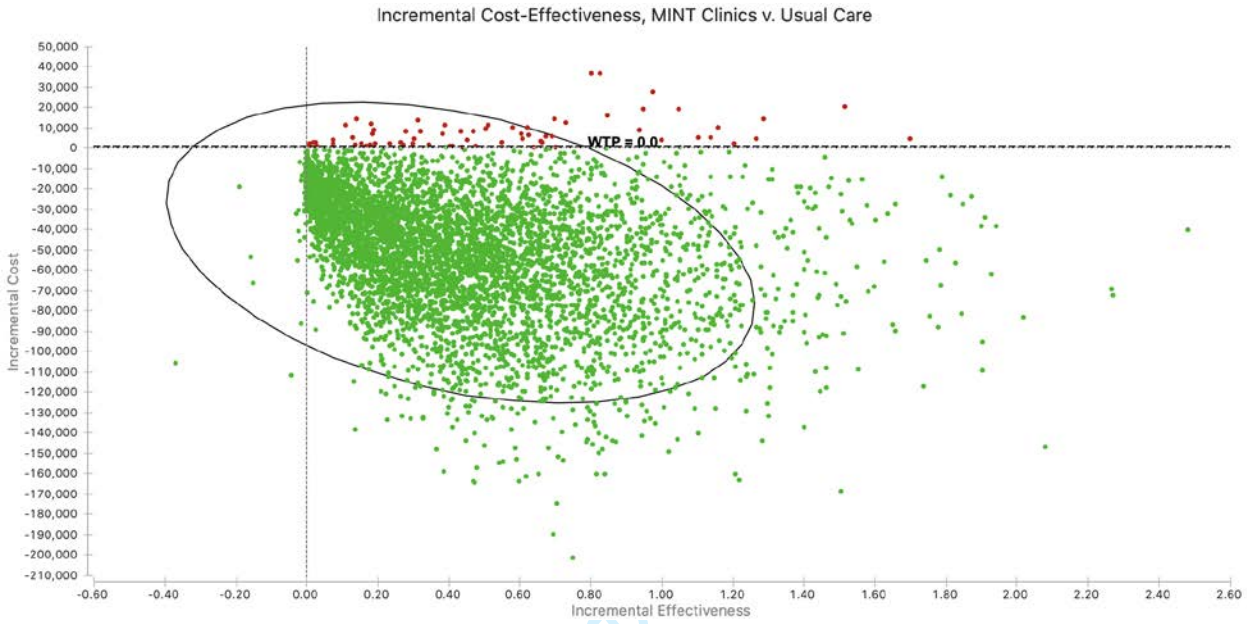
Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality Adjusted Life Year. All costs are in Canadian dollars. Crl = credible interval

[a] Scenario Analysis in which the utility scores in each CI state were based on a published study (mild CI:0.9; moderate CI:0.68; serve CI:0.45).

Supplemental Figure 1. Detailed Markov-based State Transition Model for Usual Care and MINT Memory Clinics

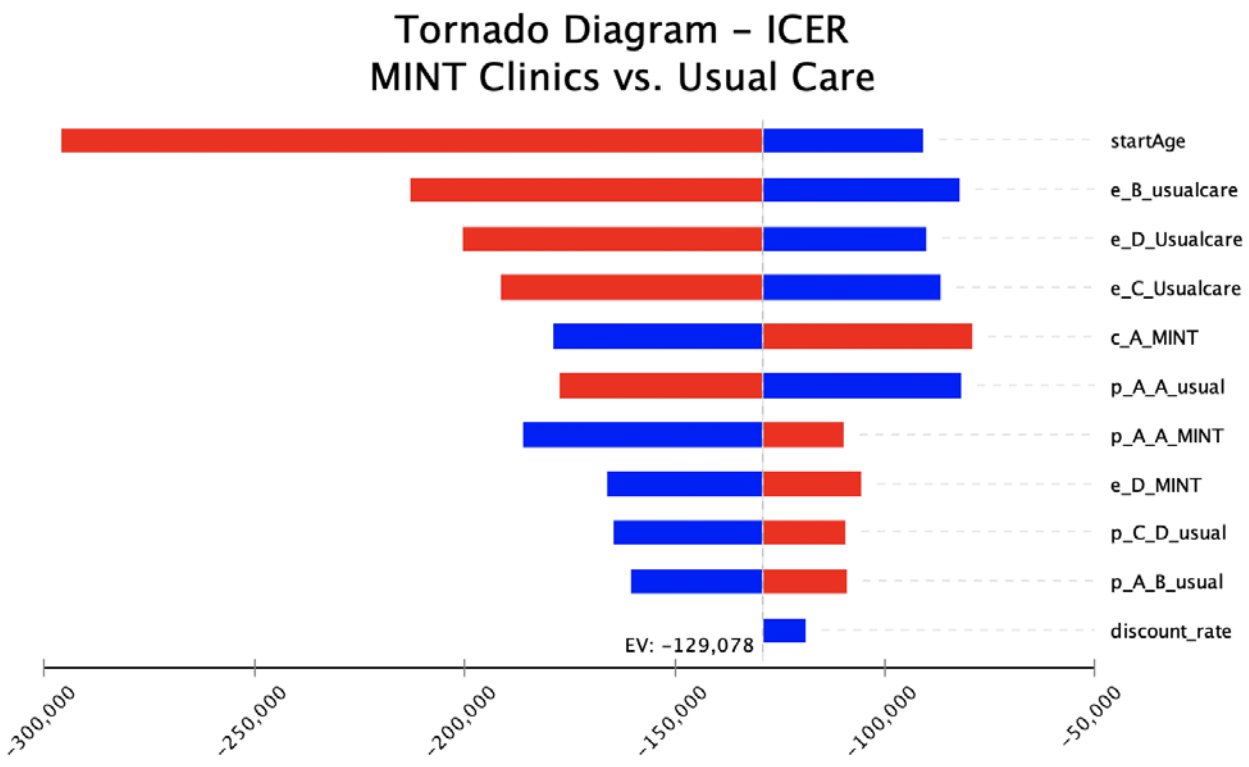


Supplemental Figure 2. Results of Probabilistic Sensitivity Analysis: Incremental Cost-Effectiveness of MINT Memory Clinics versus Usual Care



MINT Memory clinics were cost saving in 97.7% of the 5000 Monte Carlo simulations.

Supplemental Figure 3. Tornado Diagram; One-Way Sensitivity analysis of MINT Memory Clinics versus Usual Care.



startAge = The age at which patients start to receive dementia/MCI related care in MINT Memory Clinics or usual care; e_B_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 16-19 (Group B); e_D_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 2-10 (Group D);E_C_usualcare = The effectiveness and quality of life of patients in usual care who have MoCA scores of 11-15 (Group C); c_A_MINT = The cost of patients in MINT Memory Clinics per year who have MoCA scores of 20-30 (Group A); p_A_A_usual = The probability of usual care patients remaining in MoCA Group A (MoCA Score of 20-30) after one year; p_A_A_MINT = The probability of MINT Memory clinic patients remaining in MoCA Group A (MoCA Score of 20-30) after one year; e_D_MINT = The effectiveness and quality of life of patients in MINT Memory Clinics who have MoCA scores of 2-10 (Group D); p_C_D_usual = The probability of usual care patients transitioning from MoCA Group C (11-15) to MoCA Group D (2-10) within a year; p_A_B_usual = The probability of usual care patients transitioning from MoCA Group A (20-30) to MoCA Group B (16-19) within a year.

CHEERS 2022 Checklist

Topic	No.	Item	Location where item is reported
Title			
	1	Identify the study as an economic evaluation and specify the interventions being compared.	Page 1
Abstract			
	2	Provide a structured summary that highlights context, key methods, results, and alternative analyses.	Page 2
Introduction			
Background and objectives	3	Give the context for the study, the study question, and its practical relevance for decision making in policy or practice.	Page 4-5
Methods			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	Page 6
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	Page 7
Setting and location	6	Provide relevant contextual information that may influence findings.	Page 6
Comparators	7	Describe the interventions or strategies being compared and why chosen.	Page 7
Perspective	8	State the perspective(s) adopted by the study and why chosen.	Page 6
Time horizon	9	State the time horizon for the study and why appropriate.	Page 6
Discount rate	10	Report the discount rate(s) and reason chosen.	Page 6
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	Page 12
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	Page 12
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	Table 1, page 12
Measurement and valuation of resources and costs	14	Describe how costs were valued.	Page 11
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	Page 11, Supplementary File Page 1

Topic	No.	Item	Location where item is reported
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	Page 8
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	Supplementary File Page 4
Characterising heterogeneity	18	Describe any methods used for estimating how the results of the study vary for subgroups.	N/A
Characterising distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	N/A
Characterising uncertainty	20	Describe methods to characterise any sources of uncertainty in the analysis.	Page 12
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (such as clinicians or payers) in the design of the study.	N/A
Results			
Study parameters	22	Report all analytic inputs (such as values, ranges, references) including uncertainty or distributional assumptions.	Table 2
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	Page 13 and Table 3
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	Page 13-14
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	NA
Discussion			
Study findings, limitations, generalisability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could affect patients, policy, or practice.	Page 14-18
Other relevant information			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	Page 19
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	Page 20

From: Husereau D, Drummond M, Augustovski F, et al. Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) Explanation and Elaboration: A Report of the ISPOR CHEERS II Good Practices Task Force. Value Health 2022;25. doi:10.1016/j.jval.2021.10.008