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

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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 and January 2021.

Primary outcome measures Effectiveness as measured in QALY, costs (in Canadian dollars) and the incremental cost-effectiveness ratio 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 ($C51 496 (95% CrI $C4806 to $C119 367) while slightly improving quality of life (+0.43 (95 CrI 0.01 to 1.24) QALY) compared with usual care. The probabilistic analysis showed that MINT Memory Clinics were the superior treatment compared with 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 Multispecialty interprofessional memory clinic care is less costly and more effective compared with 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.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study is an economic evaluation of a multi-specialty 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 Multi-specialty INterprofessional Team (MINT) Memory Clinic care is less costly and more effective compared with 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 generalise 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 care-giving costs totalled $10.4 billion in 2016 and is expected to increase to $16.6 billion 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 US$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 hospitalisation and institutionalisation.[4]

Collaborative, multidisciplinary team approaches to healthcare represent a significant opportunity to provide patient-centred 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 (eg, 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, individualised 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 charts 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=0.86) 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 institutionalisation.[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:

- Usual (non-MINT Memory Clinic) care: patients are initially seen by their family physician for symptoms of CI and then referred to a geriatric specialist to determine a formal diagnosis and a treatment plan.
- 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 and January 2021. For inclusion, patients had to have had at least one clinic visit that documented standardised 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

Table 1 Multi-specialty INterprofessional Team 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)
High school	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)

CI, cognitive impairment; MoCA, Montreal Cognitive Assessment.

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 women. 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 mild cognitive impairment, 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 the 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 (ED), 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, ED visits, hospitalisation 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 literatures (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

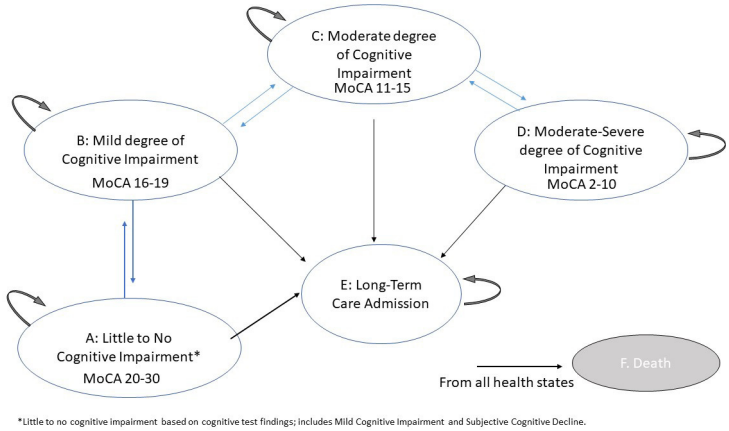

Figure 1 Markov-based state transition model for usual care and Multi-specialty INterprofessional Team Memory Clinics. *Little to no cognitive test findings; includes mild cognitive impairment and subjective cognitive decline. MoCA, Montreal Cognitive Assessment.

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.

ED visit probabilities, hospitalisation 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 two times 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 with 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 CI, 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 to 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 1 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 $C14 438 and $C21 020 for usual care. The one-time direct training cost involved in setting up the Memory Clinics was estimated at $C23 000 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 a minimum four of patients per clinic day, the one-time training cost is estimated to be $C479 per patient ($23 000/12 months/4 patients) for the first year of operation.

For hospitalisation costs, inpatient hospital stays and mental health hospital stays costs reported in the provincial evaluation were combined, using an average length of hospitalisation stay of 10 days.[29] The overall annual cost of hospitalisation was estimated at $C877 for usual care patients and $C416 for Memory Clinic patients. Similarly, annual nursing home costs were estimated at $C12 213 for usual care patients and $C9902 for MINT Memory Clinic patients. Table 2 provides an overview of all cost values used 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 used for both intervention

Table 2 Model parameters: transition probabilities, costs and utility

Variable	Value	Range	Source
Transition probabilities			
Probability of group A* staying	0.842	0.6315–0.99	MINT Memory Clinic Data
Probability of group A* to group B†	0.111	0.0832–0.1387	MINT Memory Clinic Data
Probability of group A* to group C‡	0.04	0.03–0.05	MINT Memory Clinic Data
Probability of group A* to group D§	0.007	0.00525–0.00875	MINT Memory Clinic Data
Probability of group A* entering emergency department	0.262	0.225–0.297	Voisin *et al*[21]
Probability of group A* entering nursing homes	0.01	0.005–0.015	MINT Memory Clinic Data
Probability of group B† to group A*	0.318	0.2385–0.3975	MINT Memory Clinic Data
Probability of group B† staying	0.338	0.2535–0.4225	MINT Memory Clinic Data
Probability of group B† to group C‡	0.255	0.1912–0.3187	MINT Memory Clinic Data
Probability of group B† to group D§	0.089	0.0667–0.1112	MINT Memory Clinic Data
Probability of group B† visiting the emergency department	0.262	0.225–0.297	Voisin *et al*[21]
Probability of group A* entering nursing homes	0.012	0.0001–0.028	Spackman *et al*[22]
Probability of group C‡ to group A*	0.035	0.0262–0.0437	MINT Memory Clinic Data
Probability of group C‡ to group B†	0.175	0.1312–0.2187	MINT Memory Clinic Data
Probability of group C‡ staying	0.518	0.3885–0.6475	MINT Memory Clinic Data
Probability of group C‡ to group D§	0.272	0.204–0.34	MINT Memory Clinic Data
Probability of group C‡ visiting the emergency department	0.261	0.225–0.297	Voisin *et al*[21]
Probability of group C‡ entering nursing homes	0.034	0.000–0.069	Spackman *et al*[22]
Probability of group D§ to group B†	0.019	0.0142–0.0237	MINT Memory Clinic Data
Probability of group D§ to group C‡	0.094	0.0705–0.1175	MINT Memory Clinic Data
Probability of group D§ staying	0.887	0.66525–0.99	MINT Memory Clinic Data
Probability of group D§ visiting the emergency department	0.455	0.37 to 0.54	LaMantia *et al*[23]
Probability of group D§ entering nursing homes	0.377	0.2827–0.4712	Mondor *et al*[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* to C‡	0.012	0.009–0.0015	Spackman *et al*[22]
Probability of entering nursing home from hospital for group D§	0.299	0.262–0.33	Mondor *et al*[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*[27]
Costs ($C)			
MINT Memory Clinics			
Annual cost of group A*	$14 724	$11 043–$18 407	Provincial Evaluation[14]
Annual cost of group B†	$14 857	$11 142–$18 571	Provincial Evaluation[14]
Annual cost of group C‡	$14 894	$11 170–$18 618	Provincial Evaluation[14]
Annual cost of group D§	$14 986	$11 240–$18 733	Provincial Evaluation[14]
Annual cost of emergency department visit	$941	$706–$1177	Provincial Evaluation[14]
Annual cost of hospitalisation	$416	$312–$520	Provincial Evaluation[14]
Annual cost of nursing home care	$9902	$7426–$12 378	Provincial Evaluation[14]
One-time training cost	$23 000	$17 250–$28 750	MINT Memory Clinic Data

Continued

Table 2 Continued

Variable	Value	Range	Source
Usual care ($C)			
Annual cost of group A*	$21 020	$15 765–$26 275	Provincial Evaluation[14]
Annual cost of group B†	$21 020	$15 765–$26 275	Provincial Evaluation[14]
Annual cost of group C‡	$21 020	$15 765–$26 275	Provincial Evaluation[14]
Annual cost of group D§	$21 020	$15 765–$26 275	Provincial Evaluation[14]
Annual cost of emergency department visit	$1912	$1434–$2390	Provincial Evaluation[14]
Annual cost of hospitalisation	$876	$657–$1095	Provincial Evaluation[14]
Annual cost of nursing home care	$12 212	$9159–$15 266	Provincial Evaluation[14]
Health state utilities			
MINT Memory Clinics			
Utility for group A*	0.8288	0.697–0.961	MINT Memory Clinic Data
Utility for group B†	0.8461	0.739–0.953	MINT Memory Clinic Data
Utility for group C‡	0.8502	0.721–0.979	MINT Memory Clinic Data
Utility for group D§	0.8222	0.675–0.970	MINT Memory Clinic Data
Utility for LTC	0.52	0.28–0.76	Brandauer *et al*[42]
Usual care			
Utility for group A*	0.8276	0.621–0.99	MINT Memory Clinic Data, Michalowsky *et al*[30]
Utility for group B†	0.8449	0.634–0.99	MINT Memory Clinic Data, Michalowsky *et al*[30]
Utility for group C‡	0.8490	0.635–0.99	MINT Memory Clinic Data, Michalowsky *et al*[30]
Utility for group D§	0.8211	0.616–0.99	MINT Memory Clinic Data, Michalowsky *et al*[30]
Utility for LTC	0.52	0.28–0.76	Brandauer *et al*[42]

*Group A, little to no cognitive impairment (MoCA score 20–30).
†Group B, mild degree of cognitive impairment (MoCA score 16–19).
‡Group C, moderate degree of cognitive impairment (MoCA score 11–15).
§Group D, moderate-severe degree of cognitive impairment (MoCA score 2–10).
LTC, long-term care; MINT, Multi-specialty INterprofessional Team; MoCA, Montreal Cognitive Assessment.

groups is presented in table 2. The total effectiveness of care is presented as a sum of the 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, Massachusetts, USA).

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 $C145 805 (95% CrI $C42 594 to $C244 574) and $C197 301 (95% CrI $C59 539 to $C331 406), throughout their entire care journey, respectively. The cost difference between Memory Clinic and usual care is $C51 496 (95% CrI $C4806 to $C119 367), 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 to 12.86) QALY), in

Table 3 Cost effectiveness of MINT Memory Clinics versus usual care: base case analysis and scenario analysis results

Analysis	Total cost ($C) mean (95% CrI)	Incremental cost ($C) mean (95% CrI)	Effectiveness (QALY) mean (95% CrI)	Incremental effectiveness mean (95% CrI)	ICER ($C/QALY)
Base case analysis MINT Memory Clinics	145 805 (42 594 to 244 574)	0	7.86 (2.34 to 12.86)	0	0
Usual care	197 301 (59 539 to 331 406)	51 496 (4806 to 119 367)	7.43 (2.31 to 7.56)	−0.43 (−0.01 to −1.24)	Dominated
Scenario analysis* MINT Memory Clinics	145 805 (42 594 to 244 574)	0	7.86 (2.34 to 12.86)	0	0
Usual care	197 301 (59 539 to 331 406)	51 496 (4806 to 119 367)	7.44 (2.33 to 11.97)	−0.42 (−0.01 to −1.23)	Dominated

All costs are in Canadian dollars.
*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.
CrI, credible interval; ICER, incremental cost-effectiveness ratio; MINT, Multi-specialty INterprofessional Team; QALY, quality-adjusted life years.

comparison with usual care (7.43 (95% CrI 2.31 to 7.56) QALY), which translates to a gain of 0.43 (95% CrI 0.01 to 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 (online 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 with patients who entered usual care at the same age. Level of cost-saving was affected by the lower health service usage in MINT Memory Clinic care compared with 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 with 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 used 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 care; 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 has 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 with usual care services.[30] Based on main cost-per-QALY analysis, care provided by an integrated multidisciplinary diagnostic facility was deemed cost-effective.[34] Finally, an economic evaluation

comparing the cost-effectiveness of 1-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 with usual care,[35] which may be attributable to the short follow-up time period. A 1-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-centred care and early access to support and coordinated care for each patient and caregiver dyad compared with patients receiving usual care may reduce healthcare costs in the long term by decreasing frequency of ED visits and delaying institutionalisation. 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 CI and/or dementia in yielding economic benefits.[37]

Similar to all studies that use convenience sampling, our results may have underestimated or overestimated 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 programmes 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 among 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 used in our study is a gross overestimation as most health professionals are already employed within the primary care site and their work in the clinic is infrequent, in some cases just 1 day per month, given the efficiencies of a shared care model with the patients' own family physicians. Finally, as our data are most relevant to Canada, and in a particular to community care settings, it may be difficult to generalise 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 with 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.

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Competing interests SW and CL are employed by the Centre for Family Medicine Family Health Team.

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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).

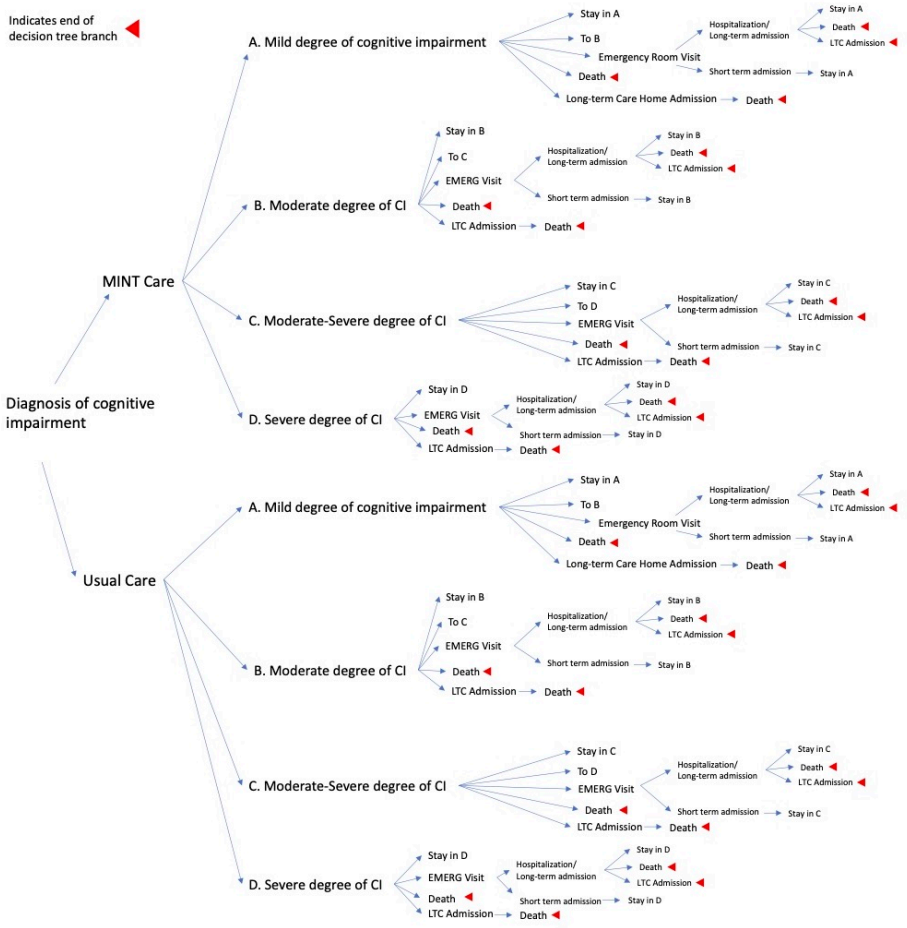
Supplemental Table 2. Scenario Analysis Results

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

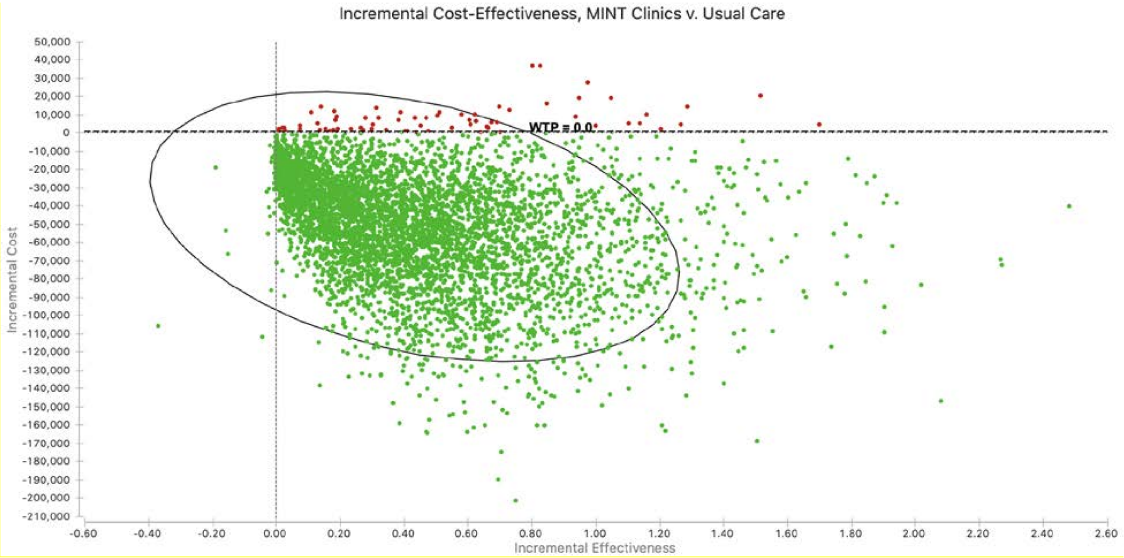
Notes: ICER = Incremental Cost-Effectiveness Ratio; QALY = Quality Adjusted Life Year. All costs are in Canadian dollars. Crl = credible interval

[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

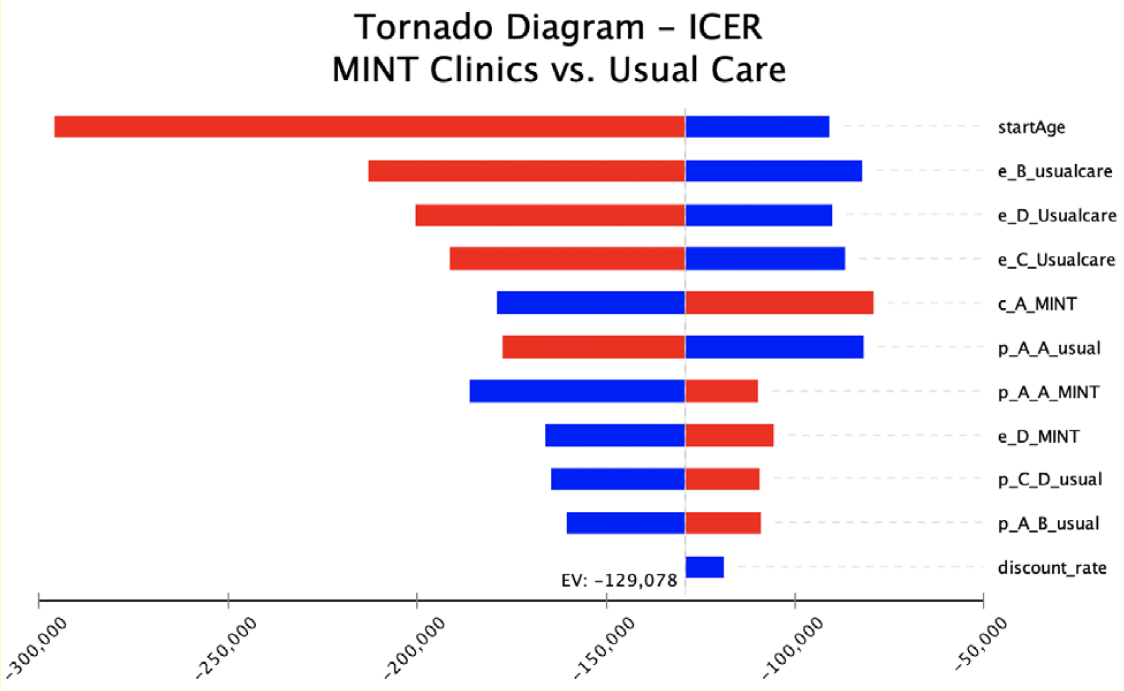


Supplemental Figure 2. Results of Probabilistic Sensitivity Analysis: Incremental Cost-Effectiveness of MINT Memory Clinics versus Usual Care



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.