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The Impact of Financial Incentives for Cervical Cancer Screening in Ontario's Primary Care Delivery Models

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A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

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Integrated Article

by

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Abstract

Physicians practicing in capitation-based Family Health Organizations and fee-for-service-based Family Health Groups receive bonuses for delivering preventive care, including cervical cancer screening, while those practicing in the traditional fee-for-service model do not. Financial incentives were introduced to increase Ontario's cervical screening rate to 85%. To date, the impact of incentives for cervical screening on screening rate and cost-effectiveness have not been assessed. Patient-level data obtained from the Institute for Clinical Evaluative Sciences were used to estimate primary care model screening rates and cancer treatment costs. A microsimulation model was developed from published cervical cancer natural history models and parameterized using Ontario data. My results show significant differences in Pap smear rates across primary care model type, and that financial incentives are associated with slightly greater quality-adjusted life years. In conclusion, primary care models featuring incentives are associated with higher screening rates and appear cost-effective compared to the traditional FFS model.

Keywords

Primary care, financial incentives, pay-for-performance, remuneration, fee-for-service, capitation, cost-effectiveness, cervical cancer screening, Ontario.

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List of Abbreviations

AC: Adenocarcinoma

ADG: Aggregated Diagnosis Group

AGC: Atypical Glandular Cells

AIS: Adenocarcinoma In Situ

ASC-H: Atypical Squamous Cells-Cannot Exclude High-Grade Squamous Intraepithelial Lesion

ASCUS: Atypical Squamous Cells of Unknown Significance

B&T: Bang and Tsiatis

CAPE: Client Agency Program Enrolment

CCRS: Continuing Care Reporting System

CIHI: Canadian Institute for Health Information

CIN: Cervical Intraepithelia Neoplasia

CIN1: Cervical Intraepithelial Neoplasia grade 1

CIN23: Cervical Intraepithelial Neoplasia grades 2-3

CIS: Carcinoma In Situ

CPWC: Cost Per Weighted Case

CPWD: Cost Per Weighted Day

DA: Dissemination Area

DAD: Discharge Abstract Database

ED: Emergency Department

FFS: Fee-For-Service

FHG: Family Health Group

FHO: Family Health Organization

HCD: Home Care Database

HIV: Human Immunodeficiency Virus

HSIL: High-Grade Squamous Intraepithelial Lesions

HPV: Human Papillomavirus

ICD-9: International Classification of Diseases, ninth revision

ICER: Incremental Cost-Effectiveness Ratio

ICES: Institute for Clinical Evaluative Sciences

IMG: International Medical Graduate

IPDB: Institute for Clinical Evaluative Sciences Physician Database

LEEP: Loop Electrosurgical Excision Procedure

LSIL: Low-Grade Squamous Intraepithelial Lesions

LOS: Length of Stay

MOHLTC: Ministry of Health and Long-Term Care

NACRS: National Ambulatory Care Reporting System

NRS: National Rehabilitation System

OCR: Ontario Cancer Registry

ODB: Ontario Drug Benefit

OHIP: Ontario Health Insurance Plan

OMHRS: Ontario Mental Health Reporting System

OMI: Ontario Marginalization Index

P4P: Pay-for-Performance

PCP: Primary Care Physician

QALY: Quality-Adjusted Life Year

RIO: Rurality Index of Ontario

RIW: Resource Intensity Weight

RPDB: Registered Persons Database

RUB: Resource Utilization Band

SCC: Squamous Cell Carcinoma

SDS: Same Day Surgery

SOB: Schedule of Benefits

Chapter 1

1 Introduction

1.1 Cervical Cancer

Cervical cancer is a chronic disease caused by persistent infection with human papillomavirus (HPV) in the epithelial cells of the cervical transformation zone. The cervix connects the vagina to the uterus and has two main parts: the exocervix and the endocervix. The transformation zone is where the cervical epithelial cells change from glandular cells of the endocervix to squamous cells of the exocervix.

While infection with HPV is a necessary cause for cervical cancer, infections are common and the majority regress spontaneously [1,2]. The outcome of an infection is largely dependent on HPV type [3,4]. Although around 40 HPV types are known to infect the genital tract, about 15 types are considered to have a high-risk of developing cervical cancer [3-5]. The most prevalent types among cervical cancer cases are HPV-16 and HPV-18 representing 70% of cases [5]. Low-risk types are usually associated with benign changes in the cervical epithelium, but cervical intraepithelial neoplasia (CIN) may be associated with a low-risk type [6].

Infection occurs when the virus binds to and enters the basal epithelial cells of the cervical transformation zone [5,7]. Infection may cause increased basal and suprabasal cell proliferation, which may eventually lead to lesion formation in the cervix [5]. Most infections and lesions are transient and clear on their own [8]. However persistent infection may cause the development of neoplastic cells if the viral genome is integrated into the host chromosome [7]. There are two main types of cervical cancer: squamous cell carcinoma (SCC) accounts for approximately 85% of cases and adenocarcinoma (AC) accounts for 15-20% [9,10]. Women with a persistent infection of the squamous cells with one or more high-risk type may develop low-grade squamous intraepithelial lesions (LSIL). These lesions are indicative of mild to moderate cervical dysplasia and are classified as CIN grade 1 or 2. LSIL may regress, experience no change or progress to high-grade squamous intraepithelial lesions (HSIL) [7]. HSIL represents severe cervical

dysplasia and is classified as CIN grade 3 or carcinoma in situ (CIS). Women with HSIL may also clear their infections partially or completely, but their infections are more likely to persist and progress to SCC [7]. AC is caused by persistent infection in the glandular cells and is preceded by adenocaricnoma in situ (AIS). The natural history of AC is not well understood compared to SCC [10].

HPV is transmitted sexually, so risk of infection and developing cervical cancer are related to sexual behaviour. Infection risk is influenced by age of first sexual activity, number of lifetime partners, condom use and sexual encounters with high-risk individuals [2,7,11,12]. Peak infection rate occurs in women under 25 years, and incident infections are mostly transient among women of all ages [8]. Increasing parity, long-term oral contraceptive use, smoking and infection with human immunodeficiency virus (HIV) are also associated with an elevated risk of cervical cancer [8].

1.2 Burden of Cervical Cancer

Cervical cancer accounts for 9% of new cases of cancer in women worldwide, making it the third most commonly diagnosed cancer in women [13]. In 2008 there were an estimated 529,000 incident cases of cervical cancer and 275,000 related deaths [13]. However developing countries are disproportionately affected and account for over 85% of cervical cancer cases and deaths [14]. Incidence and mortality rates in developed countries are a fraction of those in developing regions, which is predominantly due to a lack of screening in low-resource countries [14]. The cumulative risk of developing cervical cancer for a woman in the developing world is 1.9% [14], whereas a Canadian woman has a 0.7% lifetime risk [15].

Each year about 91,400 Canadian women are diagnosed with cancer, and cervical cancer accounts for 1.6% of all cases [15]. In 2013 there were an estimated 1,450 incident cases and 380 deaths from cervical cancer, and each year an estimated 610 women are diagnosed with and 150 die from cervical cancer in Ontario [15].

The five-year relative survival ratio for Canadian women is 72% [15]. Age at diagnosis is an important prognostic factor, which may be related to later stage at diagnosis of older

women who are less likely to be screened [16]. Peak excess mortality occurs in the first year after diagnosis [17].

1.3 Cervical Cancer Screening

Cervical cancer screening is a method of secondary prevention that aims to reduce cervical cancer risk by detecting and treating cervical lesions that may become malignant [18]. Screening with the Papanicolaou (Pap) smear was first introduced in Canada in 1949, and widespread uptake of screening began in the 1970s [19]. Although the effectiveness of Pap smears for preventing cervical cancer has never been studied in a clinical trial, there is substantial epidemiological evidence to support its use for reducing cervical cancer incidence and mortality [20-22]. Between 1972 and 2006, Canadian incidence and mortality rates decreased by 58% and 71%, respectively [19]. The drastic decline in rates is largely attributed to the successes of screening [19]. The slow progression from HPV infection to dysplasia to invasive cancer may take years [23]; therefore regular screening and follow-up of abnormal results can prevent cancer by detecting and treating precancerous lesions [19,21]. Pap smears can also detect preclinical cancers at an earlier stage, which require less aggressive treatment and have better survival.

Ontario guidelines recommend women who are or have ever been sexually active be screened with a Pap test once every three years beginning at age 21 and ceasing at age 70 given adequate negative screen history [18,20]. The Ontario Cervical Screening Program has sent letters to eligible women to invite them to screening, advise them of Pap test results and remind them to return for screening since 2013. A woman's primary care physician usually performs Pap tests.

Screening participation has increased slightly since 2000, but is well below the provincial target of 85%. The estimated three-year screening rates among women aged 20 to 69 in 2010 and 2011 were between 65% and 72% [24,25]. Some groups of women are less likely to be screened than others. Screening participation decreases with age and women living in low-income area are less likely to be screened than women from high-income

areas [25]. Women with access to a primary care physician are more likely to be screened than those without a regular provider [26,27].

1.4 Cervical Dysplasia and Cervical Cancer Care

Abnormal Pap smear results are not uncommon and about 5.5% of women screened in 2012 had an abnormal result [24]. Women with a test result of atypical squamous cells of unknown significance (ASCUS) are recommended to undergo active surveillance with repeat Pap testing every six months. Women with LSIL are often recommended active surveillance, but some may receive immediate treatment. If a repeat Pap smear is abnormal then women are referred to colposcopy for further investigation. After three negative smears over a period of a year and a half, women may return to the normal screening interval. Referral to colposcopy is also recommended for a primary test result of HSIL, atypical squamous cells cannot exclude HSIL (ASC-H), atypical glandular cells (AGC), CIS, AIS or other malignant neoplasms.

Colposcopy is a diagnostic procedure that magnifies the inside of the cervix and vagina for inspection. A biopsy is usually taken concomitantly for a definitive diagnosis of CIN or cancer. Women with CIN or CIS may be treated with loop electrosurgical excision procedure (LEEP), laser excision, cone biopsy, cryosurgery or hysterectomy. If a biopsy reveals malignant cells then the cancer is staged and graded before deciding on a treatment course.

Primary treatment of early stage cancers is often surgical. A hysterectomy removes the entire uterus and may be accompanied by removal of the pelvic or para-aortic lymph nodes. A radical hysterectomy is when the uterus and surrounding parametrium are removed and the pelvic lymph nodes are dissected. Younger women wishing to preserve their fertility may receive a radical cervicectomy with or without lymph node dissection, which removes the cervix while leaving the uterus in tact. Over half of Ontario cases receive surgery for their cancer with younger women being most likely to have surgery [28]. Older women, those with significant comorbidities, or advanced cases are recommended primary treatment with radiation therapy with or without concurrent cisplatin [28]. Concurrent radiation and cisplatin is also recommended for high-risk early

stage cancers following hysterectomy [29]. Recurrent, metastatic or persistent cancers are recommended treatment with cisplatin in combination with topotecan [30]. After successful treatment, follow-up is recommended every three to four months in the first two disease-free years and every six to 12 months between years three and five [31]. Women may return to annual assessment with their family physician after five years of remission [31].

1.5 Interventions to Increase Cervical Cancer Screening

Women that are never screened or not screened during the recommended interval have increased risks of cervical cancer, later stage at diagnosis and cervical cancer-related mortality [32-33]. Despite the risks of non-compliance and widespread availability of screening, many women do not participate. Effective interventions to increase screening participation are necessary to reduce the risks of cervical cancer and future burden on the healthcare system. Patient-directed interventions, such as tailored reminders and education programs, have been shown to effectively increase cancer screening rates [35,36]. However provider-directed interventions are also needed, as physician recommendation to screen is a strong predictor of screening adherence [37]. Provider reminders, audit and feedback, and recall systems are recommended to increase cervical, breast and colorectal cancer screening rates [35,36,38]. Provider incentives are being increasingly advocated to improve quality of health care services, including improved cancer screening; however the existing findings are inconclusive and further research is needed to assess their effectiveness [35,36,39-41].

1.6 Financial Incentives

Financial incentives are implicit or explicit rewards to encourage a physician to provide high quality care and deliver cancer screening manoeuvres. Remuneration schemes are implicit incentive contracts that link a principal (e.g. government health plan, private insurer) to an agent (e.g. primary care physician) to provide targeted services. The traditional funding model is a fee-for-service (FFS) system where a physician is paid for each service provided to patients. One alternative to FFS is a capitation payment system, in which a physician receives a fixed payment for each patient enrolled and is obliged to

provide specific services to these patients. Explicit incentives directly reward physicians for quality in specific areas of care. Explicit incentives include one-time bonuses, per-patient premiums or pay-for-performance (P4P) bonuses with stepped payments.

The effect of provider remuneration on preventive care delivery has not been widely studied and is poorly understood (detailed literature review in the following section). Some studies on P4P incentives report modest improvements in cervical cancer screening, but the evidence is inconclusive [36,39-41]. Few studies have evaluated implicit or explicit incentives in Canada, and it is difficult to draw conclusions from evidence from other health care systems within the context of universal healthcare in Canada.

To date there has been no economic analysis of financial incentives for cervical cancer screening. As the popularity of alternative funding arrangement and P4P incentives grow in Ontario and throughout Canada, it is imperative that the most cost-effective ways of delivering care are chosen.

1.7 Literature Review

1.7.1 Primary Care

Primary care is the patient's first point of contact with the health care system providing a point of referral to specialists if needed [42]. A primary care physician may be a family physician, general practitioner, general pediatrician or general internist [43]. The primary care physician-patient relationship is long lasting and focused on overall patient health, whereas the specialist-patient relationship may be shorter and more disease focused [42,43]. Primary care physicians provide comprehensive care and their services range from preventive to rehabilitative [42,43]. Providers address the majority of their patients' health care needs and are usually the point of referral to specialists [42].

Strong primary care systems lead to better health outcomes and areas with more primary care physicians are consistently associated with lower rates of all-cause and cancer-related mortality and improved patient satisfaction [43]. Access to a primary care physician increases the chances of receiving needed services and earlier diagnoses

[44,45] and reduces the likelihood of emergency room visits and hospitalizations [46]. Women with regular family physicians are more likely to be screened for cervical (odds ratio [OR]: 1.30, 95% confidence interval [CI] 1.17 – 1.46) and breast cancer (OR: 1.38, 95% CI 1.16 – 1.64) [47]. Similarly, Ontario breast cancer patients living in areas with greater supplies of general practitioners were significantly more likely to be diagnosed with localized cancer, indicating higher mammography rates in areas with better access to primary care [48]. Increased health promotion and screening rates of primary care providers may lead to earlier cancer diagnoses and improved survival [49]. Indeed, increased supply of family physicians is associated with decreased rates of cervical cancer incidence and related mortality [50].

1.7.2 Primary Care Reform

The association between strong primary care systems and improved health outcomes sparked interest in optimizing the organization, delivery and funding of primary care models to deliver high-quality, cost-effective, equitable care [51]. Many developed nations strengthened their primary care systems and access to care towards the end of the 20th century; however Canada, and particularly Ontario, lagged behind [52,53]. A survey of primary care physicians from Canada, Australia, New Zealand, the United Kingdom and the United States reported that Canadian physicians were most concerned about health care quality [54]. Canada had the highest proportions of physicians reporting that their ability to provide quality care had deteriorated in the past five years (59%) and that they were very concerned about increasing wait times (75%) [54]. In 1998 Canada had the third lowest ratio of physician to population among eight developed nations [55] and was the only country to have a negative growth rate of physicians per population [56].

Within Canada, Ontario's primary care systems lagged behind the other provinces. The absolute number of primary care physicians remained relatively constant during the 1990s, but population growth resulted in a decline in the number of physicians per population [57,58]. By 2000 Ontario had the second lowest provincial ratio of family physicians to population with only 85 physicians per 100,000 persons [57]. Limited access to primary care in Ontario was due in part to higher specialist income, maldistribution of physicians and preference for graduates to specialize [59,60].

Primary care systems are often defined by their organizational structure, delivery methods and remuneration model [61]. Historically, the primary care landscape in Ontario was made up by privately owned and managed solo or small group practices of family physicians and general practitioners [61]. Since the majority of primary care providers were physicians, of whom less than 10% worked in multidisciplinary practices, delivery of primary care had a strong physician focus [61]. While alternative payment schemes existed, the vast majority of Canadian primary care physicians were reimbursed on a fee-for-service (FFS) basis. In 1998 89% of Canadian family physicians received some income from FFS payments, which accounted for an average 88% of their total income [62]. About 20% of family physicians received a salary, which accounted for 56% of their total income [62]. Only 1.5 of FPs received capitation based payments, which derived 72% of their total income [62].

Innovations to primary care in Canada have been introduced several times during the 20th century, but thus far failed to achieve true reform [52]. In the late 1970's Health Services Organizations (HSO) and Community Health Centres (CHC) were introduced to Ontario as alternatives to conventional practices [61]. These organizations delivered PC differently by incorporating nurses, nurse practitioners and other healthcare providers [61]. While HSOs remained physician owned, CHCs are governed by a community board. They also adopted alternative funding methods with HSOs being capitation based and CHCs being salaried. Pilot primary care models, such as Primary Care Networks, were launched in the mid-1990s in Ontario in the hopes of identifying innovative ways of organizing, delivering and funding primary care [61]. Despite the calls for and attempts of innovation and reform to Canadian primary care systems, little change was achieved [62,62]. In the early 2000s the federal government established five national reform goals: increased access to primary care services, increased emphasis on health promotion, preventive health and chronic disease management, increasing all-day access to essential services, increasing the number of primary care physicians working in interdisciplinary teams, and integrating primary care with other healthcare services [52].

In response to the new national objectives, Ontario took steps to overhaul its primary care system. New organizational and funding models were created to meet the diverse needs

of providers and communities, promote inter-professional delivery of care, increase patient access and improve efficiency [52]. Common elements of the new models include group practices with shared responsibilities, provision of after-hours care, and patient enrolment. Participation in the new models is voluntary, so financial incentives were embedded in the new contract models. One of the biggest policy changes in the last wave of reform was introducing new remuneration schemes and the shift away from FFS payments.

1.7.3 Theoretical Background of Financial Incentives

Remuneration schemes link physicians to patients, insurers, or government health plans through incentive contracts [64]. A health plan (the principal) gives incentives to encourage quality physician (the agent) performance [64]. Incentives range from explicit incentives like targeted bonuses for achieving performance standards to implicit incentives like remuneration method. Physician behaviour is affected by their payment method, which is designed to provide high agent rewards at low cost to the principal [64]. Economic theory of physician behavior posits that physicians want to maximize their income while still providing acceptable patient care and will attempt to do so by altering practice size, working hours, visit duration and time per patient [65]. However other factors, such as intrinsic motivation to care for patients or desire for work-life balance, may also affect practice patterns.

Physicians practicing in FFS systems receive a fee for each service provided. Since their income is dependent on the volume of services provided, there is an incentive to provide more services and treat high-use patients [65]. Economic theory suggests that FFS systems align patient and physician interests: the patient seeks the best possible medical service and physician seeks to maximize profits by providing more services [66]. In practice best medical care differs between patients and some patients may not wish to access the healthcare system at all. Quality of care is high in FFS practices according to patient and physician satisfaction [67,68]. Neither physician nor patient has an incentive to restrict health care utilization, which puts the principal at risk for increasing health care expenditures [64,66].

In capitation systems, physicians receive set payments for each patient to provide treatment. Capitation schemes improve efficiency because there's no incentive to provide unnecessary services and many contracts stipulate that payments are reduced if patients seek care outside of the practice. Capitation rates may be age, sex and/or risk adjusted, but physicians still risk attracting less healthy patients. The amount necessary to provide quality care for a patient may be more or less than actual capitation payments, which shifts the financial risk from the principal to the agent [64,65]. The failure to motivate quality care is an example of the principal-agent problem, and physicians may under provide if gaps exist between physician financial interest and patient medical interests [64,66]. If capitation rates are not risk-adjusted, physicians may seek to maximize income by cream skimming, or enrolling many low-risk patients that will require little care [66]. While comprehensiveness of care may be impacted, capitation systems may achieve better continuity of care because physicians have incentives to maintain long-lasting relationships [66]. Capitation systems may encourage physicians to provide preventive care services and health promotion to reduce future services needed by their patients [69].

A recent systematic review of the literature suggested that payment method affects physician behaviour [69]. FFS physicians are more productive and treat sicker patients, whereas capitation improves efficiency [64,69]. These findings are supported by evidence from Ontario. FFS physicians conduct 29% more visits than their non-FFS counterparts [70]. However there was no significant difference in total hours worked per week between FFS and other remuneration schemes [71]. Physicians practicing in FHNs provided slightly fewer services than those in FHGs, but continuity of care was similar in both models [59]. Capitation-based practices in Ontario have wealthier patients with fewer comorbidities than FFS based models, which is likely a result of capitation rates not being adjusted for risk [60].

The problems of FFS and capitation systems may be addressed with blended payment models, which combine fixed and variable payments [64,65]. In blended capitation models, physicians receive their primary income from capitation payments to cover a core basket of services for enrolled patients. Variable income is generated by full FFS payments for all services provided to non-enrolled patients and non-core services

provided to enrolled patients. These payments encourage broader scope of practice [64]. Some systems encourage enrolling sicker patients with fractional FFS payments for all core services [64]. Pay-for-performance programs may also generate variable income. Physicians practicing in Ontario's FHNs and FHOs are primarily reimbursed by capitation payments, but receive additional variable income for providing non-core services, P4P incentives and other incentives. In such models, physicians are encouraged to provide efficient services while maintaining a broad scope of practice and high quality of care [64]. Ontario's FHGs are an example of a blended FFS model: enhanced FFS payments are combined with explicit incentives like preventive care bonuses, comprehensive care fees and diabetes management incentives.

Bonuses are direct incentives that aim to change physician behaviour [72]. Pay-for-performance (P4P) schemes are explicit financial incentives to deliver services at high quality levels. Various P4P schemes have been introduced worldwide based on the theory that they are the most efficient way of achieving high-quality, equitable care [73]. Ontario's Cumulative Preventive Care Bonus is typical of most P4P programs where physicians receive additional payments for delivering specified levels of service. Performance based payments aim to reduce variations in delivery of service and increase productivity [73]. The rationale for P4P schemes is they may resolve the principal-agent problem by aligning physician and patient interests [74]. If quality of care affects financial success, then physicians will devote more time and resources to achieving such levels of quality. High-performing physicians will be rewarded and low-performing physicians will be motivated to improve performance; however bonuses may fail to affect physician behaviour if there is no negative consequence for underperformance [72].

1.7.4 Ontario's Reformed Primary Care Delivery Models

There are ten primary care enrolment models (PEM), but this discussion is limited to three: Family Health Networks (FHN), Family Health Groups (FHG) and Family Health Organizations (FHO). The remuneration schemes of the new models differ somewhat, but have some common commitments and incentives. Practices must have a minimum of three physicians and provide after-hours care. Formal enrolment of patients is strongly encouraged; however patients are not required to enroll, and physicians cannot refuse a

patient enrolment based on their health or service needs. Rostering a patient formalizes the patient-physician relationship; patients commit to seek treatment from their physician's practice and physicians commit to providing comprehensive care. The Unattached Patient Fee is a one-time incentive to enroll new patients. Physicians receive a monthly comprehensive care fee for each rostered patient in addition to their primary funding. Other incentives exist for seeing patients after hours, achieving targeted levels of preventive care services and chronic disease management.

Two blended capitation models were introduced: the Family Health Network (FHN) in 2002 and Family Health Organization (FHO) in 2007. Physicians receive monthly age- and sex-adjusted capitation payments for each rostered patient to cover a basket of core services. The FHO base rate payment is greater than the FHN rate, but the basket of core services is much greater. In addition to capitation payments, physicians receive a percentage of FFS payments for core services provided to rostered patients, and full FFS payments for all services provided to non-enrolled patients and non-core services provided to enrolled patients. Access Bonuses are additional payments and reduced dollar for dollar when rostered patients seek core services outside the group practice.

In 2003 the blended FFS Family Health Group (FHG) was introduced. Physicians receive full FFS payments and premiums for after-hours care and comprehensive fee codes. Like physicians in capitation-based models, FHG physicians also receive monthly comprehensive care fee for their rostered patients and targeted incentives.

A primary care team is not a funding model, but an interdisciplinary practice model. Family Health Teams (FHTs) consist of professionals from different disciplines, such as physicians, nurse practitioners, dieticians, pharmacists and social workers. In contrast, a traditional practice usually consists of physicians, office assistants and occasionally nurses. Primary care teams in Ontario were first established with CHCs in 1979 and then expanded with FHTs in 2005. CHCs focus on hard-to-serve populations, whereas FHTs offer patients access to different types of health care providers in one place. FHTs receive a global budget from the MOHLTC, which funds everything except physician services

and some clinical and support staff of FHT physicians. FHT physicians bring their own funding through a FHN or FHO, but must meet all PEM and FHT requirements.

The MOHLTC introduced Cumulative Preventive Care Bonuses in 2006 to increase delivery rates of preventive care services. Eligible PEM physicians may claim an annual bonus for achieving targeted levels of preventive care services among their enrolled patients in the following categories: influenza vaccinations, childhood immunizations, colorectal cancer screening, mammography and Pap smears. The Pap smear bonus is based on the percentage of a physician's target population that have been screened for cervical cancer in the 30 months prior to March 31st of the fiscal year when the bonus is being claimed. The target population for cervical cancer screening includes all enrolled female patients aged 35 to 69 years except women with history of hysterectomy or screening for cervical diseases that preclude regular Pap smear testing. There are five bonus levels corresponding to stepped achieved compliance rates. Physicians achieving 65% compliance receive a $220 bonus and those achieving 80% or higher receive $2,200.

The primary care landscape in Ontario has shifted greatly in the past ten years. The new PEMs proved attractive, as the average payments per active physician in a PEM were higher than FFS physicians [75]. In 2002, the majority (94%) of family physicians practiced in traditional FFS models [52]. By 2012, only 24% practiced in FFS arrangements and 76% of family physicians practiced in one of the new models [52]. FHGs were the most popular PEM until the end of 2010 when FHOs became the most common PEM [75,76]. Delivery of primary care also shifted away from a physician focus, with the number of physicians practicing in interdisciplinary primary health teams growing from 176 to over 3,000 between 2000 and 2012 [62]. The majority (2,400) of physicians joined one of the province's 200 FHTs [62]. Patient enrolment increased from only 600,000 enrolled patients province-wide in 2002 to 9.9 million, or 73% of the provincial population, in 2012 [62].

1.7.5 Evidence on the Effectiveness of Financial Incentives

The impact of financial incentives on delivery of preventive care or effectiveness for improving performance measures has not been clearly demonstrated. The literature is

inconsistent and many studies are plagued with methodological issues. Few studies have assessed the impact of incentives with randomized controlled trials (RCT), and the majority of available evidence comes from weaker designs such as controlled before and after studies (CBA) or observational studies. Design limitations limit the ability to assess the impact on health outcomes, so instead process indicators or intermediate outcomes are reported. A theme amongst the evidence is that studies with weaker designs report greater effect sizes than those with stronger designs [76]. Comparing results form various studies is not always appropriate because of differences in incentive type, health care system or setting. Therefore the study context and its relevance to the Ontario health care system is must be considered when reviewing the evidence [77,78].

1.7.5.1 Remuneration/Implicit Incentives

There is some evidence suggesting that primary payment method influences physician visit patterns and service volume, but the effects on quality and comprehensiveness of care remain a concern [69]. Physicians reimbursed with capitation payments provide more efficient service than those in FFS practices, but observing and verifying quality of care remains a challenge [69]. In theory, capitation systems deliver improved preventive care but there is scarce empirical evidence to support this claim [65]. Evidence suggests that alternative payment methods (capitation or salary) are associated with greater provision of preventive care [79], but there is limited empirical evidence on the effect on remuneration scheme on cancer screening.

A Scottish study evaluated the effect of a new reimbursement contract for Pap smears on screening rates [80]. Physicians were formerly paid for each Pap performed, but the new contract linked remuneration to meeting performance targets of 50% and 80% [80]. Within six months of introducing the new contract, screening coverage increased from 78% to 85% ($p < 0.05$) [80]. However the effect of temporal trend cannot be ruled out since there was no comparison group.

Health maintenance organizations (HMO) and managed care plans in the US provide some insight on delivery of preventive care in capitation-based models, but are not generalizable to the Canadian system. Enrollees in HMOs are more likely to receive

preventive care services [81,82]. Cervical screening rates are statistically higher among patients of fully-capitated Medicaid managed care plans than those in the Medicaid FFS program (71% versus 39%; $p < 0.0001$) [83]. Similarly, greater proportions of HMO enrollees receive Pap smears and mammograms than patients enrolled in traditional indemnity plans [84,85]. Increased coverage of screening and preventive services may have contributed to earlier stage cancer diagnoses of Medicare HMO enrollees than FFS enrollees [86]. Compared to non-enrollees, HMO members were less likely to be diagnosed with regional or distant cervical cancer (OR: 0.34; 95% CI 0.21 – 0.56), distant breast cancer (OR: 0.73; 95% CI 0.57 – 0.94), regional breast cancer (OR: 0.78; 95% CI 0.69 – 0.87) and regional colon cancer (OR: 0.85; 95% CI 0.75 – 0.96) [86]. American evidence supports the theory that preventive care is more likely in capitation models, however this different may reflect improved insurance coverage rather than quality [81,82]. Therefore evidence from a mixed-payer system doesn't necessarily reflect what will occur under universal health care.

Evidence from Ontario suggests that capitation-based practices may deliver better preventive care than FFS based practices. Dahrouge *et al*. (2012) [87] calculated preventive care scores from chart audits of the following manoeuvres: cervical, breast and colorectal cancer screening, influenza immunizations, and visual and auditory impairment screening. After adjusting for physician and patient characteristics, FHN practices had significant higher preventive care scores than FFS based (traditional FFS and FHG) practices or established capitation (HSO) [87]. During the study period, only FHN practices were eligible for preventive care bonuses, which may have biased the effect of funding model [87]. However including practice organizational factors in the model showed that practice characteristics were the primary determinants of preventive care scores rather than funding model [87]. This study failed to meet sample size requirements, which may explain the finding of no effect when including all independent variables in the model [87]. The importance of organizational factors is supported on delivery is supported by the findings of Thind *et al*. (2008) [88]. Preventive care scores were significantly higher among practices participating in a PEM than those that weren't (OR: 1.58; $p = 0.032$) [88] Since both studies used prevention scores across several measures, the effect on individual manoeuvres cannot be determined.

In contrast, Jaakimainen *et al*. (2011) [89] examined delivery rates of individual preventive services before and after joining a FHN or FHG. Participation in cervical cancer screening increased by 1.9% ($p < 0.001$) after joining a FHG and 4.6% ($p < 0.001$) after joining a FHN [89]. Among physicians joining a FHG, mammography rates decreased by 3.3% ($p < 0.001$); however rates increased by 2.4% ($p < 0.001$) among physicians that joined a FHN [89]. After joining a FHG and FHN, FOBT screening rates increased by 3.2% ($p < 0.001$) and 7.4% ($p < 0.001$), respectively [89]. Overall cervical and colorectal screening rates were not different between FHGs and FHNs; however overall mammography rates were significantly higher among FHNs [79]. The authors noted that statistically significant differences might not be meaningful at a population health level because sample sizes were very large [89]. Secular trends for cancer screening were already increasing, which may account for a significant portion of all of the observed increases [89]. Without a traditional FFS comparison group or analysis from multiple time points, observed uptake cannot be unequivocally attributed as a model effect [89].

Kralj *et al*. (2013) [90] compared provider behaviour of physicians that switched from a FHG to FHO with physicians remaining in FHGs to assess the effect of capitation. Physicians that switched provided 6-7% fewer visits and services per day, but worked similar hours [90]. Switching physicians were more likely to receive each type of preventive care bonus and about 10% more likely to receive one for Pap smear coverage [90]. This indirect measure suggests that joining a capitation is associated with improved delivery [90]. These results suggest that capitation is more efficient without comprising quality.

1.7.5.2 Explicit Incentives

The empirical evidence of the effectiveness of explicit financial incentives on physician behaviour is also inconclusive. The effect of P4P incentives for all performance measures has been estimated as a modest improvement of 5% [77]. Improvements have been reported for process and intermediate clinical outcomes for chronic diseases, but the evidence on cancer screening is less consistent. Two systematic reviews found insufficient evidence to support the use provider incentives for increasing cancer

screening [36,39]. However a more recent systematic review suggested Incentives could have a modest effect and that more evidence was needed [78]. While some studies report significant effects of P4P programs, the effect sizes are usually modest and methodological quality issues often limit their interpretation. Similarly, it is often hard to determine if findings of no effect are due to program or study design flaws.

There have been two RCTs that assessing the impact of bonuses or P4P programs on cancer screening uptake and both found no effects [91,89]. Hillman *et al.* (1998) [91] evaluated a tournament style bonus program to improve cancer screening referrals among women in Medicaid managed care plans in the USA. Primary care sites randomized to the intervention group were eligible to receive group bonuses worth up to 20% of plan capitations [91]. During the 18-month study period referrals for breast, cervical and colorectal cancer screening increased, but there were no significant between-group differences [91]. Grady *et al.* (1997) [92] evaluated the effects of reminders, audit and feedback, and incentives on mammography referral and compliance rates. American family practices were randomized to the following groups: education (control), education plus cue enhancement with chart stickers, and education plus cue enhancement plus feedback and rewards (incentive) [92]. Physicians in the incentive group received a $50 bonus if they achieved a 50% referral rate [92]. During the one year study period, the incentive group's referral and compliance rates increased by 26% and 17.9%, respectively [92]. Control referral and compliance rates were significantly lower than both intervention groups, but since there were no differences between intervention group rates, the effect was attributed to the reminder intervention [92]. Both trials had short study periods and small sample sizes, which may have influenced the finding of no effect. The designs of these P4P programs have been criticized as having insufficiently sized bonuses to be effective and poor program awareness among physicians [41]. Therefore the finding of no effect may be due to weak study design, a poorly planned incentive program or a combination of both.

There are many pay-for-performance programs implemented by various health insurance plans in the USA. Results from different programs are mixed and difficult to compare due to program, plan and population differences. Lack of standardization across different

programs places an administrative burden on providers eligible for bonuses that may not be worth the payout [93]. The results of programs run by PacifiCare, the Integrated Health Association (IHA) of California, Physician Quality and Service Recognition (PQSR) program and Blue Cross Blue Shield Alternative Quality Contract (AQC) are discussed below.

Medical groups in California were exposed to two P4P contracts over the past decade: PacifiCare's Quality Improvement Program (QIP) and the IHA's P4P contract. Both programs have been evaluated using a CBA design using a comparison group of medical groups in the Pacific Northwest contracted to the same health plans that were unexposed to incentives [94,95]. The QIP, launched in July 2003, enabled physicians to receive quarterly bonuses of $0.625 per plan member for meeting or exceeding clinical targets in the following areas: cervical cancer screening, mammography, HbA1c testing among diabetics and two other measures [94]. In the program's second year, a second performance tier worth twice as much was added. In July 2004, the IHA bonus program began and the same medical groups could receive bonuses for performance in the same performance areas as the QIP for members of five other health plans [95]. Incentives varied slightly between different health plans, but performance scores were based on clinical quality measures, patient experience and adopting IT to support care (Pink 2006). The IHA greatly expanded the bonus potential for physicians by about ten times for the average medical group [95]. Rosenthal *et al*. (2005) [94] reported the results of PacifiCare's QIP program, and Mullen *et al.* (2010) [95] reported findings from the IHA scheme. During the QIP's first year, Pap smear and mammography rates increased by 5.3% ($p < 0.001$) and 1.9% ($p < 0.04$), respectively [94]. Compared to controls, Pap smear rates increased by 3.6 percentage points more ($p < 0.02$), but there was no significant difference in mammography rates [94]. Low performing physicians had the greatest response to the incentive program, increasing screening rates by 11.1% [95]. However about 75% of payments went to physicians already achieving target levels raising the question that targets were set too low to achieve a meaningful increase [56]. The effect of QIP may be biased due to physician exposure to the IHA [51,56,57]. Medical groups were aware that the IHA would begin the following year and anticipatory effects may overestimate the QIP effect [39,95]. Indeed Mullen *et al*. (2010) [95]

reported no significant effects on performance in the period when physicians were only exposed to the QIP. In the first year of the IHA, an increase in Pap smear rates of 3.5 percentage points more than controls suggests that the findings of Rosenthal *et al*. (2005) [94] reflect the IHA effect [95]. The results of both studies show the importance of incentive size.

The PQSR program in Hawaii is a voluntary P4P program for generalists and specialists with Preferred Provider Organization (PPO) contracts. Bonuses are awarded by rankings of composite score of all program components [96]. Participating physicians received between 1 and 5% of their base professional fees in 1998-2001 and up to 7.5% from 2002 onwards [96]. In 2001, an additional bonus was added for significant performance improvement [96]. Chen *et al*. (2010) [97] analyzed rates of cervical, breast and colorectal screening of physicians in the first four years after joining the program. Physicians with PPO contracts and without P4P incentives from outside Hawaii were used as a comparison group [97]. The increase in cervical screening between program years one and two was 6.6 percentage points greater for P4P physicians than the comparison group ($p < 0.001$) [97]. The difference-in-difference was 1.4 percentage points ($p < 0.001$) between years two and three, which suggests P4P is more effective during its first year [97]. However the impact on colorectal rates were delayed. The rate of increase in the P4P group was significantly lower than that of the control group until the last year of the program when this finding was reversed [97]. The program had little effect on mammography rates, which changed by less than 1% per year [97]. The greater improvements were observed in low performing physicians, who increased Pap smear rates by 13.6%, 0.5% and 7.4% each year [97]. Results from the PQSR must be interpreted with caution for several reasons. Data from before the program started was not available to assess the effect of temporal trends [96]. Risk of selection bias is high in voluntary programs and cannot be ruled out without pre-program rates. Gilmore *et al.* (2007) [96] tried to account for selection bias by comparing the previous year's performance rates for physicians that joined after program year one with those that did not join in a given year. Physicians that joined in 1999 had significantly higher performance in 1998 for cervical ($p = 0.03$), colorectal ($p = 0.03$) and breast cancer screening ($p = 0.003$) than physicians that did not join [96]. When interpreting the results

of Chen *et al*. (2010) [96], it's important to consider the limitations of using comparison data that differs by year and region. It's possible that the P4P and control groups experienced different regional and secular trends that weren't controlled for. Considering the limitations of the comparison and that no pre-program trends were reported, it's unclear if increased screening rates were a result of the program or existing trends.

The Alternative Quality Contract (AQC) of Blue Cross Blue Shield of Massachusetts is a modified global payment model where physician groups and hospitals are at full or partial risk for spending beyond negotiated budgets [98]. Annual payments to groups are linked to per member per month budgets, which cover all services to plan enrollees regardless of where they receive their care [98]. Groups under budget keep some or all of the surpluses, while those over budget are responsible for some or all deficits [98]. Participating groups are eligible for quality incentive payments worth up to 5% of total per member per month payments for performance on 32 ambulatory care measures and services [98]. Screening rates increased for breast, cervical and colorectal cancer after program implementation [99]. Compared to physician groups that did not enter the contract, there was significant improvement for breast cancer screening in program years one and two, but the effects were modest [99,100]. There was no significant effect on cervical or colorectal cancer screening compared to the control group over the first two years [100].

Significant improvements in colorectal screening rates are reported after initiating an annual bonus program for private insurance plan members [101]. The bonus formula is proprietary, so no details on bonus eligibility, method of calculation or incentive magnitude were provided. Since Armour *et al*. (2004) [101] were unable to determine which physicians were eligible, only those receiving bonuses were included in the analysis. After program year one, fecal occult blood testing (FOBT) increased by 2.8% ($p < 0.01$) and overall colorectal screening increased by 3% ($p < 0.01$) [101]. Since there was no control group, the temporal effect of change cannot be clearly distinguished from that of the bonuses [101].

Gavagan *et al*. (2010) [102] compared screening rates of six community health centres participating using financial incentives with those at five centres without bonuses. If a clinic met two of three quality indicator targets then all clinic physicians received a bonus [102]. The maximum bonus was $4,000 per year, representing 3 – 4% of a physician's salary [102]. Mammography and cervical cancer rates increased over the four-year study period, but there were no significant differences between clinics with incentives and without [102]. Significantly higher proportions of non-incentivized clinics met Pap smear targets early in the study period, but this trend was reversed during the later quarters of the study period [102]. These results suggest the incentive effect may be delayed, but overall there were no significant differences in performance rates of Pap smears or mammography between incentivized and non-incentivized clinics [102]. Features of the incentive program may have caused finding of no effect. Group incentive programs are unlikely to be as effective as incentives for individual physicians, and individual physician productivity bonuses may have been more of an incentive [102]. Participating physicians reported that bonuses were the least effective quality improvement intervention, which may be due to insufficient incentive size [102]. Physicians were aware of the program, but not told which indicators were incentivized to avoid selective performance improvements [102]. About 50% of physicians were unable to correctly identify the incentivized indicators, so lack of program knowledge may have contributed to findings of no effect [102]. The study period was only 18 months, but practices may take longer to adjust to the program. In addition to program limitations, this study's small sample size meant it was only powered to detect a very large effect size [102].

A Dutch P4P program designed by primary care providers led to quality improvements for some clinical indicators, but not for Pap smears [103]. Physician groups were awarded bonuses for performance in three quality areas: clinical care indicators, patient management and patient experience Improvement [103]. The study timeframe was only one year, but the cervical screening interval is usually three years. A year may have been too short to cause an effect. The greatest improvements were reported for low-performing indicators, so the baseline rate may have been too high to cause much of an effect [103]. Since group bonuses were awarded based on performance scores in over 30 clinical

indicators, it's possible that the bonus size was too small to cause an effect in many indicators.

An Australian P4P program with per patient bonuses for under screened women and those screened over target reported short-term increases in cervical cancer screening for all physicians [104]. There was no significant association between increased screening rates and participating in the program or claiming bonuses, which suggests that screening rates were already increasing [104]. There is high risk of selection bias in this study as participation in the program was voluntary; already high-performing physicians may have chosen to join the program [104]. Participating physicians reported that the program didn't modify their practice and the burden of tracking and billing incentive codes was greater than the amount of the bonus [104].

Interestingly one study found removing targeted incentives was more impactful on Pap smear coverage than introducing them [105]. Screening only increased by 0.6% during the two years it was incentivized and decreased by 1.6% yearly over the next five years when incentives were removed [105]. Rates then began to increase when incentives were reintroduced [105].

The few preliminary before and after studies assessing the impact of preventive care bonuses on rates of targeted services in Ontario have reported modest effects. Li *et al*. (2014) [106] used a difference-in-difference approach to control for selection bias to compare rates of preventive care services between physicians eligible for bonuses and FFS physicians. Preventive care bonuses increased Pap smear and colorectal cancer screening rates by 3.1% and 9.5%, respectively [106]. There was no significant difference in mammography rates [106]. Bonuses increased absolute levels of compliance by 4.1% ($p < 0.01$), 1.8% ($p < 0.01$) and 8.5% ($p < 0.01$) for Pap smears, mammography and colorectal cancer screening, respectively [106]. Compared to baseline compliance, Pap smear, mammography and colorectal cancer screening rates increased by 7%, 2.8% and 57%, respectively [106]. The parallel trend test failed to reject the null hypothesis of a common trend between physicians eligible for P4P and non-P4P physicians for Pap smears, but the null hypothesis was rejected for mammography and colorectal cancer

screening [106]. However results from the differential trend model are not qualitatively different from the fixed-effects model [106]. Subgroup analyses revealed greater responses among physicians with lower baseline compliance [106], which is consistent with the findings of Chen *et al*. (2010) [96] and Rosenthal *et al*. (2005) [94]. The incentive effect also varied with physician age and practice size with younger physicians and larger practices having a greater response [106].

The Provider and Patient Reminders in Ontario: Multi-Strategy Prevention Tools (P-PROMPT) project found similar modest results [107]. After one year of the project, time-appropriate delivery of Pap smears and mammography increased by 6.26% (95% CI 5.12 – 7.45) and 5.3% (95% CI 4.2 – 6.4), respectively [107]. The proportion of practices with Pap smear coverage less than 60% decreased from 25% to 14%, and the proportion at the highest performance level (<80%) increased from 31.5% to 55.6% [107]. Nurse practitioners were deployed to some clinics, but comparable rates were observed for clinics with and without nurse practitioners [107]. There are several limitations of that limit the findings of Kaczorowki *et al*. (2013) [107]. The P-PROMPT project evaluated a complex intervention including patient and provider reminders, deployment of nurse practitioners and P4P bonuses, so the effect of incentives cannot be distinguished from the co-interventions [107]. Furthermore, physicians survey responses indicate that other aspects of the project, like reminder letters, were more useful for improving compliance [108]. There was no contemporaneous control group, so improvements may be due in part or whole to temporal trends.

1.7.6 Cost-Effectiveness

The cost-effectiveness of financial incentives for improving cancer screening has not been investigated to date. A few economic analyses have evaluated pay-for-performance programs and implicit financial incentives for improving other process of care outcomes or intermediate outcomes. However few full economic analyses exist, and the incentives and outcomes of these studies are not relevant to this analysis.

Bonus programs are often not cost-effective because previously high-performing physicians must also be rewarded to cause change among those not meeting performance

targets [72]. Depending on baseline performance and the structure of the P4P program, the physicians previously meeting targets may receive the majority of bonus payments. It is argued that explicit incentives are unsustainable since they add new costs to the healthcare system when costs are already increasing [72]. However if expected savings resulting from bonus-induced performance improvements are used to fund reward payments then the program may be cost-effective.

Cancer screening was one of the first interventions to have a systematic cost-effectiveness analysis [109] and over the past 40 years studies of the cost-effectiveness of cervical cancer screening continue to be published. The reductions of the incidence and mortality of cervical cancer after introducing Pap smears clearly demonstrated the effectiveness of screening. However it was not clear at what ages women should be screened or the interval length between screens. Cost-effectiveness analyses of screening details have informed development of screening guidelines and programs [109]. With the advent of new technologies such as liquid-based cytology and HPV DNA testing, recent analyses have focused on the most cost-effective test. To date no there have been no cost-effectiveness analyses of physician payment method or bonuses on cancer screening.

Early economic analyses reported that screening programs increase total cervical cancer-related costs, but also improve health effects like life-years gained [110]. Despite lower terminal treatment costs, the increases in diagnostic costs leads to greater total costs [110]. Factors like screening ages, interval and attendance rates all influence the cost-effectiveness of a screening program [111]. Identical programs with higher attendance rates result in greater health effects and total costs, but costs increase less than proportional to that of attendance [111]. Therefore programs with higher screening rates are more cost-effective than those with lower attendance [111,112].

1.8 Research Objectives

I aim to contribute to the growing body of evidence on financial incentives for improving cancer screening performance. Three research objectives are:

1. Assess the difference in cervical cancer screening rates across three of Ontario's primary care delivery models:

    a. Compare the traditional FFS model with the Family Health Group (FHG), which is an enhanced FFS model eligible for P4P incentives.

    b. Compare the traditional FFS model with the FHO, which is a capitation model eligible for P4P incentives.

    c. Compare the FHG and FHO models, which are both eligible for P4P incentives, but have different base remuneration schemes.

2. Estimate the overall and specific healthcare costs associated with cervical cancer treatment in Ontario during the first three years after diagnosis.

3. Conduct a cost-effectiveness analysis of remuneration and P4P eligibility for cervical cancer screening in Ontario's primary care delivery models.

Screening rates of Ontario FFS, FHG and FHO physicians were assessed from population-based administrative databases held at the Institute for Clinical Evaluative Sciences (ICES). Physician practice screening rates from 2010/2011 were adjusted for patient and physician characteristics and compared across models. Costs were assessed using ICES administrative data holdings for a cohort of Ontario cervical cancer cases diagnosed between 2007 and 2010. Costs were estimated for the first three years following cervical cancer diagnosis and adjusted for censoring. A microsimulation model was developed from published natural history models and parameterized to Canada HPV prevalence and cervical cancer incidence rates. This model was populated using screening rates assessed in objective 1 and costs assessed in objective 2.

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Chapter 2

2 Financial Incentives and Cervical Cancer Screening Participation in Ontario's Primary Care Delivery Models

2.1 Introduction

Cervical cancer is the third most commonly diagnosed cancer in women worldwide and ranks 11th in Canada [1-3].[1] Following the introduction of universal health insurance in Canada in the early 1970s, uptake of cervical cancer screening with the Papanicolaou (Pap) test increased considerably [3]. Between 1972 and 2006 cervical cancer incidence and mortality rates declined by 58% and 71% and these reductions are largely attributed to higher screening participation [3]. It takes several years for infection with human papillomavirus (HPV) to progress to invasive cervical cancer, so with timely screening and follow-up of abnormal test results, many cancer cases and deaths are preventable [5]. Despite the progress in cervical cancer screening, it was estimated that 610 women were diagnosed with and 150 women died from cervical cancer in Ontario in 2013 [4]. Among incident cases in Ontario, nearly 40% had no record of screening within the four years prior to diagnosis [6].

Ontario guidelines recommend that women who are or ever have been sexually active between 21 and 69 years be screened with a Pap smear every three years [7-9]. In 2009-2011 only 65% of women aged 20-69 were screened, which is well below the provincial target rate of 85% [8]. Women who are never or inadequately screened have increased risks of cervical cancer, advanced cancer and cervical cancer-related mortality [10-12]. Thus, failure to screen at the recommended interval presents a serious health challenge for women and costs the health care system significantly. Primary care physicians, thus, play an instrumental role in educating patients on the risks of cervical cancer and benefits of screening with Pap tests.

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[1] The 2008 global cervical cancer age-standardized incidence rate (ASIR) and age-standardized mortality rate (ASMR) were 15.2 and 7.8 per 100,000 women, respectively [1]. The 2013 Canadian ASIR and ASMR were 7 and 1.6 per 100,000 women, respectively [4].

In an effort to improve delivery of preventive health care services by primary care physicians, the government of Ontario introduced primary care reforms in the early 2000s. Financial incentives for physicians and the mode of physician remuneration were two mechanisms by which the government of Ontario aimed to improve the delivery and uptake of a basket of preventive care services. After a transition period when physicians quit the traditional fee-for-service (FFS) model, the Family Health Group (FHG) and the Family Health Organization (FHO) models emerged as Ontario's dominant primary care delivery models [13-15]. A detailed comparison of model differences is described in Appendix A2.1. In brief, the FHG is an enhanced FFS model where physicians submit billing claims as in the traditional FFS model. The FHO is a blended capitation model that reimburses physicians with age- and sex-adjusted capitation payments to provide a set of services. FHO physicians are incentivized to submit shadow billings -- they receive 15% of the FFS payment for each core service submitted. In addition to base remuneration, FHG and FHO physicians receive several incentives that are not available to physicians practicing in the traditional FFS model [16].

A key incentive eligible to physicians practicing in FHGs or FHOs is the Pap smear Cumulative Preventive Care Bonus. This pay-for-performance (P4P) program rewards physicians each year with stepped payments based on the proportion of their enrolled patients aged 35 to 69 years who received a Pap smear in the 30 months prior to March 31st of that fiscal year. Women who have had hysterectomies are excluded from the target population. Physicians that have 60% of their patients screened receive a $220 bonus, and physicians achieving the highest performance level (80%) receive $2,200. Table 2.1 summarizes the payments for each target coverage level.

Despite the increasing popularity of incentive-based payments to physicians to achieve desirable health outcomes worldwide, the effectiveness of incentives is ambiguous [17-19]. Some studies have found that financial incentives are associated with a modest (<10%) improvement in cervical cancer screening rates, while others have found no effects [20,21]. The evidence on the effect of remuneration is quite limited. Some studies suggest that capitation-based practices deliver better preventive care compared to FFS counterparts [22], but the effects of blended payment models are unclear to date [13].

The objectives of this study are to compare cervical cancer screening rates in three of Ontario's primary care delivery models by incentive eligibility and remuneration. I compared the traditional FFS model with the FHG, an enhanced FFS model where physicians receive incentives if they meet target participation levels. I also compared the FFS model with the FHO, where physicians are paid on a capitation basis and may receive other incentives. Finally I compared the FHG and FHO models, both of which are eligible for incentives, but have different base remuneration. Secondary objectives include estimating the direct medical care costs of screening across the three primary care delivery models: FFS, FHG and FHO.

2.2 Methods

2.2.1 Data Sources

The data for this study came from population-based Ontario health administrative databases held at the Institute for Clinical Evaluative Sciences (ICES). These datasets were linked using unique, encoded identifiers and analyzed at ICES. A cross-sectional analysis of a population-based cohort was conducted. The Corporate Provider Database (CPDB) contains information on physicians practicing in Ontario and program eligibility. The ICES Physician Database (IPDB) contains physician demographic characteristics. The Registered Persons Database (RPDB) holds demographic information on all Ontario residents eligible for the Ontario Health Insurance Plan (OHIP). The OHIP claims database contains all billing claims and shadow billing claims made by all Ontario physicians. The Client Agency Program Enrolment (CAPE) tables were used to identify patients rostered to physicians practicing in a FHG or FHO. Patients of physicians practicing in a FFS practice were identified from OHIP claims using a validated ICES algorithm [23].[2] Statistics Canada's Postal Code Conversion File [24] was used to assign

[2] The practice populations of FFS physicians are defined by claims submitted for primary care visits. All patients that the physician billed OHIP for at least one visit in the previous fiscal year and any additional patients with at least one visit in each of the two previous fiscal are assigned to that physician. If patients meet these criteria for more than one physician, they are assigned to the physician with the most claims in the most recent year. If the numbers of claims are equal across physicians then the patient is assigned to the physician with the most recent visit.

patients to census dissemination areas (DAs), which were then linked to the Ontario Marginalization Index (OMI) and the Rurality Index of Ontario (RIO) [25]. The OMI captures neighbourhood socio-economic factors across four dimensions: material deprivation, residential instability, dependency and ethnic concentration [26]. Each dimension is a composite of several indicators from the 2006 census (Appendix A2.2), and data from each dimension is organized into quintiles where 1 is least marginalized and 5 is most marginalized.[3] Individuals with a RIO of 40 or higher were considered to reside in rural areas [25].

2.2.2 Study Physicians and Study Patients

All full-time comprehensive primary care physicians (PCPs) practicing in a FHG, FHO or traditional FFS model on March 31st, 2011 were included [27]. This date was chosen to be consistent with the date used to calculate bonus payments and capture the most recent data available. Ontario women aged 35 to 69 years inclusive on the index date that were patients of FFS physicians or enrolled to FHG or FHO physicians were first selected for inclusion.[4] Women were excluded from the study population if there was evidence of previous gynaecological cancer diagnoses in the Ontario Cancer Registry (OCR). The OCR is a population-based registry that captures information on all Ontarians with incident cancer cases except non-melanoma skin cancer. The Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD) holds information on all inpatient hospitalizations and was used to exclude women with evidence of hysterectomy. Women with evidence of infection with human immunodeficiency virus (HIV) in the ICES HIV database [28] were also excluded because they have increased risk of cervical cancer and are precluded from regular screening [29].

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[3] Areas in quintile 1 are the least deprived, least unstable with respect to housing, least dependent and have low ethnic concentrations. Quintiles 1 and 2 represent areas with the highest socioeconomic status and socioeconomic status decreases with increasing quintile. Areas in quintile 5 are the most deprived, unstable and dependent, and have the highest ethnic concentrations.

[4] Note that women aged 21 to 34 years are eligible for screening, but were not part of the target population for the cumulative preventive care bonus.

Patient and physician-level characteristics were obtained on the index date (March 31st, 2011). Patient characteristics included age, rural residence and OMI quintiles. Physician characteristics included age, gender, experience (defined as years since graduation), international medical graduate (IMG) status and number of patients in the Pap smear bonus target population.

Patient-level screening status was assessed from the OHIP claims database using a validated billing code algorithm [30].[5] A woman was considered adequately screened if at least one OHIP claim with a Pap smear billing code was made in the 30 months prior to March 31st, 2011, as specified by the Cumulative Preventive Care Bonus guidelines. The screening rate was defined as the number of eligible women receiving a Pap smear divided by all eligible women in the corresponding physician's practice.

Cumulative Preventive Care Bonuses claimed for Pap smears were identified from OHIP claims. Physicians are responsible for calculating their coverage level and submitting bonus claims to OHIP. The Ministry of Health and Long-Term Care sends each eligible physician a Target Population Service Report, which defines the target population for each bonus category. For Pap smears this includes all enrolled women aged 35 to 69 inclusive on March 31st of a given year. Women who have had a hysterectomy are excluded. The Target Population Service Report, clinical records and other data sources are used to identify which women were screened in the coverage period, and the coverage level is calculated by dividing the number of women covered by the target population. Documentation of services provided is not required for submission.

2.2.3 Analyses

Bivariate analyses using ANOVA and the Chi-square statistic where appropriate were used to compare patient- and physician-level characteristics across model types and to assess the associations between these characteristics and screening rates. The associations

[5] Patients with at least one procedure, lab or applicable visit code billed to OHIP were considered adequately screened.

between physician-level factors and claiming a bonus among FHG and FHO physicians were also assessed using ANOVA and the Chi-square statistic.

Physician practice-level screening rate was the primary outcome of this study. Patient- and physician-level covariates that were available from administrative databases were included. However dependency and physician age were excluded because they were highly correlated with material deprivation and physician experience, respectively. Patient-level characteristics were aggregated to the physician's practice. Mean patient age and the proportion of a physician's practice living in rural areas were calculated. Socioeconomic status and ethnicity were estimated by calculating the proportion practice patients living in quintiles 1 and 2 (least marginalized) in the following dimensions: material deprivation, residential instability and ethnic concentration. The influence of the Cumulative Preventive Care Bonus was assessed by comparing screening rates of FFS with FHG physicians. In these two models physicians receive FFS payments, but only FHG physicians are eligible for bonuses. The influence of remuneration (capitation versus FFS) was assessed by comparing screening rates of FHG and FHO physicians. Finally, performance of FFS physicians was compared to FHO physicians to assess the overall impact of incentives and remuneration on screening rates and costs.

Since the outcome variable, screening rate in physician's practice, is bounded between zero and one the fractional logit regression model was considered [31]. I used a generalized linear model with a binomial distribution and logit link function, so predicted screening rates of 0% and 100% were attainable. Three fractional logit models were fit to compare different pairs of primary care delivery models: 1) FFS with FHG 2) FHO with FHG and 3) FFS with FHO. The dependent variable was physician-level screening rate and the exposure variables of interest are the primary care delivery models. Patient-level variables, physician gender, physician experience and number of patients in the Pap smear target population were controlled (Box 2.1). Each regression model was fit using data from physicians practicing in one of the two models being compared (i.e. regression model 1 comparing FFS with FHG was fit using data from FFS and FHG physicians). Marginal effects were obtained using the method of recycled predictions where predicted screening rates are generated after fixing the values of primary care program model (e.g.

in regression model 1 fix program to 0 for FFS to generate predictions and then fix program to 1 for FHG to generate predictions) [32]. The predictions are then averaged to estimate the conditional mean of a particular primary care model [32]. Regression analyses were performed for the cohort and sensitivity analyses was conducted with physicians with at least 100 eligible patients.

The costs of cervical cancer screening in Ontario were estimated in two steps: 1) estimating delivery costs; and 2) estimating bonus costs for FHG and FHO physicians. First, the service cost, exclusive of bonus payments, for Pap smear delivery was obtained from Ontario's schedule of fees and benefits [33]. Both the procedure fee ($6.75) and laboratory fee ($11.55) were included in delivery costs [33]. It was assumed that all Pap smears were performed outside of hospital and thus eligible for the laboratory fee. Procedure codes are not eligible for payment when billed in conjunction with a consultation, but it was assumed that the unit cost of all Pap smears would equal the rate listed in the provincial fee schedule ($18.30). Pap smears are included of the basket of services covered by base capitation payments in the FHO model, so FHO physicians don't receive the same fee as FFS or FHG physicians. However FHO physicians receive the laboratory fee if performed outside of hospital and it was also assumed that the Pap smear procedure fee is built into capitation payments. Therefore the unit cost of $18.30 was assigned to the FHO and delivery costs, excluding bonus payments, were the same across all models. I assumed that the number of women screened over the study period was distributed evenly. Thus, the number of women screened each year was estimated by dividing the total screened by three (the number of years of coverage). Annual Pap smear delivery costs were estimated by multiplying the number screened annually by the unit cost. The second step in estimating the costs of screening was to estimate the overall and per woman cost of bonuses paid to physicians. In the FHG and FHO models, the bonus payments claimed by physicians in 2010/2011 were summed to obtain total bonus payments, which were added to delivery costs to estimate the total costs of screening in a given year. The cost per screen was estimated by dividing the total annual cost by the annual number screened.

All analyses were performed using SAS 9.2 at ICES Western.

2.3 Results

There were 7,382 full-time comprehensive primary care physicians practicing in a FFS, FHG or FHO model on March 31st, 2011. Fifty-eight physicians did not have any patients that met eligibility criteria and were excluded from further analyses. Twenty-six physicians listed as FFS physicians claimed a bonus in 2011. Since FFS physicians cannot claims bonuses, their primary care delivery model could not be accurately identified and they were also excluded. The remaining 7,298 physicians had a total of 2,083,633 female patients aged 35-69 eligible for cervical cancer screening. Tables 2.2 and 2.3 summarize the characteristics of patients and physicians across model type.

Overall 80% of women had at least one Pap smear between 2009 and 2011. Seventy-three per cent of FFS patients, 79% of FHO patients and 84% of FHG patients were screened at least once Bivariate analysis suggested that each patient- and physician-level characteristic was associated with patient-level screen status (Appendix A2.3). The mean screening rate per physician was 79% across all three models; 72% among FFS physicians, 79% among FHO physicians and 83% among FHG physicians (Figure 2.1a).

Primary care model type remained a statistically significant predictor of screening rate after adjusting for patient- and physician-level characteristics (Appendix A2.4). Screening rates of FHG physicians were 7.7% higher ($p < 0.0001$) than those of FFS physicians (Table 2.4; Figure 2.1b). Compared to FHO physicians, rates of FHGs were 2.3% higher ($p < 0.0001$; Figure 2.1c). Adjusted performance of FHO physicians was 6.2% higher than that of FFS physicians ($p < 0.0001$; Figure 2.1d). Results from sensitivity analyses of physicians with at least 100 eligible patients were similar to those from the whole cohort.

Fifty-six per cent of FHG and 81% of FHO physicians claimed a Cumulative Preventive Care Bonus for Pap smear delivery in 2010/11 (Table 2.5). Sixty-five per cent of physicians claiming a bonus claimed the highest award level. There were significant associations between claiming a bonus and all physician characteristics (Appendix A2.5). In total $7.195 million in bonuses were paid to family physicians in FHGs and FHOs in the 2010/11 fiscal year.

The total one-year costs of cervical cancer screening ranged from $965,764 in the FFS model to $9,498,350 in the FHO model. The FFS model has the lowest cost per woman screened (the unit cost of $18.30) and adjusted screening rate (Table 2.6; Figure 2.2). The costs per woman screened, including bonus payments, in the FHG and FHO models were $29.71 and $35.02, respectively.

2.4 Discussion

In 2000-2002 cervical cancer screening participation among eligible Ontario women aged 20-69 was 61.6% [9]. Reforms to Ontario's primary care system began in 2002, leading to a transition period when physicians were joining the new patient enrolled models, which stabilized around 2010 [13,14]. Previous research showed that in the first two years after joining a FHG, the cervical screening rate increased by 1.9% ($p < 0.001$), while among physicians joining the blended capitation Family Health Network (FHN) model the screening rate increased by 4.6% ($p < 0.001$) [33]. The provincial screening rate among women aged 20-69 steadily increased by 2.4% ($p < 0.0001$) since 2002 and by 2008-2010 had improved to 72% [35].

My results show significant differences in cervical cancer screening rates between FFS and two dominant reformed models in Ontario. These findings suggest that physician payment method and incentives may affect Pap smear delivery. Screening rates were significantly higher among FHO physicians, who receive FFS payments and are eligible for incentives, compared to FFS physicians, suggesting that financial incentives combined with a FFS payment scheme would achieve higher cervical screening rates. The theoretical effect of remuneration on preventive services is unclear. FFS physicians have an incentive to provide a high volume of services, which could include cervical screening [36,37]. Physicians in capitation systems may have an incentive to reduce services because they do not receive reimbursement for additional services [36,37]. However physicians paid under capitation may also try to reduce future care needed by their patients and minimize financial risk by providing preventive care and health promotion activities [38-40]. My results show that physicians in a blended capitation system have significantly higher cervical screening participation than those in the FFS

model. Blended systems like the FHO attempt to combine incentives from FFS and bonus payments for providing higher quality care [38-40].

My results are generally consistent with past research suggesting that P4P incentives have modest effects on cervical cancer screening rates [41]. Compared to the FFS model, FHGs and FHOs have 7.7% and 6.2% higher screening rates. A previous analysis of financial incentives in Ontario estimated that the bonus increased Pap smear delivery by 7% [25]. Another Ontario study found no difference in screening trends before and after the introduction of the incentive [42]. In addition, patients who enrolled in a FHG or FHO were more likely to receive cancer screening before incentives were introduced [42]. These findings suggest that observed differences in screening participation rates between the incentivized models (FHG and FHO) and FFS model may be due to higher baseline rates. This in turn may suggest that P4P incentives could be ineffective. It should be noted that I found poor agreement between physician screening participation rate and bonus claimed for FHG and FHO physicians. While many physicians claimed a bonus that matched their observed screening rate, there were many physicians that did not claim any or the full bonus corresponding to their observed screening rate. There were also many physicians who claimed a bonus higher than that corresponding to their observed rate. This may be due to insufficient bonuses, practice culture, administrative burden of claiming a bonus, and the accuracy in calculations of screening rates by physicians when claiming a bonus and in my estimates from administrative data. Bonuses claimed by physicians rather than those corresponding to their observed rate were used to estimate costs because these payments reflect the true cost to the ministry. While some physicians may be claiming upwards, currently there is no mechanism for the ministry to audit bonus claims.

The empirical evidence on the effect of remuneration for cancer screening has not been widely studied. An analysis of preventive care delivery in Ontario after joining a reformed model reported that cervical screening rates among physicians joining FHNs were 1% higher than those joining FHGs [33]. Another Ontario study reported that FHO physicians were 10% more likely to claim a Pap smear preventive care bonus, which suggests that they achieve higher screening rates [13]. This is consistent with my finding

that greater proportions of FHO physicians claimed bonuses than FHG physicians, and FHO physicians were 45% more likely to claim a bonus than FHG physicians (relative risk (RR) = 1.45, 95% confidence interval (CI): 1.40-1.51). Previous research suggesting that capitation performs better is not consistent with my finding since FHOs had slightly lower rates than FHGs. This may be due to underestimating FHO rates or a true difference. Pap smears are included in the basket of FHO services, so a physician receives a fraction of the fee paid to FFS or FHG physicians for providing a Pap smear. It is plausible that FHO physicians do not consider this payment worth the administrative burden of submitting a shadow billing claim, which may underestimate my estimates of FHO screening rates.

There are several reasons why a woman may choose not to be screened for cervical cancer. Women may not be aware of the risks of cervical cancer or the benefits of screening, and they may not perceive themselves to be at risk of developing cervical cancer. Pyschosocial barriers to screening include embarrassment, fear of Pap testing, lack of a female provider to perform testing and cultural beliefs about cervical cancer and screening [43]. Despite the best efforts of a woman's physician, some women may choose to not participate.

This analysis has several strengths. My results contribute to the literature on the role of remuneration on quality of care and provide updated estimates on the influence of incentives on cervical cancer screening in Ontario. These analyses highlight the impact of incentives on physician behaviour by estimating practice screening rate as an outcome rather than individual screening status as an outcome variable. Financial incentives are directed towards physicians not patients, so their impact on clinical practice is meaningful at the physician level rather than at the patient level. My analysis examines the influence of incentives across different primary care delivery models in contrast to previous research that considered all models eligible for incentives as one group [27,32]. I examined both performance and costs to get a better understanding of the impact of Cumulative Preventive Care Bonus program on cervical cancer screening.

This analysis also has several limitations. First, I was unable to assess temporal trends in cervical cancer screening rates. Second, as previously mentioned, if FHO physicians do not submit shadow billings my estimates of screening rates in this model may be biased downward. FHO physicians not affiliated with a hospital receive the full laboratory fee and in theory would submit these claims, which would limit the degree to which my results underestimate FHO rates. Third, it was assumed that Pap smear delivery costs (excluding bonus payments) in the FHO model were equal to those in the FFS and FHG models to simplify calculating the costs of screening. However this assumption may not hold true in some practices depending on a woman's use of the healthcare system. For example, the proportion of capitation payments attributed to screening would be higher for a woman who only sees her primary care physician once every three years for a Pap test than a sicker woman who sees her physician monthly. Without knowing the healthcare utilization of FHO patients, I was unable to assess the impact of this assumption on my screening cost estimates. Fourth, the switch from the FFS practice to a FHG or FHO was voluntary; physicians joining a FHG or FHO may differ systematically by provider behaviour or other unknown physician characteristics. Although I controlled for several physician and patient characteristics, there may be some selection bias. Physicians joining a FHG had greater productivity before joining than those that did not switch [44] and physicians joining FHG or FHO had higher baseline screening rates than those remaining in the FFS model [40]. Physicians with complex and less affluent patients were more likely to join a FHG than remain in the FFS model [44] or join a capitation-based model [45]. Differences in baseline screening, productivity and patient populations may bias my results. Fifth, I was unable to assess socio-economic status or ethnicity at the patient-level as only neighbourhood-level data was available. Low income, certain ethnic groups (e.g. South Asian women) and recent immigration status are associated with a lack of screening [30,46], so individual-level data on these variables would have been preferable to include in the model. Finally, my screening estimates are about 15% higher than those reported by the Ontario Cervical Screening Program (OCSP) for the same time period [9], which may suggest that my rates are overestimated. However this difference could be due to differences in study populations. The OCSP included eligible women aged 20-69, but my analysis was limited to women aged 35-69

who were enrolled with a FHG or FHO or active patients of a FFS physician. Patients with a regular family physician may be more health conscious and more likely to be screened than those without [47-49]. The billing code algorithm used has very high sensitivity (99%) at the expense of specificity (61%) [30], which may overestimate the proportion screened. While this may have some upward bias in my screening results, it is unlikely that my conclusions are affected across primary care delivery model types.

2.5 Conclusions

Ontario's reforms have shifted the primary care landscape from small private practices reimbursed on a fee-for-service basis towards interdisciplinary practices with blended remuneration schemes. Throughout Canada the proportion of physician income coming from alternative payments is increasing compared to FFS payments [49], so it is interesting to understand its impact on outcomes. My results contribute to the growing body of empirical evidence on the effects of remuneration and incentives on quality. I found significantly higher cervical cancer screening rates among models eligible for preventive care bonuses than the FFS model. There was a small but statistically significant difference across remuneration with the enhanced FFS model having higher rates than the blended capitation model. Average costs per screening were lowest in the FFS model and highest in the FHO model as a result of bonus payments. However many physicians claim the highest bonus level, which may be due to historically high screening rates. Linking bonus payments to change in screening rates may encourage low performing physicians to improve their screening rates.

Future research can expand on the impact of incentives on other preventive care services such as breast or colorectal cancer screening or the effect of Ontario's chronic disease management incentive on quality of care. Performance could be assessed in other primary care delivery models. Finally, future research could examine how recent changes to the target population and coverage period of the Cumulative Preventive Care Bonus for Pap smears will affect screening rates and costs.

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2.7 Tables and Figures

Table 2.1: Cumulative preventive care bonuses for cervical cancer screening

Achieved Screening Participation Rate	Fee Payable
60%	$220
65%	$440
70%	$660
75%	$1,320
80%	$2,200

$$E(y_i) = g^{-1}(x_i\beta),\ y_i \sim Bin$$
$$g(.) = \log it$$
$$y_i = PCP\ practice - level\ screening\ rate$$
$$x_i = \beta_0 + \beta_1 program_i + \beta_2 mean\_age_i + \beta_3 rural_i + \beta_4 deprivation_i + \beta_5 instability_i +$$
$$\beta_6 ethnic\_concentration + \beta_7 PCP\_gender + \beta_8 PCP\_\exp erience_i + \beta_9 screen\_practice\_size_i$$

Box 2.1: Fractional logit regression used to estimate screening rates

Where $program_i$ is a dummy variable representing primary care delivery model. In regression model 1 $program_i$ is equal to 0 for the FFS model and equal to 1 for the FHG. In regression model 2 $program_i$ is equal to 0 for the FHO and equal to 1 for the FHG. In regression model 3 $program_i$ is equal to 0 for the FFS model and equal to 1 for the FHO.

Table 2.2: Characteristics of study physicians

Model	FFS	FHG	FHO	Total
N (%)	1,172 (16.1%)	2,847 (39.0%)	3,279 (44.9%)	7,298
Age, Years				
Mean (95% CI)*	53.7 (52.9-54.5)	52.5 (52.1-52.9)	51.0 (50.7-51.4)	52.0 (51.8-52.3)
Gender, %*				
Female	36.3%	40.9%	42.1%	40.7%
Medical Training, %*				
IMGs	26.9%	29.3%	11.1%	20.7%
Experience, Years Since Graduation				
Mean (95% CI)*	27.1 (26.3-27.9)	26.4 (26.0-26.8)	24.6 (24.3-25.0)	25.7 (25.5-26.0)
Experience Category, %*				
< 10 years	15.8%	7.1%	10.0%	9.8%
10-19 years	15.3%	21.6%	22.6%	21.0%
≥ 20 years	68.9%	71.3%	67.4%	69.2%
Number of Patients in Pap Smear Target Population*				
Mean (95% CI)	185 (172-190)	293 (286-300)	315 (310-320)	286 (282-289)
Number of Patients in Pap Smear Target Population Category, %*				
≤ 100 women	35.4%	14.2%	4.5%	13.3%
> 100 women	64.6%	85.8%	95.5%	86.7%

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization; CI = confidence interval

* $p < 0.001$

Table 2.3: Characteristics of study patients

Model	FFS	FHG	FHO	Total
N (%)	216,609 (10.4%)	833,706 (40.0%)	1,033,318 (49.6%)	2,083,633
Age, Years				
Mean (95% CI)*	49.38 (49.35-49.42)	49.58 (49.56-49.6)	50.38 (50.36-50.40)	49.96 (49.94-49.97)
Age Category, %*				
35-39 years	21.0%	20.0%	17.7%	19.0%
40-49 years	31.8%	32.2%	30.7%	31.4%
50-59 years	31.7%	32.0%	33.8%	32.9%
60-69 years	15.4%	15.7%	17.7%	16.7%
Rural, %*				
Rural	6.1%	2.2%	7.5%	5.2%
Ontario Marginalization Index Quintiles, %				
Material Deprivation*†				
Q1	23.5%	28.9%	29.4%	28.5%
Q2	20.9%	23.7%	24.2%	23.6%
Q3	20.1%	19.5%	19.6%	19.6%
Q4	17.8%	14.8%	15.0%	15.2%
Q5	16.4%	12.4%	11.0%	12.1%
Missing	1.4%	0.7%	0.8%	0.8%
Dependency*†				
Q1	26.6%	28.7%	20.8%	24.5%
Q2	23.8%	26.2%	22.6%	24.1%
Q3	18.9%	18.4%	20.7%	19.6%
Q4	15.0%	13.6%	17.8%	15.8%
Q5	14.4%	12.4%	17.3%	15.0%
Missing	1.4%	0.7%	0.8%	0.8%
Ethnic Concentration*†				
Q1	8.4%	6.5%	14.2%	10.5%
Q2	11.0%	10.4%	19.7%	15.1%
Q3	13.9%	13.9%	20.7%	17.3%
Q4	19.6%	20.7%	22.0%	21.2%
Q5	45.8%	47.8%	22.6%	35.1%
Missing	1.4%	0.7%	0.8%	0.8%
Residential Instability*†				
Q1	26.2%	32.8%	27.3%	29.4%
Q2	19.0%	20.9%	22.7%	21.6%
Q3	14.5%	13.6%	17.2%	15.5%
Q4	18.5%	16.1%	17.2%	16.9%
Q5	20.5%	15.8%	14.7%	15.8%
Missing	1.4%	0.7%	0.8%	0.8%

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization; CI = confidence interval

* $p < 0.001$, † Q1 is the least marginalized & Q5 is the most marginalized

Table 2.4: Regression model predictions of mean physician practice screening rate

Model	Mean Predicted Screening Rate (95% CI)		Difference	*p*-value
Model 1: FFS versus FHG				
	FFS	**FHG**		
	74.16% (73.95-74.37)	81.86% (81.69-82.02)	7.70 (7.65-7.74)	< 0.0001
Model 2: FHG versus FHO				
	FHO	**FHG**		
	79.6% (79.43-79.77)	81.88% (81.73-82.04)	2.28 (2.27-2.30)	< 0.0001
Model 3: FFS versus FHO				
	FFS	**FHO**		
	72.51% (72.29-72.73)	78.75% (78.56-78.93)	6.24 (6.21-6.28)	< 0.0001

CI = confidence interval; FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization

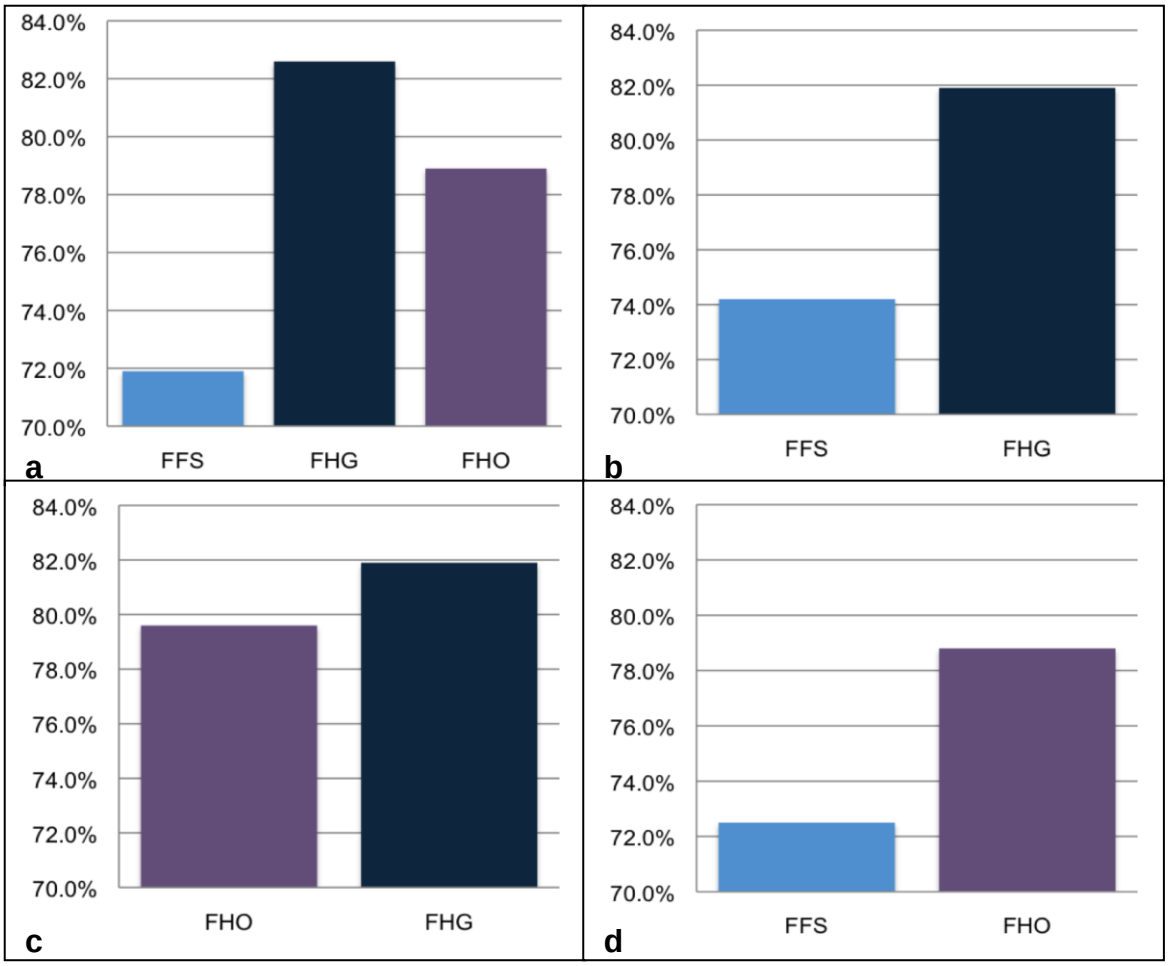

Figure 2.1: (a) Mean unadjusted physician practice rate by primary care delivery model; (b): predicted physician practice screening rates from regression model 1; (c): predicted physician practice screening rates from regression model 2; (d) predicted physicians practice screening rates from regression model 3

Estimates of mean screening rates in Figure 2.1 (b)-(d) were predicted using the method of recycled predictions [32].

Table 2.5: Cumulative preventive care bonuses for Pap smear delivery claimed by FHG and FHO physicians in 2010/2011

	FHG	FHO	Total
N	2,847	3,279	6,126
Physician Bonus Claims, N (%)			
No claim	1,257 (44.2%)	622 (19.0%)	1,879 (30.7%)
Bonus claimed	1,590 (55.8%)	2,657 (81.0%)	4,247 (69.3%)
Performance Level Claimed, N (%)			
$220 (60%)	128 (8.1%)	190 (7.2%)	318 (7.5%)
	$28,160	$41,800	$69,960
$440 (65%)	126 (7.9%)	179 (6.7%)	305 (7.2%)
	$55,440	$78,760	$134,200
$660 (70%	120 (7.5%)	216 (8.1%)	336 (7.9%)
	$79,200	$142,560	$221,760
$1,320 (75%)	202 (12.7%)	326 (12.3%)	528 (12.4%)
	$266,640	$430,320	$693,000
$2,200 (80%)	1,014 (63.8%)	1,746 (65.7%)	2,760 (65.0%)
	$2,230,800	$3,841,200	$6,072,000
Total Payments	$2,660,240	$4,534,640	$7,194,880

FHG = Family Health Group; FHO = Family Health Organization

Table 2.6: Average costs of delivering cervical cancer screening by primary care model including bonus payments where eligible

Costs of Cervical Cancer Screening				
	FFS	**FHG**	**FHO**	**Total**
1-year Paps, N	52,774	233,134	271,241	557,149
Pap Delivery Costs*	$965,764	$4,266,352	$4,963,710	$10,195.827
Bonus Payments	-	$2,660,240	$4,534,640	$7,194,880
Total 1-year Costs	$965,764	$6,926,592	$9,498,350	$17,390,708
Average cost per screening	$18.30	$29.71	$35.02	$31.21

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization; ICER = incremental cost-effectiveness ratio

* Annual costs of delivering Pap smears where a Pap smear is valued at $18.30.

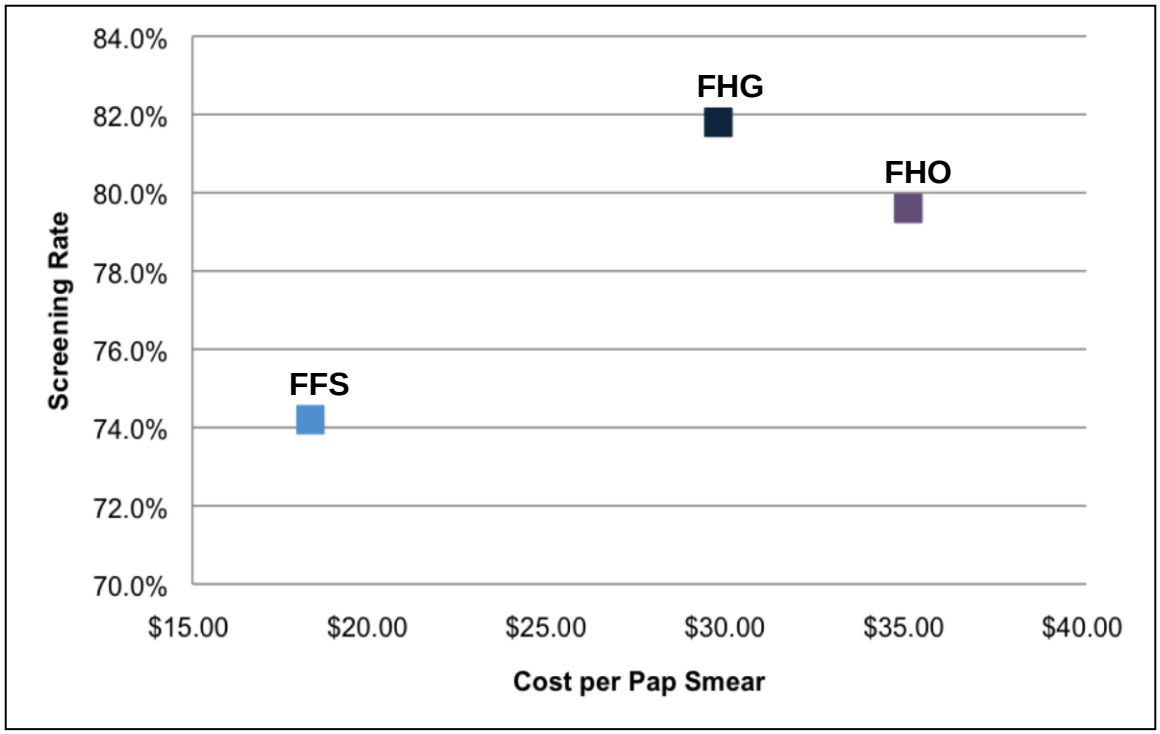

Figure 2.2: Predicted screening rates and cost per woman screened

Estimates of mean screening rates in Figure 2.2 were predicted using the method of recycled predictions [32].

2.8 Appendices

2.8.1 Appendix A2.1

The Family Health Group (FHG) is an enhanced fee-for-service (FFS) based model, where physicians may receive additional incentives and premiums. The Family Health Organization (FHO) is a capitation model, where physicians receive age- and sex-adjusted capitation payments and may also receive incentives for enrolled patients. Common features of both models include: a group practice model, formal patient enrolment or rostering, after-hours care requirements and performance-based financial incentives. Organizational and funding characteristics of selected primary care delivery models are summarized in Table 2.7. One of the key incentives offered exclusively to physicians practicing in reformed models is the Cumulative Preventive Care Bonus. This pay-for-performance (P4P) program rewards physicians with stepped payments for delivering target levels of service coverage among their enrolled patients for five preventive care services (Pap smears, mammograms, colorectal cancer screening, toddler immunizations and senior flu shots). With respect to Pap smears, physicians could receive up to $2,200 depending on the rate of service coverage among enrolled women aged 35-69 in the prior 30 months (Table 1). [6]

[6] In fiscal year 2013/2014 the Pap smear target population was expanded to enrolled women aged 21-69 years and the coverage period was extended to 36 months.

Table 2.7: Characteristics of selected primary care delivery models in Ontario

Model Characteristic	Fee-for-service (FFS)	Family Health Group (FHG)	Family Health Organization (FHO)
Year of introduction	1966	2003	2006
Physician remuneration	FFS	Enhanced FFS	Blended capitation
Targeted incentives	No	Yes	Yes
Group organization	Usually solo physician-led	Minimum 3 physicians; physician-led	Minimum 3 physicians; physician-led
Formal patient enrolment	N/A	Patients assigned to virtual roster based on visit history, but formal enrolment is encouraged	Active enrolment required
Core services	N/A	33 fee codes (e.g. office visits)	132 fee codes (e.g. office visits, Pap smears)
FFS payments	100% schedule of benefits (SOB) rate	100% SOB rate + 10% premium for core services delivered to enrolled patients	Shadow billings at 15% SOB rate for core services & 100% SOB rate for non-core services delivered to enrolled patients and all services to non-enrolled patients
Capitation payments	N/A	Comprehensive care management fee for enrolled patients	Age- and sex-adjusted base rate + access bonus & comprehensive care management fee for enrolled patients
Cumulative preventive care bonuses	N/A	Eligible if minimum roster size of 650 patients met	Eligible; no roster size requirements

2.8.2 Appendix A2.2

Table 2.8: Ontario Marginalization Index dimension census indicators

Material Deprivation	Dependency	Residential Instability	Ethnic Concentration
Indicators			
Proportion of population ≥ 15 years that are unemployed	Proportion of population ≥ 15 years that are unemployed*	Proportion of population living alone	Proportion of population that are recent immigrants (≤ 5 years)
Proportion of population ≥ 20 years without high-school diploma	Proportion of population ≥ 65 years	Average persons per dwelling*	Proportion of population identifying as visible minorities
Proportion of population receiving government transfer payments	Dependency ratio: population 0-14 and ≥ 65 years / population 15-64 years	Proportion of dwellings that are rented*	
Proportion of population considered low income		Proportion of dwellings that are apartment buildings	
Proportion of families that are single parent families		Proportion of population that moved within past 5 years	
Proportion of dwellings in need of major repair		Proportion of population that are single, divorced or widowed*	
		Proportion of population ≥ 16 years*	

* Census indicators that were reverse coded for the index (i.e. proportion of population < 16 years in census was used to find the proportion ≥ 16 years)

Adapted Matheson *et al.* 2012 [23]

2.8.3 Appendix A2.3

Table 2.9: Bivariate analyses of physician factors associated with patient-level screen status

Screen status	Screened	Not screened
N (%)	1,671,443 (80.2%)	412,344 (19.8%)
Program Model, %*		
FFS	73.1%	26.9%
FHG	83.9%	16.1%
FHO	78.8%	21.2%
Mean Age (95% CI)*	52.60 (52.59-52.62)	53.65 (53.62-53.68)
Gender, %*		
Female	86.4%	13.6%
Male	75.6%	24.4%
Medical Training, %*		
Trained in Canada	79.8%	20.2%
Foreign Training	81.7%	18.3%
Missing	44.8%	55.2%
Experience, Years Since Graduation		
Mean (95% CI)*	26.47 (26.45-26.48)	27.42 (27.38-27.45)
Experience Category, %*		
< 10 years	80.6%	19.4%
10-19 years	81.6%	18.4%
≥ 20 years	79.8%	20.2%
Number of Patients in Pap Smear Target Population		
Mean (95% CI)*	390.09 (389.74-390.44)	381.12 (380.56-381.68)
Number of Patients in Pap Smear Target Population Category, %*		
≤ 100 women	76.6%	23.4%
> 100 women	80.3%	19.7%

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization; PCP = primary care physician

* $p < 0.001$

Table 2.10: Bivariate analyses of patient factors associated with patient-level screen status

Screen status	Screened	Not screened
Mean Age (95% CI)*	49.60 (45.59-49.62)	51.38 (51.35-51.44)
Age Category, %*		
35-39	84.0%	16.0%
40-49	81.7%	18.3%
50-59	79.2%	20.8%
60-69	75.0%	25.0%
Rural, %*		
Rural	72.2%	27.8%
Urban	80.7%	19.3%
Ontario Marginalization Index Quintiles, %		
Material Deprivation*†		
Q1 (least marginalized)	84.1%	15.9%
Q2	81.6%	18.4%
Q3	79.1%	20.9%
Q4	76.9%	23.1%
Q5 (most marginalized)	74.7%	25.3%
Missing	74.1%	25.9%
Dependency*†		
Q1 (least marginalized)	82.3%	17.7%
Q2	81.5%	18.5%
Q3	79.7%	20.3%
Q4	78.4%	21.6%
Q5 (most marginalized)	77.7%	22.3%
Missing	74.1%	25.9%
Ethnic Concentration*†		
Q1 (least marginalized)	75.7%	24.3%
Q2	77.5%	22.5%
Q3	79.2%	20.8%
Q4	81.5%	18.5%
Q5 (most marginalized)	82.6%	17.4%
Missing	74.1%	25.9%
Residential Instability*†		
Q1 (least marginalized)	83.1%	16.9%
Q2	81.0%	19.0%
Q3	79.0%	21.0%
Q4	78.1%	21.9%
Q5 (most marginalized)	77.6%	22.4%
Missing	74.1%	25.9%

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization; PCP = primary care physician

* $p < 0.001$

† Q1 is the least marginalized & Q5 is the most marginalized

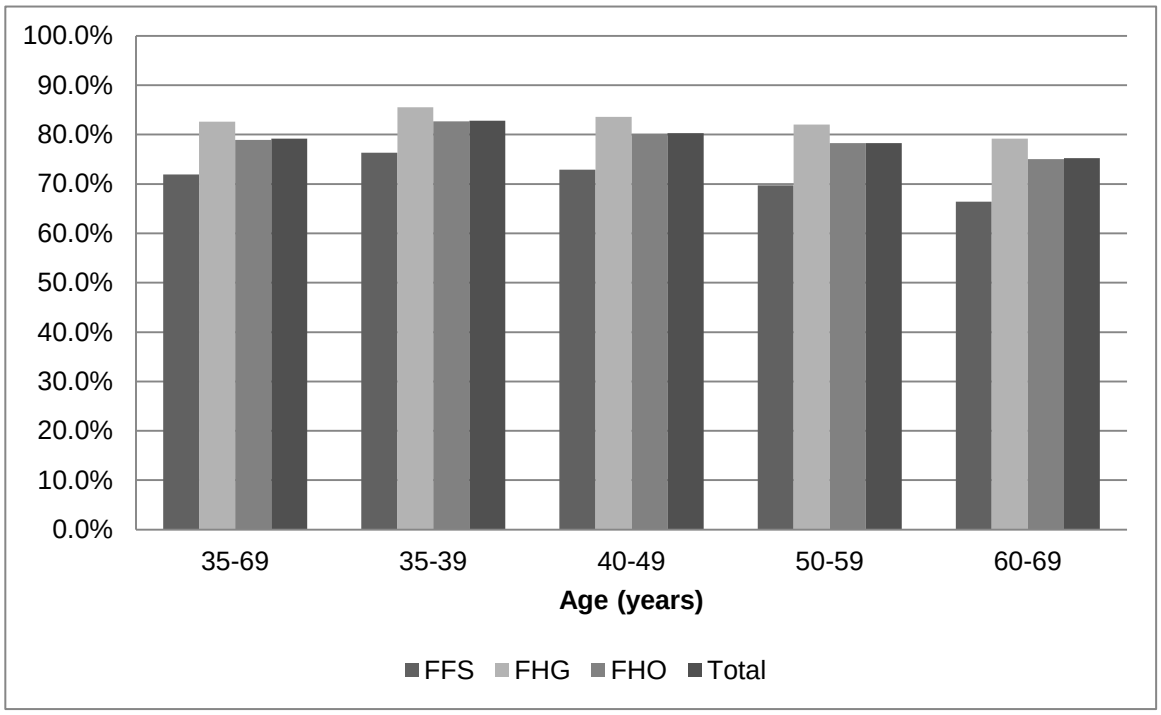

Figure 2.3: Mean unadjusted physician practice screening rate by age group and primary care model

2.8.4 Appendix A2.4

Table 2.11: Parameters from fractional logit models predicting screening rates

Regression Model	**1: FFS-FHG**	**2: FHO-FHG**	**3: FFS-FHO**
	β (SE)	β (SE)	β (SE)
Characteristic			
Intercept	0.046 (0.423)	1.698 (0.461)**	-0.229 (0.453)
Program Model†	0.463 (0.031)***	0.151 (0.023)***	0.349 (0.034)***
Mean Patient Age	0.009 (0.009)	-0.020 (0.009)^^	0.016 (0.009)^
% Rural	-0.021 (0.117)	-0.44 (0.092)	0.250 (0.066)**
% Deprivation Q1&2	0.651 (0.094)***	0.749 (0.097)***	0.798 (0.106)***
% Ethnic Con. Q1&2	-0.682 (0.102)***	-0.756 (0.075)***	-0.832 (0.073)***
% Instability Q1&2	0.113 (0.103)	0.142 (0.070)^^	-0.067 (0.010)
Female PCP	0.496 (0.029)***	0.543 (0.023)***	0.551 (0.025)***
< 10 Years Experience	-0.083 (0.032)^^	0.010 (0.026)	0.004 (0.028)
10-19 Years Experience	-0.109 (0.046)^^	0.043 (0.041)	-0.09 (0.037)^^
≤ 100 patients in Pap smear target population	0.221 (0.039)***	0.346 (0.052)***	0.093 (0.045)^

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization; SE = standard error; Q = quintile; PCP = primary care physician

† Program = FHG in Models 1&2 and program - FHO in Model 3

^ $p < 0.1$, ^^ $p < 0.05$, * $p < 0.01$, ** $p < 0.001$, *** $p < 0.0001$

2.8.5 Appendix A2.5

Table 2.12: Bivariate analyses of factors associated with claiming a Cumulative Preventive Care Bonus for Pap smear coverage

Characteristic	Bonus Claimed	No Bonus Claimed
N (%)	4,247 (69.3%)	1,879 (30.7%)
Program Model, %*		
FHG	55.8%	44.2%
FHO	81.0%	19.0%
Mean Age (95% CI)*	50.71 (50.41-51.01)	54.01 (53.48-54.54)
Gender, %*		
Female	79.7%	20.3%
Male	62.0%	38.0%
Medical Training, %*		
Trained in Canada	72.6%	27.4%
Foreign Trained	55.9%	44.1%
Experience, Years Since Graduation		
Mean (95% CI)*	24.47 (24.16-24.78)	27.73 (27.18-28.27)
Experience Category, %*		
< 10 years	71.6%	28.4%
10-19 years	74.0%	26.0%
≥ 20 years	67.5%	32.5%
Number of Patients in Pap Smear Target Population Category, %*		
≤ 100 women	22.4%	77.6%
> 100 women	74.0%	26.0%

FHG = Family Health Group; FHO = Family Health Organization; CI = confidence interval

* $p < 0.001$

Chapter 3

3 Costs of Cervical Cancer Treatment: Estimates from Ontario, Canada

3.1 Introduction

The leading cause of death in Canada is cancer, which accounts for nearly 30% of all deaths [1]. Cancer is one of the most costly diseases [2], so it is no wonder that the economic burden of cancer is substantial in Canada. The direct cost of cancer care in Canada in 2008 was estimated at $4 billion [3]. Cervical cancer is the second leading cause of cancer death among Ontario women aged 20 to 44 years [4], and the fourth most common cause of cancer death among women worldwide [5]. During their lifetime, one in 145 Ontario women will be diagnosed with cervical cancer, and each year in Ontario 610 women are diagnosed with cervical cancer and 150 will die from cervical cancer [1].

Treatment for cervical cancer is complex, which may include surgery, chemotherapy and radiation therapy. Among Ontario women diagnosed with cervical cancer in 2003/04, over 30% of patients received chemotherapy and an estimated 55% received radiation therapy [6]. More than half of Ontario cervical cancer patients had a cancer-related surgical procedure, and each case had an average 1.5 hospital admissions within 12 months of diagnosis [6]. Resource consumption is highest during the initial phase of treatment and the terminal phase before death [7]. Resource consumption in the first year after diagnosis is very high as this is the period when cervical cancer patients undergo primary treatment and experience the greatest mortality [8,9].

Estimates of the costs of cancer care are necessary inputs for economic evaluations, policy decisions and forecasting future medical care expenditures relating to cancer treatment. However there are few studies estimating the costs of cervical cancer treatment in Canada. To the best of my knowledge, no Canadian study has examined cervical cancer costs beyond the first year after diagnosis or accounted for variable lengths of follow-up. Moreover, previous publications on cost estimates using Ontario administrative data did not include costs associated with visits to cancer clinics or

dialysis clinics or mental health admissions as these data were not available before 2007. The objective of this study is to fill this gap by providing estimates of the total direct medical care costs of treating cervical cancer in the first three years post-diagnosis from the perspective of the Ontario Ministry of Health and Long-Term Care (MOHLTC). I accounted for censoring while estimating the cost of cervical cancer.

3.2 Methods

3.2.1 Patient Cohort

Ontario women aged 35 to 69 years with incident primary cases of cervical cancer (International Classification of Disease, ninth revision, ICD-9 180.x) diagnosed between January 1, 2007 and December 31, 2010 were identified from the Ontario Cancer Registry (OCR). The study index date for each patient was her date of diagnosis. Baseline characteristics included age at diagnosis, rural residence, number of Johns Hopkins Aggregated Diagnosis Groups (ADGs) and expected resource utilization band (RUB). Note that cost data are unavailable for cancer clinic visits, dialysis clinic visits and mental health hospital admissions before 2007. Since exclusion of these costs may underestimate the total medical care costs, I did not performe cost analyses for patients diagnosed prior to January 2007.

3.2.2 Data Sources

Data were obtained from the Institute for Clinical Evaluative Sciences (ICES), which holds population-based health administrative databases needed for this study. The OCR is a population-based registry containing all incident cases of cancer and cancer deaths in Ontario. Cervical cancer cases were identified from the OCR and were linked to other administrative health databases using unique, encoded identifiers and analysed at ICES. The Registered Persons Database (RPDB) contains demographic information on all individuals covered by the Ontario Health Insurance Plan (OHIP). The OHIP claims database contains all fee-for-service billing claims made by Ontario primary care physicians, specialists and other health care providers in private practice, hospital or other health facilities. The Client Agency Program Enrolment (CAPE) tables contain patient rosters of primary care physicians who receive age- and sex-adjusted capitation payments

for each enrolled patient. Shadow billings claimed by primary care physicians and other providers in alternative payment plans are captured by the OHIP claims database. The Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD) contains administrative and clinical data on all inpatient hospitalizations. The National Ambulatory Care Reporting System (NACRS) holds records of all ambulatory visits to Ontario hospitals. NACRS captures data on emergency department (ED) visits, same day surgery (SDS) procedures and visits to ambulatory clinics, such as regional cancer centres and dialysis clinics. The National Rehabilitation Reporting System (NRS) database holds data on all admissions to rehabilitation beds in hospital. The Continuing Care Reporting System (CCRS) provides information on individuals receiving long-term care in complex continuing care beds. The Ontario Mental Health Reporting System (OMHRS) captures administrative and clinical data on all adult mental health admissions. The Home Care Database (HCD) contains demographic and service information for individuals receiving in-home services. The Ontario Drug Benefit (ODB) Program provides prescription drug coverage to individuals aged 65 and older, residents of long-term care facilities and other groups. ODB database contains prescription drug costs for those aged 65 and older. The Office of the Registrar General collects vital statistics on Ontario residents including date and cause of death.

3.2.3 Cost Estimates

Estimates of total direct medical care costs were computed using the %getcost SAS macro developed for ICES data holdings [11]. The macro uses entries in a number of administrative databases to calculate total medical care costs for a defined time period. Costs captured include those from cancer clinic visits, hospital-based care, tertiary care, physician services, outpatient prescription drugs (ODB recipients) and other sources of care (Table 3.1). Cancer clinic costs captures all costs associated with chemotherapy, radiation therapy and other cancer-related services.

The ICES cost macro use both top-down and bottom-up costing methodology depending on the type of cost [11]. When unit prices are unavailable, the top-down method is used to assign costs using the average cost of a given metric (e.g. per diem cost or relative value weights). The following costs were calculated using the top-down approach:

inpatient hospitalizations, same-day-surgery procedures, ED visits, dialysis clinic visits, cancer clinic visits, rehabilitation admissions, mental health admissions, complex continuing care and long-term care. The unit cost for inpatient hospitalizations, SDSs, ED visits, rehabilitation and ambulatory clinic visits is the Cost Per Weighted Case (CPWC) [12]. All patients are assigned a Resource Intensity Weight (RIW) based on Case Mix Group, which estimates expected resource utilization relative to the average patient (RIW = 1). Total spending is divided by the sum of all RIWs to obtain CPWC. The cost of a specific case is the product of assigned RIW and CPWC (Box 3.1). Longer episodes of care, such as mental health or complex continuing care admissions, have a unit cost of Cost Per Weighted Day (CPWD). For each patient stay, Case Mix is periodically assessed to assign a relative weight for each day of care, which estimates an overall weighted length of stay (LOS). Case cost is the product of CPWD and weighted LOS. Bottom-up costing methods assign unit costs associated with a particular procedure, service or drug. The following costs were calculated using the bottom-up approach: home care services, outpatient physician visits and procedures, prescription drugs, outpatient laboratory tests and other outpatient services covered by OHIP. Records of healthcare utilization in the HCD, ODB and OHIP databases are multiplied by the associated unit cost set by the Ontario Ministry of Health and Long-Term Care to estimate overall resource consumption. Capitation payments for patients in the CAPE tables are calculated by age and sex.

Costs were computed from the date of diagnosis until December 31st of that year or death if earlier. Subsequently annual costs were computed until the earliest of the following events: 1) death or 2) December 31st, 2010. Costs for each year were adjusted for inflation to 2010 Canadian dollars using the Statistics Canada's Consumer Price Index for healthcare.

3.2.4 Analysis

Descriptive results are reported for baseline characteristics of the study cohort. Mean costs and mean cumulative costs were calculated each year following diagnosis for this cohort. Costs were broken down by resource category to identify the largest drivers of cost in each year of treatment. Complete cost data are available for cases where death is

observed. However, differential follow-up due to varying index dates means that some cases are censored (i.e. those who do not die during the study period and have incomplete cost data). Thus, I estimated costs using three methods: a) naïve estimator, b) simple weighted estimator proposed by Bang and Tsiatis (B&T) in 2000 and c) an improved estimator adapted by Pfeifer and Bang (2005) from B&T's estimators.

Equation 3.1: The naïve estimator for estimating costs of a cohort of patients

$$\hat{m} = \frac{1}{n}\sum_{i=1}^{n} M_i. \qquad (1)$$

In equation (1), $\hat{m}$ is the estimated arithmetic mean costs, M_i is cost accumulated by patient *i* during a given time period. The estimates based on equation (1) will bias the mean downward as costs accrued after observed follow-up are equated to zero [13,14]. Estimates from only complete observations will be biased upward to patients with shorter survival time [14]. Applying standard survival analysis techniques to costing analyses is also invalid as censoring and cost are not independent [12,15,16]. Patients that slowly accumulate costs are more likely to be censored than high cost users; therefore the mean is biased upward [15,16]. Given that censoring increases with follow-up, appropriate statistical methods that address censoring are required to reduce bias in estimates of costs.

Simple Weighted Estimator: One way to improve the naïve estimator is to estimate mean time-restricted cost in the presence of censoring using inverse probability weighting. Complete cases are those that die or are observed until the end of the study interval. Costs are weighted by the Kaplan-Meier estimate of the inverse probability of not being censored at the end of the interval. In 2000, B&T proposed a simple weighted estimator, which averages the weighted overall costs of complete cases for the entire study period.

Equation 3.2: The simple weighted estimator for estimating costs of a cohort of patients

$$\hat{m}_{WT} = \frac{1}{n}\sum_{i=1}^{n}\frac{\Delta_i M_i}{\hat{K}(T_i)}. \quad (2)$$

In equation (2), $\hat{m}_{WT}$ is estimated mean costs based on the simple weighted estimator, Ti indicates a failure time and C_i indicates a censored time. Observed follow-up time, $X_i = min(T_i, C_i)$, $\Delta_i = I(T_i \leq C)$. $I(.)$ is the indicator function where $I=1$ indicates a failure and $I=0$ indicates a censored observation. T is bounded by the maximum follow-up time L, where $T_i \leq L$ and $Pr(C_i \geq L)>0$. $K(T_i)$ is the Kaplan-Meier estimate of the probability of not being censored at failure time T_i or censoring time Ci. Estimates based on equation (2) allows for continuous death and censoring times, and provides a consistent estimate of mean cumulative medical care cost [13,17,18]. However, this estimator is inefficient as it relies on costs from patients with complete data and may be unstable with heavy censoring [13,17].

Improved Weighted Estimator: The improved partitioned B&T estimator attempts to improve upon the simple weighted estimator by using data from censored cases if detailed cost history is available [17]. The study period is partitioned into smaller intervals where complete cases die during or are observed until the end of a given interval [17]. The simple weighted method is used to estimate accumulated cost in each interval and the weighted costs across all intervals are summed [17]. The partitioned estimator is usually, but not necessarily, more efficient than the simple weighted estimator [17].

Zhao and Tian adapted the improved B&T method to propose an estimator that is more efficient and convenient, but does not require detailed cost history or partition the study period [13,19]. This analysis used the improved estimator proposed by Pfeifer and Bang, which is a simpler, user-friendly formula adapted from Zhao and Tian [20].

Equation 3.3: The improved weighted estimator for estimating costs of a cohort of patients

$$\hat{\eta}_{IMP} = \frac{1}{n}\sum_{i=1}^{n}\frac{\delta_i M_i}{\hat{K}(T_i)} + \frac{1}{n}\sum_{i=1}^{n}\frac{(1-\delta_i)\{M_i - \overline{M(C_i)}\}}{\hat{K}(C_i)} \quad ; \quad \overline{M(C_i)} = \frac{\sum_{j=1}^{n} I(X_j \geq C_i) M_j(C_j)}{\sum_{j=1}^{n} I(X_j \geq C_i)}. \tag{3}$$

In equation (3), $\hat{\eta}_{IMP}$ is the estimated mean costs based on the improved estimator, *M(Ci)* is the mean cost of all individuals still under observation at censoring time C_i, X_j indicates that individual *j* is still under observation beyond individual *i*'s censoring time, and $M_j(C_j)$ is the cost accumulated by individual j at time Ci.

The improved estimator has two parts: 1) mean cost of complete cases estimated by the simple weighted B&T method; 2) an efficiency term that estimates the costs of censored cases [18]. Censored costs are adjusted by subtracting the mean cost of all other cases still under observation at that censoring time. Adjusted censored costs are then weighted by the Kaplan-Meier inverse probability of not being censored at that time. The efficiency term is the average of weighted censored costs.

Overall and specific costs during the first year after diagnosis were estimated without taking censoring into account for the cohort and by one-year vital status. Cumulative overall and cancer clinic costs were estimated using naïve, simple weighted and improved weighted estimators for years one through three following cervical cancer diagnosis. Annual overall and cancer clinic costs were also estimated using naïve, simple weighted and improved weighted estimators for the first three years post-diagnosis. All analyses were conducted using SAS and Zhao and Wang's SAS code was used for censored cost estimators [14].

3.3 Results

The study cohort included 784 cases of cervical cancer diagnosed between 2007 and 2010. Mean age at diagnosis was 49 years, and baseline characteristics are summarized in Table 3.2. About 32% (254) of patients died within three years of diagnosis and 71%

(181) of deaths were caused by cervical cancer. Vital status and cause of death information were available to a later date than cost data were for the whole cohort. Therefore there are some patients who died within a year of their diagnoses, but their cost data are censored before their death. In the first year after diagnosis about 27% of the cohort had censored cost data. Administrative censoring increased steadily and by the end of year three almost 65% of patients had censored cost data (Table 3.3). Throughout the study period, there were 78 cases that died within three years of diagnosis whose cost data were not observed at their time of death.

Table 3.4 reports the mean costs for the study cohort and by one-year vital status without taking censoring into account. Overall mean costs during the first year post-diagnosis were $35,700 (standard error [SE]: $1,239). Mean costs were much higher among those who died within one year from diagnosis ($63,016; SE: $4,246) compared to those surviving longer than one year ($31,195; SE: $1,177). The highest cost category was cancer clinic costs (41%) for those who survived one year or longer (Table 3.4; Figure 3.1) and inpatient hospitalization (54%) for patients who died within a year (Table 3.4; Figure 3.2). Mean overall and cancer clinic costs by one-year vital status estimated using the simple weighted and improved methods are summarized in Appendix 3.1 Table 3.6.

Mean cumulative costs estimated using naïve, simple weighted and improved methods are reported in Table 3.5 and Figure 3.3. Annual costs were highest during year one ($40,231; SE: $1,356) and decreased during subsequent two years ($14,459; SE: $1,787) and three ($9,383; SE: $1,678). Estimates of mean cost that did not account for censoring were consistently lower than the B&T estimators. Mean cumulative one- and three-year costs were $35,700 (SE: $1,239) and $45,317 ($1,942), respectively, when using naïve methods. Using the improved estimator, cumulative one- and three-year costs were $40,231 ($1,356) and $59,314 ($2,898), respectively. Estimates using simple weighted and improved methods were similar, but the variance of the improved estimator was smaller and thus more efficient. Cancer clinic costs were $14,124 (SE: $370) in year one and $16,434 (SE: $545) during years one through three (Appendix 3.1 Table 3.7). Specific costs estimated using simple weighted methods are presented in Appendix 3.1 Table 3.7.

3.4 Discussion

This study estimated direct medical care costs of cervical cancer patients in Ontario during the first three years following diagnosis of cervical cancer. Cumulative three-year cancer clinic and overall costs were $16,434 and $59,314 per case, respectively. Cost accumulation was greatest during the first year after diagnosis. This seems reasonable since treatment is most aggressive during this period [7,8,10]. Annual total medical care costs decreased from $40,231 per case in the first year post-diagnosis to $14,459 during year two and $9,383 during year three. Patients who died within one year from diagnosis had much higher one-year costs ($66,250) than patients who survived at least one year ($35,759).

I found that cancer clinic and hospital admissions were the two largest drivers of costs in the first year after diagnosis. These cost categories capture costs associated with cancer-related treatments such as chemotherapy, radiation therapy and cancer-related surgeries. A previous study of cancer costs in Ontario also found that inpatient hospitalizations and cancer-related care were the two greatest sources of cost [10]. My estimate of inpatient admissions ($6,914) was similar to those of de Oliveira et al ($6,761). However, my estimate of cancer-related care ($12,941) was much higher than their estimates of chemotherapy ($804) and radiation therapy ($3,468) combined. This difference is likely due to my estimates including all cancer clinic visits, which are not limited to chemotherapy and radiation therapy, and include additional services such as palliative care, surgical oncology and supportive services. Furthermore, de Oliveira et al may have underestimated the costs of radiation therapy as the cost per fraction of radiation was estimated using data from the 1990s.

To the best of my knowledge, this is the first Canadian study of medical care costs associated with cervical cancer patients that takes censoring into account. A previous Ontario study reported mean one-year costs of $18,055 (2009 Canadian dollars) for cervical cancer patients who survived one year and $41,536 for cases who died within one year [10]. My naïve estimates are much higher, which is due to different estimation methods of cancer-related costs and inclusion of costs associated with rehabilitation, mental health admissions, dialysis clinic visits, and all OHIP billings. As far as I know,

there are no Canadian studies of cervical costs beyond year one to compare with my results. Resource consumption was highest during year one, accounting for 67% of cumulative three-year costs. This result is similar to Insinga et al's finding that 69% of three-year costs were incurred during year one [9]. Similar to other studies of cervical and other cancer patients, I found that patients who died had much higher mean costs than those surviving [8,10]. End-of-life care is a significant source of cancer costs; the cost of care for Ontario genitourinary/gynaecologic cancer patients during the six months before death was estimated at $23,770 [21].

My study has several strengths. First, I reported overall and specific medical care costs of cervical cancer treatment for the first year and beyond the first year after diagnosis. My cost estimates may be useful for economic evaluations of interventions to prevent cervical cancer and calculation of life-time cervical cancer related costs. Second, I accounted for censoring to reduce bias in my cost estimates. My naïve cost estimates were much lower than those estimated using the simple weighted and improved methods. Thus, previous cost estimates of cervical cancer care reporting naïve estimates are likely underestimated, so my estimates are more likely to represent the true cost of treatment. Third, I included all medical care costs covered by the Ontario Ministry of Health and Long-Term Care. Estimates of overall resource utilization may be of use for decision-makers to identify and implement preventive intervention strategies. Finally, my cost estimates are more reliable for conducting cost-effectiveness analyses.

This study has several limitations. First, costs are highly skewed and estimates of mean cost are influenced by high-users. Second, cancer staging data were not available for the study cohort. Cancer stage is associated with survival, which affects resource utilization. Third, I assessed overall medical care costs of cervical cancer patients instead of net costs of cervical cancer patients. Fourth, the ODB provides prescription drug coverage for women aged 65 years and older, so I was unable to capture the costs of drugs associated with treatment for younger patients. However chemotherapy, the largest pharmacotherapy cost, is administered in hospital and captured by my estimates of cancer clinic costs. A limitation of using administrative databases and the ICES cost macro is that I was unable to separate healthcare utilization unrelated to a patient's cancer

diagnosis. However I expect costs unrelated to cancer is likely to be small for this patient population. Finally, data limitations precluded me from estimating the costs of treatment beyond three years following diagnosis.

3.5 Conclusions

This study analyzed the overall and specific medical care costs of treating cervical cancer in the first three years following diagnosis of cervical cancer in Ontario. By taking censoring into account, my estimates are more likely to reflect the true cost of cervical cancer treatment in Ontario. Overall medical care costs were approximately $40,000 in year one, $14,000 in year two and $9,000 in year three. Costs associated with cancer clinic visits and inpatient admissions were the two largest sources of cervical cancer treatment costs. However, physician services and home care were also significant drivers of costs. My estimates may be of use for future economic evaluations of human papillomavirus vaccines, screening strategies or interventions to improve screening. Decision-makers may also find my estimates useful for policy planning or projecting future costs.

3.6 References

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3.7 Tables and Figures

Table 3.1: Source database and costing methodology used to estimate costs

Resource	Source Database	Costing Methodology
Cancer clinic visits	FY2006-: NACRS	CPWC; top-down
Hospital-based care		
Inpatient hospitalizations	CIHI-DAD	Top-down: CPWC
Same day surgery procedures	NACRS	Top-down: CPWC
Emergency department visits	NACRS	Top-down: CPWC
Dialysis clinic visits	FY2006-: NACRS	Top-down: CPWC
Tertiary care		
Rehabilitation admissions	NRS	Top-down: CPWC
Mental health admissions	FY2006-: OMHRS	Top-down: CPWD
Complex continuing care	CCRS	Top-down: CPWD
Long-term care	FY2005-FY2008: OHIP & ODB FY2009-: CCRS	Top-down: CPWD
Home care services	HCD	Bottom-up: billing based
Physician services		
FFS physician billings	OHIP	Bottom-up: billing based
Physician shadow billings	OHIP	Bottom-up: billing based
Primary care capitation payments	CAPE	Age- & sex-adjusted payment
Prescription drugs	ODB	Bottom-up: billing based
Other		
Non-physician OHIP billings	OHIP	Bottom-up: billing based
Laboratory billings	OHIP	Bottom-up: billing based

NACRS = National Ambulatory Care Reporting System; CIHI-DAD = Canadian Institute for Health Information Discharge Abstract Database; NRS = National Rehabilitation Reporting System; OMHRS = Ontario Mental Health Reporting System; CCRS = Continuing Care Reporting System; HCD = Home Care Database; OHIP = Ontario Health Insurance Plan; ODB = Ontario Drug Benefit; CAPE = Client Agency Program Enrolment; CPWC = Cost Per Weighted Case; CPWD = Cost Per Weighted Day

Table 3.2: Baseline demographic characteristics of cervical cancer patients

Characteristic	
N	784
Diagnosis (ICD-9), N (%)	
Endocervix (1800)	139 (17.7%)
Exocervix (1801)	21 (2.7%)
Other specified sites (1808)	23 (2.9%)
Site unspecified (1809)	601 (76.7%)
Age at diagnosis, years	
Mean (95% CI)	49.3 (48.7-50.0)
Median (IQR)	48 (42-56)
Age category, N (%)	
35-39	120 (15.3%)
40-49	317 (40.4%)
50-59	223 (28.4%)
60-69	124 (15.8%)
Rural resident, N (%)	
No	729 (93.7%)
Yes	49 (6.3%)
Missing	6
Number of ADGs, N (%)	
0	26 (3.3%)
1-3	265 (33.8%)
4-6	389 (49.6%)
7-10	75 (9.6%)
≥ 11	29 (3.7%)

ICD-9 = International Classification of Disease, 9th edition; CI = confidence interval; IQR = interquartile range; ADGs = Aggregated Diagnostic Groups

Top-down methods

(1) $Case\ Cost_i^j = RIW_i(y)\ \times\ CPWC^j(y)$

(2) $Case\ Cost_i^j = \sum_{t=1}^{T} CMI_{it}^j\ \times\ LOS_{it}^j\ \times\ CPWD_y^j$

Bottom-up methods

(3) $Procedure/Visit\ Cost = OHIP\ fee$

(4) $Drug\ Cost =\ Unit\ Cost\ \times\ Times\ Dispensed$

Box 3.1: Estimating medical costs using top-down and bottom-up costing methods
Where $Case\ Cost_i^j$ is the cost of patient *i* hospital *j*. $RIW_i(y)$ is the resource intensity weight of patient *i* during episode of care *y*, and $CPWC^j_y$ is cost per weighted case for episode of care *y* at hospital *j*. CMI_{it}^j is case mix index of patient *i* at on day *t* at hospital *j* and *T* is the total number of days of stay. LOS_{it}^j is the weighted length of stay of patient *i* on day *t* at hospital *j* and $CPWD_i(y)$ is the cost per weighted day for episode of care *y* at hospital *j*. Bottom-up methods multiply the unit cost of a given procedure, visit, service or drug by the times used by a given patient.

Table 3.3: Distribution of complete and censored observations during the first three years after cervical cancer diagnosis

Interval	Vital status	N*	Complete observations**	Censored observations°	Proportion censored‡
Year 1	Total	784*	570	214	27.3%
	Deaths	111	99	12	
	Alive	673	471	202	
Years 1-2	Total	784*	416	368	46.9%
	Deaths	210	160	50	
	Alive	574	256	318	
Years 1-3	Total	784*	280	504	64.3%
	Deaths	254	176	78	
	Alive	530	104	426	
Year 2	Total	471*	317	154	32.6%
	Deaths	99	61	38	
	Alive	372	256	116	
Years 2-3	Total	471*	181	290	61.6%
	Deaths	143	77	66	
	Alive	328	104	224	
Year 3	Total	256*	120	136	53.1%
	Deaths	44	16	28	
	Alive	212	104	108	

* number of individuals under observation at start of interval; ** number of individuals with complete cost data during interval (cases with observed cost data until death or interval end); ° number of individuals censored during interval (cases that died during interval but with cost data censored before death and living censored cases); ‡ proportion censored during interval

Table 3.4: Average total medical care costs and specific medical care costs associated with cervical cancer cases in the first year after diagnosis

Sample	Survived longer than one year	Died within one year	Overall
N	673	111	784
Resource			
Total cost	$31,195 ($1,177)	$63,016 ($4,246)	$35,700 ($1,239)
Cancer clinic	$12,941 ($401)	$10,623 ($1,003)	$12,613 ($373)
Hospital-based care			
Inpatient hospitalization	$6,914 ($560)	$31,088 ($3,048)	$10,337 ($712)
Same day surgery	$894 ($41)	$459 ($81)	$832 ($38)
ED visits	$637 ($43)	$1,651 ($143)	$781 ($44)
Dialysis clinic	$74 ($62)	$746 ($740)	$169 ($117)
Tertiary care			
Rehabilitation admissions	$204 ($118)	$0 ($0)	$175 ($101)
Mental health admissions	$156 ($136)	$0 ($0)	$134 ($117)
Complex continuing care	$604 ($459)	$4,002 ($1,498)	$1,045 ($449)
Long-term care	$13 ($13)	$255 ($256)	$47 ($38)
Home care	$1,432 ($176)	$4,128 ($566)	$1,814 ($174)
Physician services	$6,062 ($168)	$8,113 ($458)	$6,352 ($160)
Prescription drugs	$1,034 ($171)	$1,777 ($273)	$1,139 ($152)
Other*	$230 ($10)	$173 ($20)	$222 ($9)

* Other costs include laboratory costs and non-physicians services covered by OHIP.

Figures in parentheses are standard errors

Figure 3.1: Resource utilization of cervical cancer patients in the first year after diagnosis among those surviving one year or longer

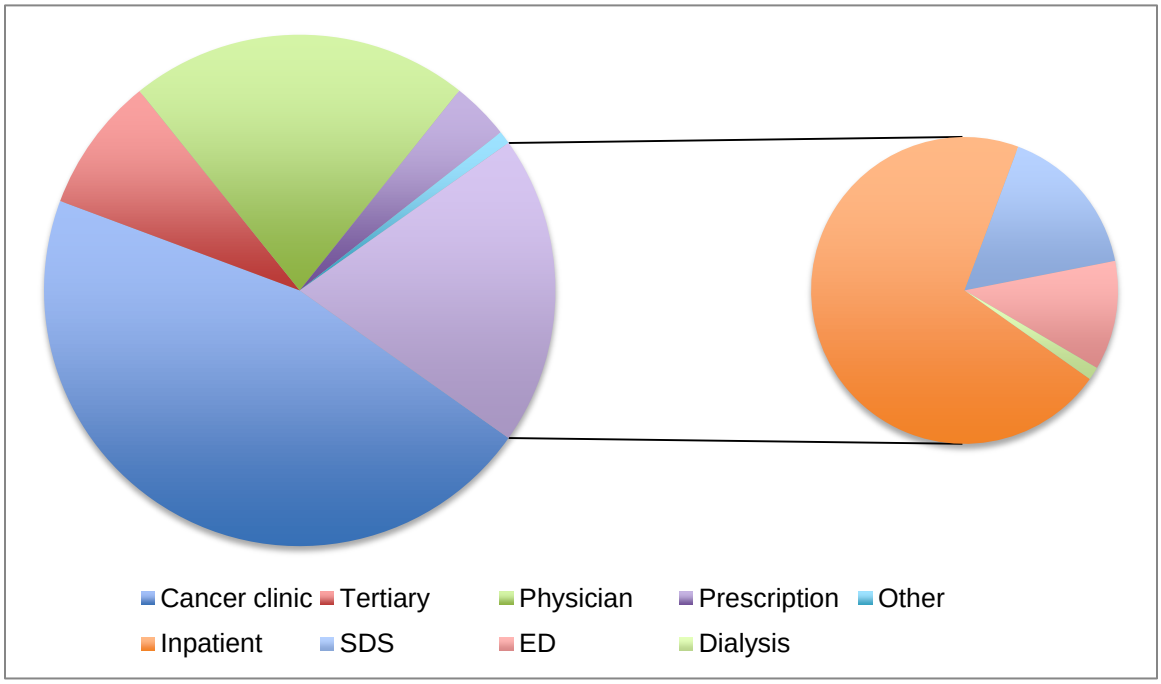


Figure 3.2: Resource utilization of cervical cancer patients in the first year after diagnosis among those that died within one year

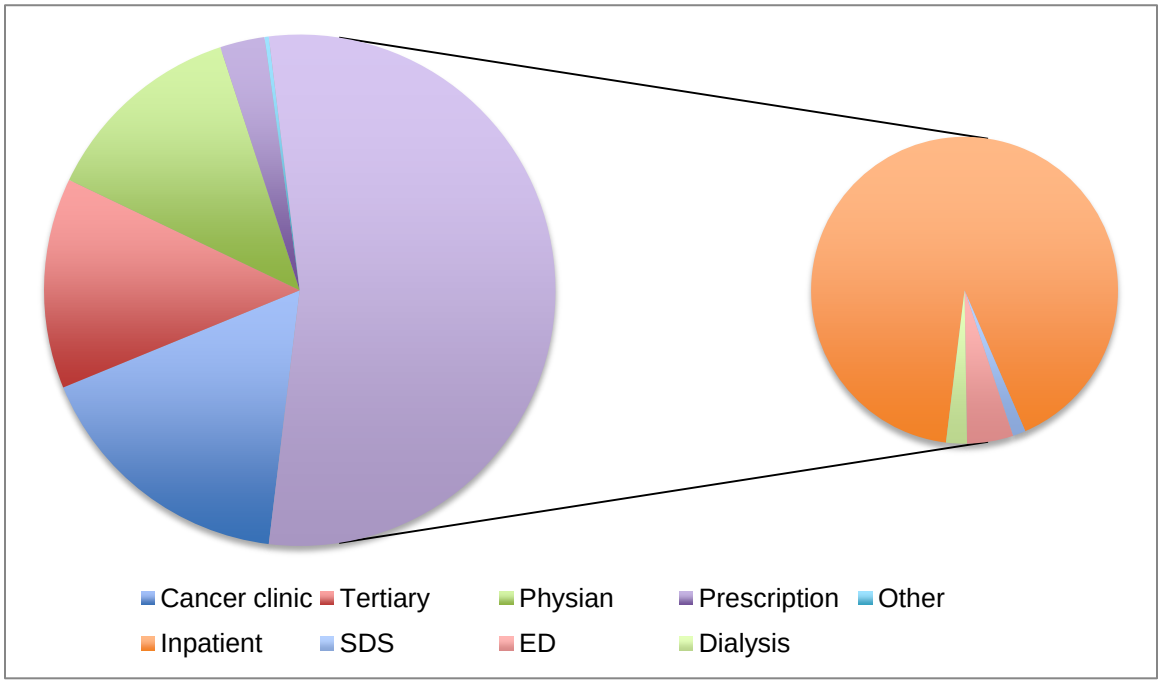


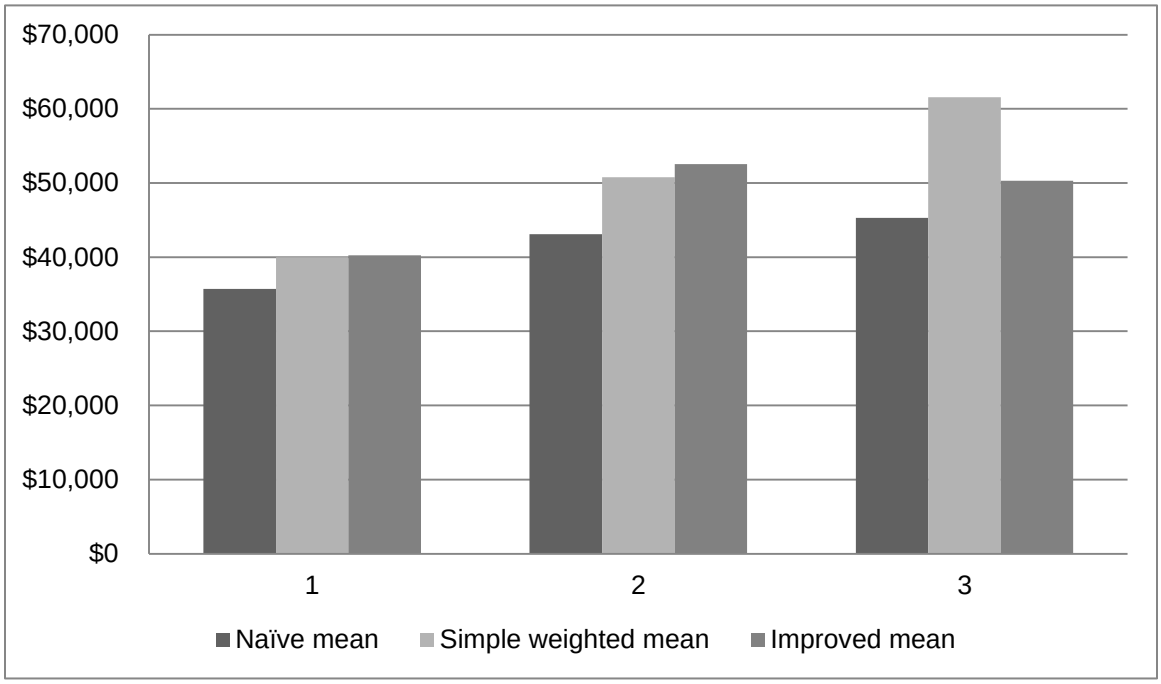
Table 3.5: Mean annual and cumulative medical care costs associated with cervical cancer cases during years one through three after diagnosis

Interval	N*	Proportion censored**	μ (SE)	μ_{WT} (SE)	μ_{IMP} (SE)	Mean F/U Time (SE)‡
Year 1	784	27.3%	$35,700 ($1,239)	$39,995 ($1,513)	$40,231 ($1,356)	338 (3)
Years 1-2	784	46.6%	$43,086 ($1,785)	$50,792 ($2,731)	$52,544 ($2,276)	622 (8)
Years 1-3	784	64.3%	$45,317 ($1,942)	$61,586 ($5,199)	$59,314 ($2,898)	873 (15)
Year 2	471	32.1%	$12,293 ($1,581)	$14,184 ($2,043)	$14,459 ($1,787)	334 (4)
Years 2-3	471	61.6%	$16,007 ($1,992)	$25,336 ($4,258)	$22,409 ($2,749)	628 (11)
Year 3	256	53.1%	$6,833 ($1,134)	$10,258 ($2,138)	$9,383 ($1,678)	347 (4)

* sample size at start of interval; ** proportion of sample censored during interval; ‡ follow-up time in days

μ = naïve mean not accounting for censoring; SE = standard error; μ_{WT} = mean estimated using simple weighted method; μ_{IMP} = mean estimated using improved method; F/U = follow-up

Figure 3.3: Cumulative overall medical care costs of cervical cancer patients in the first three years after diagnosis



3.8 Appendices

3.8.1 Appendix A3.1 Supplementary Tables

Table 3.6: Mean overall and cancer-specific costs of cervical patients during the first year after diagnosis by one-year vital status

Vital status	N	Proportion censored	μ (SE)	μ_{WT} (SE)	μ_{imp} (SE)
Alive					
Overall	673	30.0%	$31,195 ($1,177)	$35,543 ($1,538)	$35,759 ($1,351)
Cancer clinic	673	30.0%	$12,941 ($401)	$14,184 ($447)	$14,628 ($394)
Died					
Overall	111	10.8%	$63,016 ($4,246)	$65,585 ($4,159)	$66,250 ($4,084)
Cancer clinic	111	10.8%	$10,623 ($1,003)	$11,140 ($1,049)	$11,194 ($1,015)

μ = naïve mean not accounting for censoring; SE = standard error; μ_{WT} = simple weighted mean; μ_{imp} = improved mean improved.

Table 3.7: Comparison of mean cancer clinic costs across different estimation methods

Interval	N*	Proportion censored**	μ (SE)	μ_{WT} (SE)	μ_{IMP} (SE)
Year 1	784	27.3%	$12,613 ($373)	$13,747 ($414)	$14,124 ($370)
Years 1-2	784	46.6%	$13,526 ($410)	$14,946 ($562)	$15,168 ($446)
Years 1-3	784	64.3%	$13,803 ($430)	$15,755 ($894)	$16,434 ($545)
Year 2	471	32.1%	$1,520 ($172)	$1,792 ($247)	$1,755 ($215)
Years 2-3	471	61.6%	$1,980 ($252)	$2,639 ($614)	$2,713 ($384)
Year 3	256	53.1%	$848 ($220)	$914 ($894)	$1,131 ($545)

* sample size at start of interval; ** proportion of sample censored during interval

μ_{WT} = naïve mean not accounting for censoring; SE = standard error; μ_{WT} = mean estimated using simple weighted method; μ_{IMP} = mean estimated using improved method

Table 3.8: Source specific cumulative costs estimated using the simple weighted estimator

Resource	Year 1 (cumulative)	Year 2 (cumulative)	Year 3 (cumulative)
Overall	$39,995 ($1,1513)	$50,792 ($2,731)	$61,586 ($5,199)
Cancer clinic	$13,747 ($414)	$14,946 ($562)	$15,755 ($894)
Hospital-based care			
Inpatient hospitalization	$11,773 ($861)	$16,113 ($1,312)	$19,919 ($2,171)
Same day surgery	$851 ($45)	$936 ($113)	$1,101 ($113)
ED visits	$880 ($56)	$1,190 ($80)	$1,411 ($143)
Dialysis clinic	$90 ($75)	$421 ($393)	$1,531 ($1,502)
Tertiary care			
Rehabilitation admissions	$248 ($144)	$557 ($278)	$857 ($443)
Mental health admissions	$190 ($165)	$60 ($35)	$83 ($50)
Complex continuing care	$1,382 ($611)	$1,209 ($327)	$1,702 ($499)
Long-term care	$16 ($16)	$25 ($25)	$56 ($0)
Home care	$2,203 ($233)	$3,267 ($360)	$4,494 ($687)
Physician services	$6,985 ($197)	$9,595 ($938)	$11,219 ($1,291)
Prescription drugs	$1,395 ($211)	$2,129 ($293)	$3,026 ($587)
Other*	$235 ($11)	$235 ($23)	$422 ($34)

Chapter 4

4 An Economic Analysis of Financial Incentives for Cervical Cancer Screening in Ontario's Primary Care Delivery Models

4.1 Introduction

Cervical cancer screening with the Papanicolaou (Pap) smear test can prevent cervical cancer by detecting and treating cervical dysplasia before it becomes malignant [1-3]. Screening may also detect earlier stage cancers, requiring less invasive treatment and better survival than symptomatic cancers [1]. The impacts of screening on cervical cancer incidence and mortality have been consistently demonstrated in epidemiological studies [4-7] and screening is considered cost-effective [8].

Despite the benefits of screening and universal access to cancer screening, many Canadian women are not screened at the recommended interval, and Canadian screening rates are consistently lower than rates in the US [9,10]. Ontario guidelines recommend that women who are or ever have been sexually active between the ages of 21 and 69 are screened with a Pap smear once every three years [2,3]. Screening participation in Ontario, Canada's largest province, has improved slightly over the past decade, but is still well below the provincial target of 85% [11]. Between 2009 and 2011 only 65% of women aged 21 to 69 years were screened [11]. Given the risks of screening non-compliance, there is a clear need to increase screening participation rates.

In an attempt to improve the delivery of preventive health care services, such as Pap testing, Ontario underwent a series of primary care reforms in the early 2000s. The Ontario government introduced reformed primary care models with alternative physician remuneration to traditional fee-for-service (FFS) payments and pay-for-performance (P4P) incentives to improve delivery of preventive healthcare services. The two dominant models are the Family Health Group (FHG) and Family Health Organization (FHO), which have enhanced FFS and blended capitation reimbursement schemes, respectively. The FHG and FHO offer patient enrolment, enhanced access and special premiums and

incentives, such as the Cumulative Preventive Care Bonus, which are unavailable in the traditional FFS model. The Cumulative Preventive Care Bonus is a P4P program where physicians are awarded stepped payments for achieving targeted participation levels. With respect to Pap testing, physicians may receive between $220 and $2,200 in bonuses for achieving the lowest and highest participation levels, respectively (Appendix 4.1).

Alternative funding plans and performance incentives are becoming increasingly popular both in the Canada and worldwide; however there is no conclusion on the effectiveness of incentives or on the optimal incentive to deliver high quality care [12-15]. There is limited evidence on the effectiveness of financial incentives for improving cancer screening rates, and to the best of my knowledge, there has been no cost-effectiveness analysis of financial incentives for improving cervical cancer screening rates.

In this study, I used estimated cancer screening rates from three primary care delivery models in Ontario to determine the cost-effectiveness of screening in the following settings: 1) FFS without P4P incentives (i.e. traditional FFS); 2) FFS with P4P incentives (i.e. FHG); and 3) capitation with P4P incentives (i.e. FHO).

4.2 Methods

4.2.1 Model Description

I adapted a previously published model of the natural history of cervical cancer [16-18]. Every 6 months my microsimulation model tracks women through a series of health states representing the progression from infection with human papillomavirus (HPV) to cervical intraepithelial neoplsia (CIN) and eventually to invasive cervical cancer (Figure 4.1). Women may progress, regress or remain in a given health state up to the cervical cancer health state where regression is no longer permitted. Natural history parameters are age-specific and dependent on HPV type (low-risk versus high-risk type) [16-20].

In addition to the natural history model, my microsimulation model incorporates screening, follow-up of abnormal results and treatment of cervical cancer precursors. The following assumptions were made for this analysis: (i) 13% of women are never screened, 70% are screened within three years and the remaining women are screened

sporadically once every six years [21,22]; (ii) in each cycle women have an age-specific probability of being screened [11]; (iii) Pap smear sensitivity and specificity are age-dependent [23-25]; (iv) women have an age-specific probability of following up with abnormal test results [11,26,27]; (v) only infections with high-risk HPV may progress to cancer; (vi) women with biopsy confirmed CIN grade 2/3 (CIN23) and cancer were compliant with treatment; (vii) women with undiagnosed cancer may progress to subsequent stages based on values found in the literature [16,17]; (viii) women in the model face age-specific probabilities of non-cervical cancer-related death [28] and hysterectomy [29]. See Appendix 4.2 for detailed model figures.

My model was developed in two steps. First, the natural history parameters of a model with entry to the well state at age 12 were calibrated to match age-specific prevalence of HPV [19,30-36] and incidence of cervical cancer [7,37]. Where possible Canadian data were selected for calibration. Additional calibration targets included the stage distribution of cervical cancer cases [11] and the ratio of deaths to incident cases [18,38]. Ranges of parameters (incidence, progression and regression of HPV infection; progression and regression of CIN) found in the literature were tested in the model until an acceptable fit was found. After selecting a set of natural history parameters (Tables 4.1 and 4.2), model entry age was changed to 35 years and women enter different initial health states to match the observed distribution of states from model calibration. The model entry and exit ages (35 and 70 years, respectively) were chosen to match the target population of the Cumulative Preventive Care bonus. Second, a decision model with three arms representing FFS, FHG and FHO was created using TreeAge Pro 2014. Each arm represents a different primary care model and holds the microsimulation model developed in step one. Across all three arms, all parameters are the same except for age-specific cancer screening rates and the cost of a screening Pap smear [39].

4.2.2 Primary Care Model Screening Rates

The results of the traditional FFS model were compared to FFG and FHO models. I also compared the results of FHO with FHG. The proportions of regular, sporadic and never screened women were altered to reflect the differences in overall screening rates across the three primary care models (Table 4.3).

4.2.3 Cost and Effectiveness Data

All cost and effectiveness data utilized in the microsimulation model are summarized in Table 4.4. The costs of screening and repeat Pap smears include both the delivery and laboratory costs [40]. Physicians practicing in the traditional FFS model do not receive incentives for cancer screening, so the cost of a screening Pap smear in this model is the base (delivery and laboratory) cost of a test [40]. In the FHG and FHO models, the costs of screening Pap smears also include the costs of bonuses paid to physicians [39]. The cost of a repeat Pap smear is the base cost in all three primary care models. Colposcopy and treatment of CIN were estimated using the provincial fee schedule and data found in the literature [18,25,40]. Cancer treatment costs were estimated from patient-level data on women diagnosed with cervical cancer in Ontario between 2007 and 2010 [41]. Treatment costs include total medical care costs after accounting for censoring and were adjusted by cancer stage using stage-specific cost distributions found in the literature [16,17,42].[7] I included treatment costs for the first three years after diagnosis as during this period most cancer-related costs are accumulated [43,44]. Health-related quality of life associated with different cervical cancer progression states were obtained from the published literature [17,45-48]. Utility values for healthy individuals were taken from published literature using the Health Utilities Index Mark-3 [45], and disease state utilities were based on time trade-off methods, the Health Utilities Index Mark-2 and the Health and Activities Limitation Index [17,46-48]. Utilities were used to estimate effects using quality-adjusted life years (QALYs).

4.3 Results

4.3.1 Model Calibration

Figure 4.2 presents the model predicted and observed age-specific HPV prevalence rates. Figure 4.3 presents the model predicted and observed age-specific incidence of cervical cancer. HPV prevalence reaches a peak around age 20 and decreases until around age 50,

[7] Mean cancer cost was assumed to represent treatment costs for stages 2-3 cancers. The percentage differences from stage 2-3 costs to stage 1 and stage 4 cancers found in the literature were then applied to my estimates of mean treatment costs.

after which it starts to increase again [19,31,32,33]. Incidence of cervical cancer peaks between the ages of 40 and 44 and then decreases thereafter [7]. The model predicted stage distribution of cases was similar to observed data [11], as was the predicted ratio of cervical cancer cases to related deaths (0.29) was similar to observed data (0.30) [18,38].

4.3.2 Model Results

Table 4.5 presents the expected lifetime numbers of cervical cancer cases, stage distribution of cases and cancer-related deaths associated with the different primary care models. The traditional FFS model and FHO were associated with the lowest and highest expected cases of cervical cancer, respectively. The FHG and FHO models were associated with the lowest and highest numbers of expected cervical cancer-related deaths, respectively. However the FHG had the lowest ratio of deaths to incident cases (0.25) and the traditional FFS model had the highest (0.31). The FHG and FHO models were associated with greater proportions of stage I cases than the traditional FFS model.

The costs and effects, measured in QALYs, are summarized in Table 4.6 (first two columns) and the efficiency curve for the three primary care models is presented in Figure 4.4. Effects were fairly similar across all three models and only differed by about 0.1-0.2 QALYs. Costs were lowest in the traditional FFS model and highest in the FHG. Compared to the traditional FFS model, the FHO model is more costly and slightly more effective. The FHG model is the most costly model, but slightly more effective than the FFS while not more effective than the FHO.

Incremental cost-effectiveness ratios (ICERs) are summarized in Table 4.6 (last two columns) Relative to the traditional FFS model, one would need to spend about an extra $8,000 for each additional QALY in the FHO model. Compared to the FFS model, an extra $23,500 is needed for each QALY gained in the FHG. The FHG is more costly and less effective than the FHO, so it is dominated.

4.4 Discussion

My results suggest that there are similar QALYs and different costs for cervical cancer screening in Ontario’s primary care delivery models. The traditional FFS model is the

least costly and least effective. The Family Health Group, an enhanced FFS model featuring pay-for-performance incentives, is dominated, as it is the most costly, but not most effective compared to FHO. The FHO, a blended capitation model featuring pay-for-performance incentives, is the most effective and less costly than the FHG model.

I found similar effects across all three models, which is somewhat surprising and my results should be interpreted with caution. In theory, the primary care model with the highest screening rate would have the greatest QALYs. There are several reasons that may explain why this was not the case in my data. The incidence of cervical cancer in Canada is low (age-standardized incidence rate: 7.8 per 100,000 women) [49], so small differences in screening rates (<10%) may not affect the number of cases diagnosed in a meaningful way. Another contributing factor may be the stage distribution of cases across primary care models. Model predictions show that the FHG and FHO were associated with higher proportions of stage I cases than the FFS model, and it is possible that this is the result of earlier diagnoses. The FHG had the highest screening participation rate overall and among the oldest age category (60-69 years). My model endpoint is when screening cessation is recommended at age 70. It is plausible that women screened during their 60s in the FHG may be asymptomatic cases that would be missed by the other models. Furthermore, the FHG and FHO had fewer expected deaths to incident cases.

It is not surprising that the FHG and FHO have the highest costs. Physicians practicing in a traditional FFS practice do not receive financial incentives for meeting Pap smear quality targets, so the cost of screening is much lower in this model than in those featuring bonuses. Furthermore, the FHG has the highest screening participation rate, which greatly increases the costs of delivering screening. With more screening tests performed in the FHG, the volume of follow-up investigations for abnormal tests and treatments for CIN are also higher, which has a substantial impact on cost. While the cost of treating a cervical cancer patient is much higher than to treat a case of CIN, the volume of cancers is so low that screening and follow-up costs are substantially higher than cervical cancer treatment costs. Considering that bonus payments nearly double the cost of a screening Pap smear and increase the service volume, it is expected that overall screening costs would be highest in the model with the highest screening rate.

My findings are generally consistent with past research suggesting that increased cervical cancer participation (through more frequent screening) is not cost-effective [50-52]. However these findings should be interpreted with caution as while the costs of screening are high, it has caused drastic declines in both incidence and mortality [7]. This study and its results present a unique addition to the literature on the cost-effectiveness of cervical cancer screening. To the best of my knowledge, this is the first economic analysis of financial incentives for cervical cancer screening. Indeed, the evidence on the cost-effectiveness of incentives for all conditions is extremely limited [13]. Compared to the traditional FFS model, my findings indicate that a capitation model featuring P4P incentives is cost-effective and that an enhanced FFS model is dominated compared to FHO.

There are several limitations to my analyses. As in all economic analyses of cervical cancer screening, there is uncertainty in the natural history data. I attempted to address this by calibrating my model to observed Canadian epidemiological data. Another potential limitation is that the Cumulative Preventive Care Bonus guidelines expanded the target population to women aged 21 to 69 years in 2013. I was unable to capture how this will affect screening among younger women and their lifetime risk of cervical cancer. Future studies of cervical cancer screening in Ontario should address this change. My model did not account for the vaccination status of women. However this may not have affected my target population as vaccination is recommended to take place during adolescence. Furthermore, there is limited data on how the HPV vaccine performs in populations or its the long-term effects [25,53]. Finally, my results may not be generalizable to other jurisdictions in Canada.

4.5 Conclusions

In conclusion, my results suggest that a capitation model with financial incentives may be more cost-effective than FFS models with and without incentives at delivering cervical cancer screening. Future research within Ontario should explore the effects of the new Cumulative Preventive Care Bonus guidelines on the costs of screening and predicted risk of cervical cancer. Future research may build upon my results by investigating the

cost-effectiveness of capitation systems without incentives, and salaried models with and without incentives.

4.6 References

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4.7 Tables and Figures

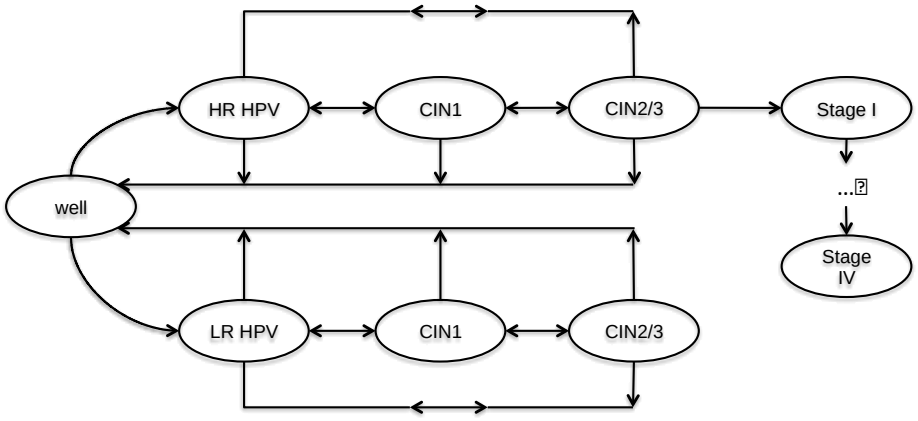

Figure 4.1: Natural history of cervical cancer

Well indicates no infection with human papillomavirus (HPV) or cervical disease. HR HPV indicates infection with high-risk type HPV and LR HPV indicates infection with low-risk type HPV. CIN1 and CIN23 indicate cervical intraepithelial neoplasia (CIN) grades one and two or higher, respectively. Stage I indicates stage one cervical cancer, which may progress to stage two and so on until stage four cancer. At any point women in the model may die or receive a hysterectomy unrelated to cervical cancer. In the absence of screening, women with cervical cancer may only be diagnosed if they become symptomatic.

Table 4.1: Natural history parameters for HPV and CIN

Variable	High- risk HPV	Low-risk HPV
Incidence of HPV infection [16-20]		
13	0.0036	0.0014
14	0.0182	0.0071
15	0.0369	0.0144
17	0.0446	0.0173
19	0.0857	0.0333
20	0.0770	0.0300
30	0.0182	0.0071
40	0.0145	0.0057
45	0.0109	0.0042
50	0.0190	0.0063
Regression from HPV to normal [16,17,20]		
13	0.280	0.230
35	0.174	0.143
Progression from HPV to CIN1 [16,17,20]		
	0.08	0.045
Progression from HPV to CIN23 [16,17,20]		
13	0.006	0.006
35	0.01	0.02
Regression from CIN1 [16,17,20]		
To well	0.15	0.162
To HPV infection	0.062	0.09
Regression from CIN23 [16,17,20]		
To well	0.001	0.003
To HPV infection	0.01	0.02
To CIN1	0.002	0.03
Progression from CIN1 to CIN23 [16,17,20]		
13	0.08	0.04
35	0.12	0.045

HPV = human papillomavirus; CIN1 = cervical intraepithelial neoplasia grade 1; CIN23 = cervical intraepithelial neoplasia grades 2-3

Table 4.2: Cancer progression parameters

Variable		
Progression from CIN23 to cancer by age [16-18,20]		High-risk HPV
15		0.0005
20		0.0008
25		0.0065
30		0.015
35		0.0255
40		0.028
45		0.0335
50		0.032
55		0.022
60		0.0180
65		0.015
70		0.025
Cancer stage progression [16,17]		
Stage I to II		0.15
Stage II to III		0.16
Stage III to IV		0.225
Probability of symptoms [16,17]		5-year survival [16,17]
Stage I	0.078	84.04%
Stage II	0.120	66.32%
Stage III	0.368	40.29%
Stage IV	0.684	15.83%

HPV = human papillomavirus; CIN1 = cervical intraepithelial neoplasia grade 1; CIN23 = cervical intraepithelial neoplasia grades 2-3

Table 4.3: Screening participation, screening test characteristics and follow-up variables

Variables	FFS	FHG	FHO
Screening rate [39]			
35	76.3%	85.5%	82.7%
40	72.9%	83.6%	80.1%
50	69.7%	82.0%	78.3%
60	66.4%	79.2%	75.0%
Test characteristics [23-25]	Sensitivity		Specificity
	CIN1	CIN23	<CIN1
15	0.42	0.57	0.97
35	0.32	0.38	0.982
12-month follow-up abnormal results [11,26,27]			
Low-grade abnormality (ASCUS, LSIL)			0.81
High-grade abnormality (ASC-H, HSIL)			0.90

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization; ASCUS = atypical cells of unknown significance; LSIL = low-grade squamous intraepithelial lesions; ASC-H = atypical cells of undetermined significance; HSIL = high-grade squamous intraepithelial lesion

Table 4.4: Cost and effectiveness variables

Cost variables				
Screening Pap smear [39,40]				
FFS				$18.30
FHG				$29.71
FHO				$35.02
Repeat Pap smear [40]				$18.30
Colposcopy and biopsy [20,40]				$152.60
CIN treatment [18,20,40]				$1,105
Cancer treatment [16,17,41,42]				
	Stage I	Stages II-III		Stage IV
Year 1	$25,345	$40,231		$55,116
Year 2	$9,109	$14,459		$19,809
Year 3	$5,911	$9,383		$12,855
Health-related quality of life [45]				
Low-grade abnormality [46]				0.97
High-grade abnormality [46]				0.93
Detected cancer [17,46-48]			In treatment	Post-treatment
Stage I			0.80	0.90
Stages II-III			0.67	0.90
Stage IV			0.48	0.62

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization

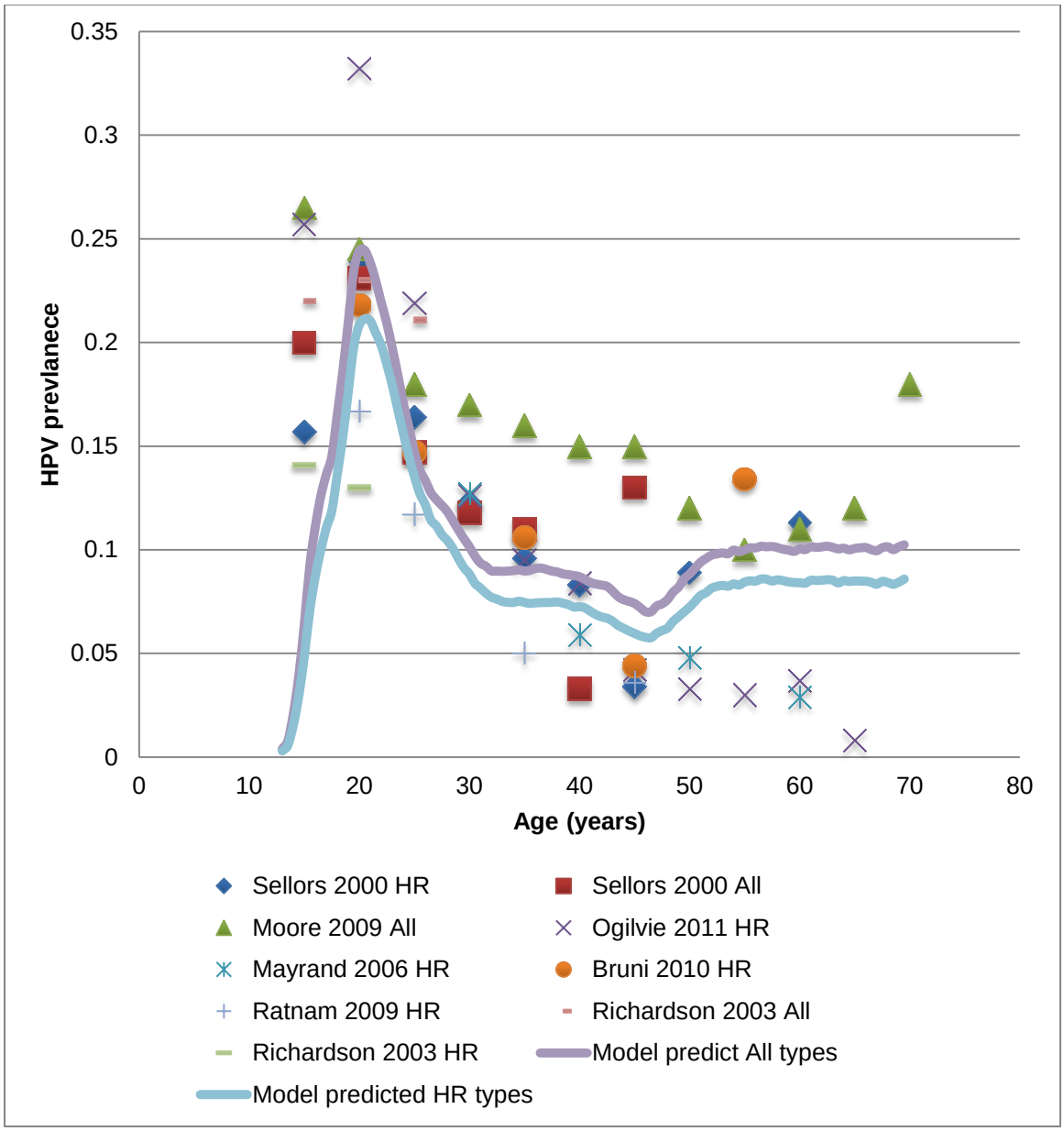

Figure 4.2: Observed and model predicted age-specific prevalence of high-risk (HR) human papillomavirus (HPV) types and all types of HPV from model calibration

Note that HR types include all carcinogenic HPV types: -16, -18, -31, -33, -35, -39, -45, -51, -52, -56, -58, -59, -68, -73, -82.

Note that observed results come from the literature [19,30-36].

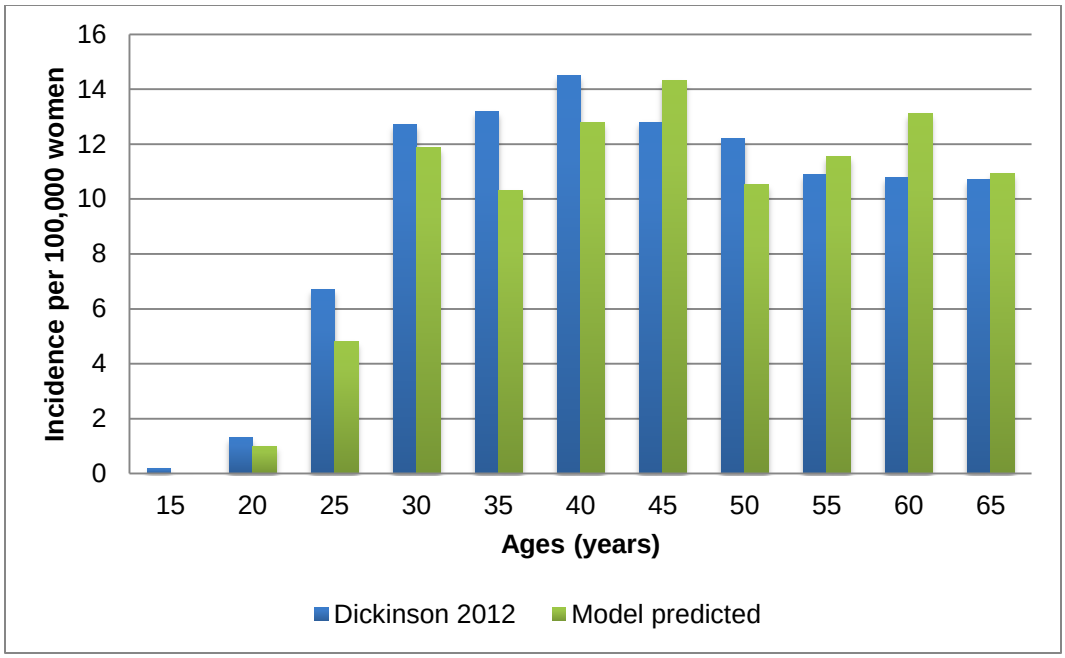

Figure 4.3: Observed and model predicted age-specific incidence (per 100,000 women) of cervical cancer from model calibration

Note that observed results come from Dickinson *et al.* (2012) [7].

Table 4.5: Model predicted cervical cancer cases, stage distribution and deaths

Primary care model	Cases	Deaths	Death to case ratio
Traditional FFS	424	131	0.309
Stage I	50.47%		
Stage II	27.12%		
Stage III	15.80%		
Stage IV	6.61%		
FHG	463	118	0.255
Stage I	57.67%		
Stage II	26.78%		
Stage III	8.86%		
Stage IV	6.69%		
FHO	474	138	0.291
Stage I	60.12%		
Stage II	23.00%		
Stage III	10.34%		
Stage IV	6.54%		

FFS = fee-for-service; FHG = Family Health Group; FHO = Family Health Organization

Table 4.6: Model predicted costs and effects by primary care delivery model and incremental cost-effectiveness ratios

Model	Costs (CAD $)	Effects (QALYs)	ICER	ICER relative to FFS
FFS	450.36	28.3552	-	-
FHO	633.34	28.3781	$7990.39	$7990.39
FHG	678.69	28.3649	Dominated	$23,539.18

ICER = incremental cost-effectiveness ratio; FFS = fee-for-service; FHO = Family Health Group; FHG = Family Health Organization

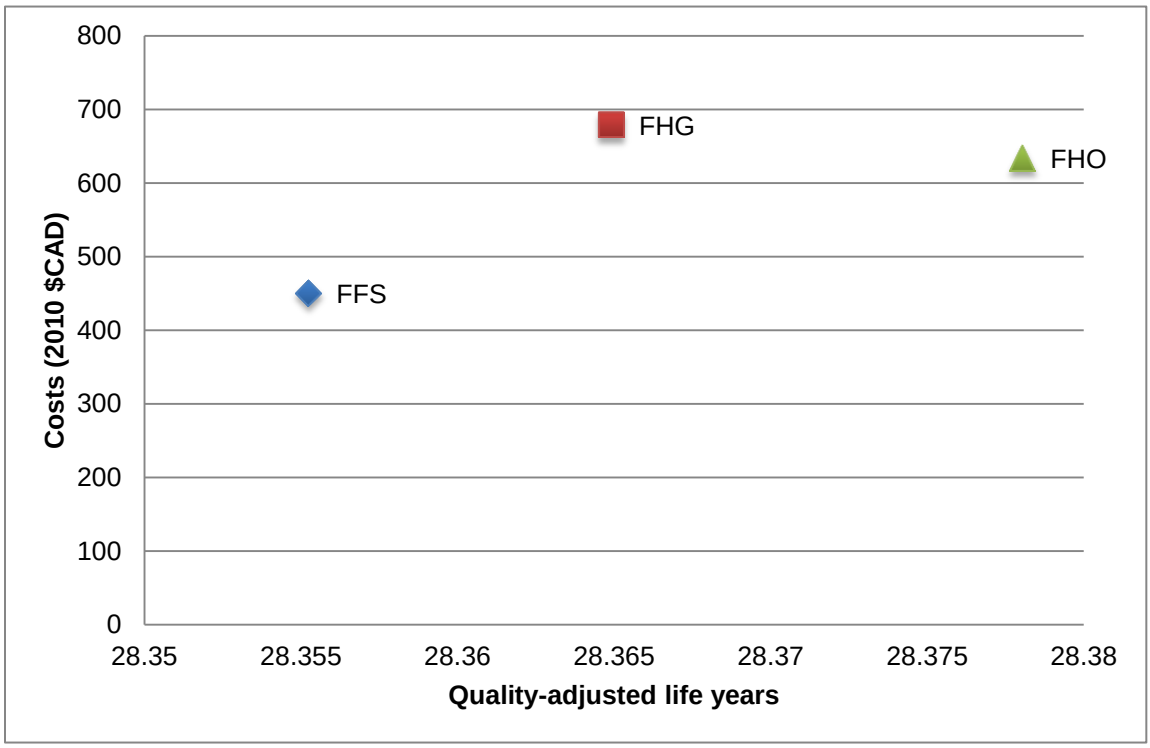

Figure 4.4: Efficiency curve of costs versus effects (quality-adjusted life years)

4.8 Appendices

4.8.1 Appendix A4.1

Table 4.7: Cumulative preventive care bonuses for cervical cancer screening

Achieved Screening Participation Rate	Fee Payable
60%	$220
65%	$440
70%	$660
75%	$1,320
80%	$2,200

4.8.2 Appendix A4.2 Microsimulation Model Figures

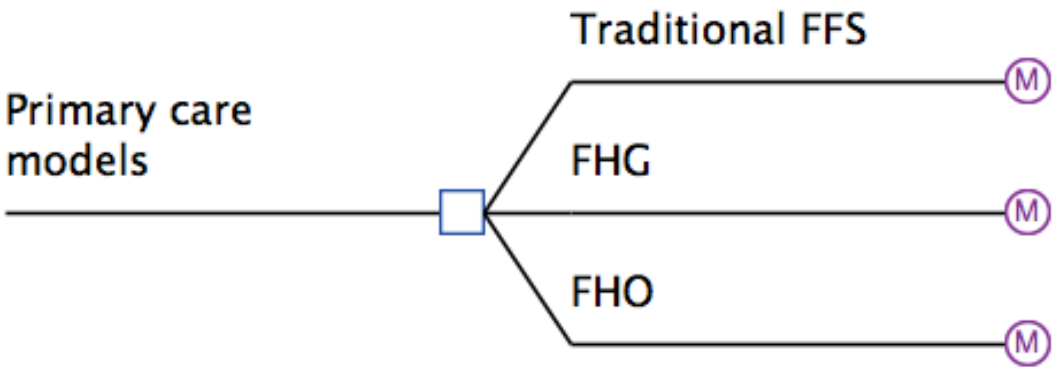

Figure 4.5: Decision analytic model

Each arm in the decision arm represents a different primary care delivery model (traditional fee-for-service [FFS], Family Health Group [FHG], Family Health Organization [FHO]), and at the end of each arm is a microsimulation model of the natural history of cervical cancer that incorporates screening, follow-up and treatment of abnormal results, and cancer treatment.

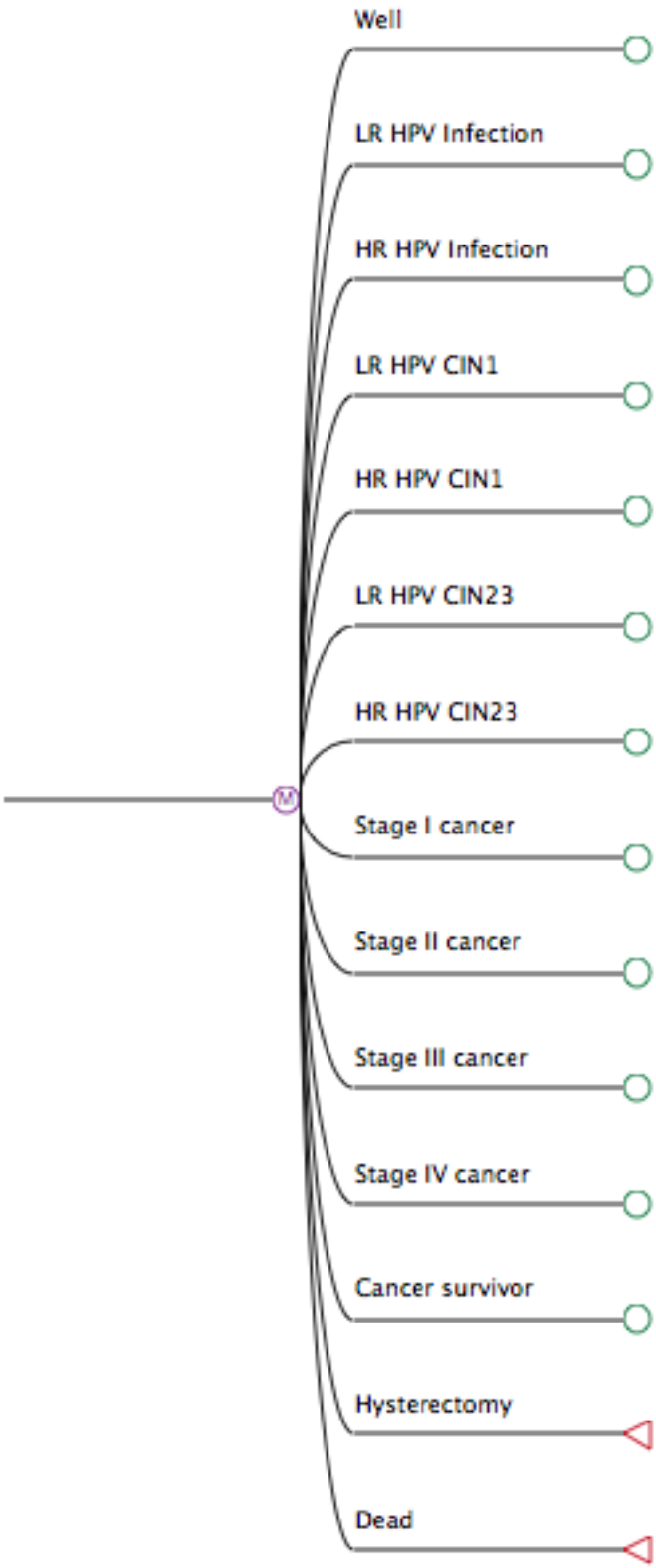

Figure 4.6: Health states in the microsimulation model

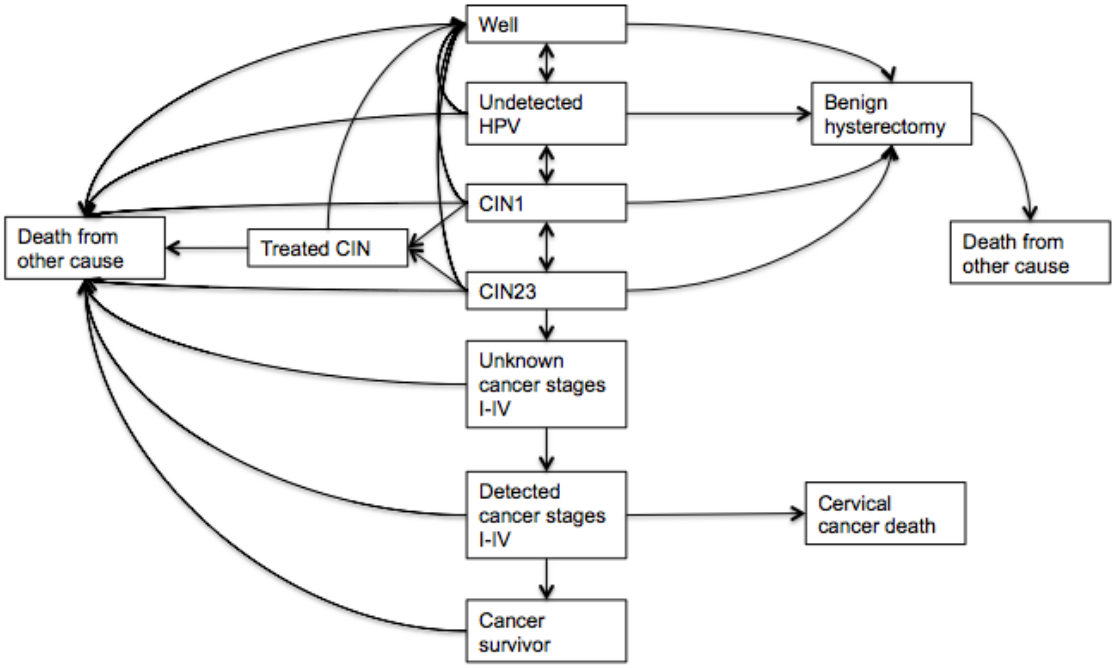

Figure 4.7: Natural history model of cervical cancer and allowable health state transitions

Note that women may be infected with low-risk or high-risk human papillomavirus (HPV) types and that both low-risk and high-risk infections may progress to cervical intraepithelial neoplasia (CIN) grade 1 (CIN1) or grades 2-3 (CIN23). However only CIN23 infected with high-risk HPV types may progress to invasive cervical cancer.

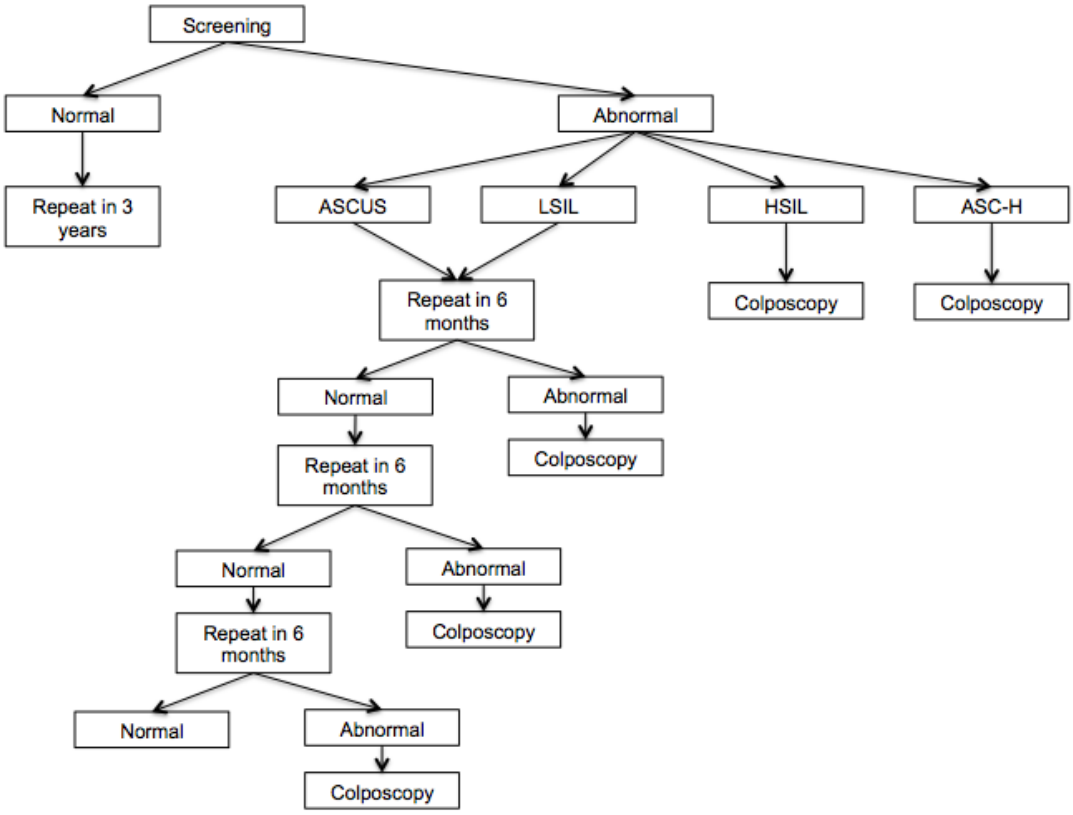

Figure 4.8: Follow-up of abnormal Pap smear results

ASCUS = atypical squamous cells of unknown significance; LSIL = low-grade squamous intraepithelial lesion; HSIL = high-grade squamous intraepithelial lesions; ASC-H = atypical cells of unknown significance – cannot exclude HSIL.

Chapter 5

5 Conclusions

5.1 Summary and Concluding Statements

I compared cervical cancer screening rates among three of Ontario's dominant primary care delivery models: the traditional fee-for-service model, the Family Health Group and the Family Health Organization. My results suggest that there are significant differences in screening participation rates between models after controlling for patient and physician characteristics. The FHG, an enhanced FFS model where physicians are eligible for financial incentives, was observed to have the highest screening participation rate. The blended capitation model (i.e. FHO) had the second highest screening rate, and the traditional FFS model, in which physicians do not receive bonuses for screening, had the lowest screening rate.

Screening rates were used to populate a decision analytic model consisting of three Monte Carlo microsimulation models representing the FFS, FHG and FHO models. This model was developed from previously published models of cervical cancer screening [1-3] and calibrated to match observed data from Ontario [4-13]. Analysis of the overall and specific costs of Ontario women diagnosed with cervical cancer was conducted to estimate the treatment costs associated with cervical cancer.

Results from the economic model suggest that the FHO is cost-effective relative to the traditional FFS model and that the FHG is dominated by the FHO. However, the model predicted effects were similar across the three primary care models and the FHG had the lowest death to incident case ratio. The FHG and FFS models were the most and least costly, respectively, but the difference in cost was about $230. It is not surprising that the FHG has the highest costs as it features screening bonuses to physicians. Furthermore the FHG has the highest screening rate, which increases the costs of delivering Pap smears and costs associated with follow-up of abnormal results. The model predicted the FHO and traditional FFS model to be the most and least effective, respectively, with a difference of 0.023 quality-adjusted life years. Compared to the traditional FFS model,

one would need to spend an additional $8,000/QALY in the FHO, which is considered cost-effective with a willingness to pay of $50,000/QALY.

Despite the FHG having significantly higher screening rates than the FHO, it had slightly lower quality-adjusted life years. The incidence of cervical cancer in Canada is very low, so small differences in screening rates may not have a large effect. As mentioned previously, my model tracked women until age 70, so higher screening rates may be effective at diagnosing cases at earlier stages and ages. However this potential effect is likely to be minimal as peak incidence occurs while women are between the ages of 40 and 45 years [13].

These results may be useful for decision makers and aid in policy development. Both reformed models featuring P4P incentives, FHG and FHO, had greater QALYs and are cost-effective relative to the traditional FFS model. It should also be noted that I was unable to assess screening rates before incentives were introduced and that differences in screening rates by physician primary care model may have existed prior to primary care reform [14]. Considering that $28.3 million was spent on cervical cancer screening bonuses between 2006/2007 and 2009/2010 and the limited effectiveness of the program, its continuation remains an open question [14].

Future research can build upon these analyses in several ways. First, I was unable to assess temporal trends in cervical cancer screening, and an economic analysis that accounts for baseline differences in screening rates is warranted. Second, the cervical cancer Cumulative Preventive Care Bonus guidelines recently changed to include women aged 21 to 34 years in the target population. This may affect screening participation and costs. Third, the effects of the breast cancer and colorectal cancer Cumulative Preventive Care Bonuses on screening rates, incidence and mortality have not been widely studied. Financial incentives have been shown to have no effect on breast cancer screening in Ontario [14,15]. However one study reported a near 10% increase in colorectal cancer screening after incentives were introduced, which is much larger than the estimated 3% increase for cervical cancer [15]. Given that colorectal screening incentives are more effective at improving participation and that the incidence of colorectal cancer is greater

than that of cervical cancer, incentives for colorectal cancer screening may be cost-effective and an economic analysis is warranted. Finally, I did not include salaried physicians in my analyses. Future work could expand my study of the effects of remuneration on cervical cancer screening to include salaried physicians.

5.2 References

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6 Supplementary Appendix

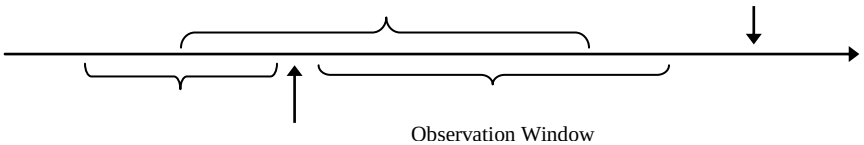
Appendix A: Dataset Creation Plan

Dataset Creation Plan

Name and Number of Study	Cost-Effectiveness of Cervical Cancer Screening in Primary Care Funding Models
Research Program	PCPH
Contacts	Ciara Pendrith Sisira Sarma Amardeep Thind
Who will be responsible for DCP updates?	Ciara Pendrith
PIA Approved?	No
DCP update history **1st Draft: November 20, 2013**	
Short Description of Research Question	**Objectives:** To conduct a cost-effectiveness analysis of financial incentives for cervical cancer screening in Ontario's primary healthcare delivery models. To assess which of the reformed primary health care model is the most cost-effective in delivering cervical cancer screening. To determine the target level of screening participation at which incentives could be cost-effective. **Main population of interest:** Female patients aged 35 to 69 years and without prior cervical cancer diagnoses or hysterectomy in the province of Ontario between the years 2005 and 2010. **Main outcomes of interest**: Outcomes are screening rates & associated costs, incidence (number of patients diagnosed with cervical cancer per year in various models), primary treatment type & associated costs, overall survival and 5-year survival.
List of Datasets Used	1. **CPDB** (required from January 1, 2005 to March 31, 2011) 2. **CAPE** (available from January 1999, required from January 1, 2005 to March 31, 2011) 3. **RPDB** (available from 1990, required from January 1, 2005 to December 31, 2012) 4. **OHIP** (available from January 1991, required from January 1991 to December 31, 2012) Claim Type ☒ All Code Types ☒ Fee codes

	☒ Diagnosis codes 5. **OCR** (available from 1964, required from 1964 to December 31, 2011) 6. **IPDB** (available from 1992, required December 31, 2010 7. **CIHI-DAD** (available from 1986, required from 1986-2011 to identify total abdominal hysterectomy)
Other Details	**1. For look-back period** Reference date ☒ Do not include index date in look-back period (stop at index-1)

Time Frame Definitions



Part A – Physician & Screening Cohorts

Accrual Start/End Dates	March 31, 2011
Max Follow-up Date	March 31, 2011
Lookback Window(s)	3 years to identify adequately screened women Maximum lookback date: April 1, 2008

Cohort Selection

Index Event	Cross-sectional analysis of population-based cohort March 31, 2011
Inclusion Criteria	**Part 1 – Defining the Physician Sample** See Table 1a for format 1. Using CPDB, select full-time comprehensive primary care physicians affiliated with a FHG, FHO or traditional FFS model on March 31, 2011. Exclude physicians with a narrow scope of practice (e.g. sports medicine, counselling, psychotherapy, etc) **Part 2 – Defining Physician Patient Populations (Screening Cohort)** See Table 1b for format 1. Identify patient populations of physician sample that are eligible for cervical cancer screening on index date 2. Select female patients aged 35 to 69 years inclusive on index date that are formally rostered to sample physicians affiliated with a FHG or FHO model 3. Analyze OHIP billings using the ICES algorithm to define practice populations of physicians affiliated with the traditional FFS model and select female patients aged 35 to 69 years inclusive on index date
Exclusions (In order)	1. Invalid IKN 2. Evidence of death of patient on or before the index date 3. Non-Ontario residents 4. Evidence of history of cervical, endometrial or ovarian cancer diagnoses. Defined by codes in Appendix A in the DXCODE variable in OCR between 1964 and March 31, 2008 5. Evidence of prior hysterectomy. Defined by procedure codes in Appendix B

	in CIHI-DAD between 1986 and March 31, 2011 6. Evidence of HIV infection by entry in HIV database up to March 31, 2011
Size of Cohort	Enter total size of cohort when available

Part B – Cancer Cohort

Accrual Start/End Dates	January 1, 2005 – December 31, 2010
Max Follow-up Date	December 31, 2012
When does observation window terminate?	Patients will be followed from index event until end of follow-up or date of death
Lookback Window(s)	10 years to assess screening history. Farthest lookback date: January 1, 1995

Cohort Selection

Index Event	Retrospective cohort study Cancer diagnosis

Defining the Cancer Cohort

See Table 1c for format

Inclusion Criteria	1. Using RPDB, identify women aged 35-69 at risk for cervical cancer each year between January 1, 2005 and December 31, 2010 2. Using OCR, identify all patients diagnosed with cervical cancer between January 1, 2005 and December 31, 2010 defined by ICD-9 codes in Appendix C in the DXCODE or DXCODE_RES
Exclusions (In order)	1. Invalid IKN 2. Evidence of death of patient on or before the index date 3. Non-Ontario residents 4. Evidence of history of cervical, endometrial or ovarian cancer diagnoses. Defined by codes in Appendix A in the DXCODE variable in OCR between 1964 and December 31, 2004 5. Evidence of prior hysterectomy. Defined by codes in Appendix B in CIHI-DAD between 1986 and December 31, 2004 6. Evidence of HIV infection by entry in HIV database prior to index date
Size of Cohort	Enter total size of cohort when available

Variable Definitions

Main Exposure or Risk Factor	**Primary Care Funding Model** 1. Traditional FFS – control 2. Blended FFS (FHG) – treatment 3. Blended capitation (FHO) – treatment **Cumulative Preventive Care Bonus** 1. Traditional FFS – control 2. FHG & FHO – treatment
Baseline Characteristics	**Assessed at index date**
Part A	**Physician Characteristics** (CPDB, CAPE, IPDB, OHIP) 1. Encrypted OHIP number from PHYSNUM (or other physician identifier) (CPDB) 2. Age from BDATE (IPDB) 3. Gender from SEX (IPDB)

	4. Year of graduation from GRADYEAR (IPDB) 5. International medical graduate status from IMG (IPDB) 6. Family Health Team membership status (CPDB) 7. Group affiliation at index date and date of eligibility for that group from GRPNUM & STRTELIG from the PHYS_AFFILIATION dataset (CPDB) 8. Patient enrolment model type from PROGTYPE (for FHG & FHO physicians) (CAPE) 9. Screen eligible practice size (CAPE, OHIP) **Patient Characteristics** (RPDB, CAPE) 1. Age, from %getdemo 2. Ontario Marginalization Index 3. Rurality index as per ICES algorithm (RPDB) 4. Include the following program enrolment variables: STATUS_CAPE, PROGTYPE, PHYSNUM (CAPE) 5. Physician number and model type for patients of FFS physicians
Baseline Characteristics	**Assessed at index date (cancer diagnosis)**
Part B	**Cancer Cohort Characteristics** (RPDB, OCR, CAPE, OHIP) 1. Ontario Marginalization Index 2. Rurality index as per ICES algorithm (RPDB) 3. Include the following program enrolment variables: STATUS_CAPE, PROGTYPE, PHYSNUM (CAPE) 4. Include physician number and model type for patients of FFS physicians 5. Diagnosis date from DXDATE & DXDATE_FLAG (OCR) 6. Age at diagnosis from AGE (OCR) 7. ICD9 reportable status & ICD9 resolved site from DXCODE & DXCODE_RES (OCR) 8. Histology and histological behaviour from HIST, HIST_RES, BEHAVIOR, BEHAVIOR_RES (OCR) 9. ACG score (use shorter version)
Outcome Definitions	**Part A** **Screening Outcomes**
Part A	1. **Screening Rates** (OHIP) see table 2a for format • Identify screening rate of each physician's patient population on index date • Patients are considered screened if they have at least one claim to OHIP with any of the fee codes in Appendix D within the past three years (April 1, 2008 – March 31, 2011) • Stratify by age groups: 35-39, 40-49, 50-59, 60-69 2. **Screening Costs** (OHIP) see table 2b for format • Identify preventive care bonuses claimed by each eligible FHG and FHO physician on March 31, 2011 from OHIP Architected Payments database • Applicable bonuses are defined by fee codes in Appendix E
Outcome Definitions	**Cancer Cohort Outcomes**
Part B	1. **Screening History** (OHIP) see table 3 for format • Link cancer cases to OHIP claims database to identify screening history • For all cancer cases, identify three most recent Pap smear billed to OHIP prior to date of diagnosis – look back a maximum of ten years

- Include dates of tests billed

2. **Diagnosis & Pre-Cancer Treatments** (OHIP)
   - For all cancer cases, identify colposcopies and procedures (defined by claims with fee codes in Appendix F) to treat pre-cancers billed to OHIP prior to date of diagnosis – look back a maximum of two years. Include FEECODE, FEESUFF, DXCODE, SERVDATE
3. **Total Healthcare Costs** (OHIP)
   - Run cost macro (%getcost) for each cancer case yearly from date of diagnosis until date of death or end of follow-up
4. **Mortality** (RPDB)
   - Identify any deaths & cause of death from RPDB

Outline of Analysis Plan

1. **Screening participation rates**
- Calculate the proportion of women adequately screened by primary care funding model and age group

2. **Screening bonus payments**
- Document the number of physicians in each funding model claiming each bonus level

3. **Follow-up of abnormalities**
- Estimate the number and proportion of women receiving colposcopy and other procedures to follow-up abnormal Pap results

4. **Incidence of cervical cancer**
- Estimate the at risk populations and proportions diagnosed with cervical cancer each year between 2005 and 2010
- Estimate proportions of cases diagnosed through screening and interval detection
- Using Kaplan-Meier survival analysis, estimate progression from date of last normal or abnormal screen to date of cancer diagnosis

5. **Cervical-cancer related mortality & survival**
- Document the number and proportion of cancer cases that have a cancer-related cause of death
- Using Kaplan-Meier survival analysis, estimate 2- and 5-year cervical cancer survival from date of diagnosis to date of death

6. **Total healthcare costs for cancer patients after diagnosis**
- Estimate total healthcare costs of women diagnosed through screening and interval detection after diagnosis

7. **Cost-effectiveness analysis**
- A decision analytic model will be used to assess the cost-effectiveness of financial incentives for cervical cancer screening. Transition probabilities between health states will be estimated using screening, cancer progression and survival rates. Costs of screening, diagnosis and cancer treatments will be estimated from OHIP billings and cost macro results. Quality-adjusted-life-years will be estimated from the product of published state-specific utilities and time spent in each health state

7 Curriculum Vitae

Name: Ciara Pendrith

Post-secondary Education and Degrees:
University of Western Ontario
London, Ontario, Canada
2012-2014 M.Sc.

Queen's University
Kingston, Ontario, Canada
2008-2012 B.Sc. (Honours)

Honours and Awards:
Western Graduate Scholarship, 2012-2013, 2013-2014

University of Toronto Dependent's Scholarship, 2008-2009, 2009-2010, 2010-2011, 2011-2012

Queen's University Dean's Honours List, 2009-2012

Queen's Excellence Scholarship, 2008-2009

Related Work Experience
Biostatistician
Women's College Institute for Health System Solutions and Virtual Care, 2014-present

Research Assistance
Women's College Research Institute, 2013

Research Intern
Women's College Research Institute, 2012

Intern, Project for an Ontario Women's Health Evidence-based Report
St. Michael's Hospital and ICES, 2010

Publications:
Pendrith C, Nazarali S, Perrier L, Tricco AC, Hamid J, Schwalm JD, et al. Automated patient reminders post health event for improving adherence to medical recommendations: a systematic review and meta-analysis. 2014. (submitted).

Conferences:
Pendrith C, Sarma S, Thind A, Zaric G. A cost-effectiveness analysis of economic incentives for cervical cancer screening in Ontario's primary healthcare delivery models. Poster presentation and elevator pitch. Ontario Institute for Cancer Research/Cancer Care

Ontario Health Services Research Program 6th Annual Meeting. Toronto, ON. Jun 19, 2014.

Mukerji G, Kainth S, Pendrith C, Wu W, Lowe J, Feig DS, et al. Perceived risk of diabetes among women with gestational diabetes. Poster presentation and guided audio tour.American Diabetes Associated 73rd Scientific Sessions. Chicago, IL. June 21-25, 2013.

Mukerji G, Kainth S, Pendrith C, Wu W, Lowe J, Feig DS, et al. Perceived risk of diabetes among women with gestational diabetes. Oral presentation. Women's College Research Institute Student Research Day. Toronto, ON. July 19, 2012.