Optimizing Health Outcomes for Children with Asthma in Delaware: An analysis of health service utilization and cost among Nemours clients enrolled in Medicaid

December 2015

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Acknowledgements

We are grateful to Norma Everett, Manager of Population Health, Alisa Haushalter, Senior Director of Population Health, and Diane Abatemarco, Senior Research Scientist, at Nemours Health and Prevention Services (NHPS) for their valuable contributions to the development of this report. Each provided important feedback on monthly data tables and helped to refine the analytical approach. We similarly acknowledge Marlon Satchell, Evaluation Scientist at NHPS, who also provided ongoing feedback and support. As the lead evaluator on the project for NHPS, Marlon's contributions were particularly useful, and her role coordinating our monthly meetings and facilitating the sharing of information between NHPS and CCRS was essential to the success of the project.

This project was conducted by the University of Delaware's Center for Community Research and Service under contract with Nemours Health and Prevention Services. Funding was provided through a Medicare & Medicaid Services Innovation (CMMI) grant.

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Introduction

Nemours launched an asthma intervention program titled, "Optimizing Health Outcomes for Children with Asthma in Delaware" on July 1, 2012 with funding from a Centers for Medicare & Medicaid Services Innovation (CMMI) Award. The three overall goals of the program were to increase the quality of care for Delaware children with asthma, improve outcomes of care for this population, and reduce the cost of asthma care over time. One focus of the intervention was on children served by the Nemours pediatric health system in general, and three Nemours duPont Pediatrics practices and the Emergency Department specifically. An additional focus was on children enrolled in Medicaid.

The design of the intervention was guided by the socio-ecological model and aimed to integrate medical care with community-based, population health services. It included a range of practice-oriented improvements, such as the enhancement of family-centered medical homes, the deployment of a Community Health Worker (CHW) workforce, the development of a primary care "integrator" model surrounding the targeted primary care sites, optimizing the use of information technology and electronic communications, and strategies for sustaining the overall intervention. The primary focus of the intervention was on the development and implementation of an asthma registry to identify, track and provide enhanced services for particularly high-risk asthma cases. More specifically, children with serious asthma were assigned to the Nemours Asthma Registry, which prompted more intensive care coordination provided by the CHWs. The CHWs were expected to provide a range of services and functions to enhance the care provided to registry clients, including but not limited to the following:

- advocate, facilitate and organize access to health and social services with/for families to improve the health and well-being of the community at large, particularly those families with children diagnosed with asthma;
- provide case management of non-medical needs to a caseload of high-needs families through regular and ongoing communication;
- utilize electronic medical records (EMR) to document patient care and communicate with the primary care team, as well collect data at set intervals through assessment tools, collaborating with the self-monitoring team to reflect issues that affect health and gauge patient progress;
- act as a liaison between the families and pediatric practices, elevating non-medical and community issues to the attention of providers and others on the primary care team that enhance or impede the relationship;
- serve as part of an interdisciplinary team participating in care team meetings, family advisory councils and patient centered medical home team meetings;
- educate, re-educate and/or coach families on asthma and asthma management; and
- conduct home visits and healthy home assessments, working with families to promote healthy, asthma trigger-free households.

The specific services provided by a CHW often depended on the nature of the child's asthma, the family and home environment, and the existing relationship between the child's family and the healthcare system. Further, the children assigned to the registry were expected to receive the same, high quality care provided to all children served in the Nemours system, including team-based and prevention-

focused care, patient- and family-centered medical home-based care, patient and family education and regular health communications, shared decision-making and parent/family empowerment, as well as other existing and emergent best practices in the delivery of pediatric health services.

Purpose - In December 2014, Nemours engaged the services of the University of Delaware, Center for Community Research and Service, to conduct an analysis of the health services utilization among children enrolled in Medicaid that are served by the Nemours health system in order to help evaluate the asthma intervention. The analysis is meant to help answer two major questions related to the initial goals of the project: (1) Compared to a period before services were provided, has the frequency of serious asthma-related health incidents (defined as emergency department visits and hospitalizations) decreased? (2) Has the total cost of these services decreased? In investigating these questions, data on asthma-related health incidents, healthcare service utilization and healthcare costs were analyzed geographically and by demographic characteristics.

This report presents the findings from our analysis of the healthcare services provided to children in the Nemours system covered by the State's Medicaid program, and compares utilization of healthcare services and costs between children assigned to the Nemours Asthma Registry with two other categories of children served by Nemours. More specifically, it compares Asthma Registry clients with a cohort of children not in the registry, but who have an asthma diagnosis; as well as with a cohort of Nemours clients without an asthma diagnosis to provide a frame of reference. Further, it examines utilization and cost across two distinct time periods, meant to represent baseline and intervention period. Medicaid claims data supplied by the Delaware Division of Medicaid and Medical Assistance (DMMA) and data supplied by the Nemours system were linked at the client level and subsequently aggregated for the purposes of this analysis. This combined database resulted in a rich source of information on the healthcare utilization patterns of children in the Nemours system and offers insights into the extent to which the CMMI-funded asthma intervention has contributed to changes in serious asthma-related incidents and related costs. At the same time, our analysis revealed many additional questions that could be explored in more detail in future studies or with a longer time period.

In addition to highlighting findings from our data analysis, this report contains a review of the relevant literature on asthma prevalence and risk factors, as well as the role of CHW-based interventions for asthma. This summary is not meant to be exhaustive, but rather presents the field's current understanding of the health needs and patterns of healthcare utilization associated with childhood asthma. It highlights special issues confronting low-income children with asthma and potential benefits of CHWs. We present this broader landscape as context for the current analysis and background for future research in which Nemours and others may wish to engage. Accordingly, the report concludes with a brief discussion of suggested next steps and recommendations for ongoing evaluation of the Nemours asthma intervention.

Literature Review

Background: Asthma Prevalence in the United States

Asthma is the most common childhood chronic illness in the United States and asthma-related morbidity has been identified as one of the major factors associated with childhood disability (Akinbami, 2006; Akinbami & Schoendorf, 2002; Newacheck & Halfon, 2000). This concern is further amplified by the fact that the number of children diagnosed with Asthma, on aggregate, (and in comparison to adults) has continued to grow since the 1960's (Mannino et al., 1998; Mannino et al., 2002; Moorman et al., 2007; Akinbami, Moorman, Garbe, & Sondik, 2009; Lara J. Akinbami et al., 2012; Moorman et al., 2012). Furthermore, while overall asthma mortality and asthma-related healthcare utilization have shown a decreasing trend over the past decade, children with asthma are seen to be utilizing higher rates of healthcare services (Primary care and ED visits) compared to adults with asthma (Akinbami et al., 2012; American Lung Association, 2012).

It has also become increasingly apparent, that a disproportionate burden of this disease is borne by children who belong to low income families and racial and ethnic minorities, however, race and asthma are not causally related (Aligne, Auinger, Byrd, & Weitzman, 2000; Schwartz, Gold, Dockery, Weiss, & Speizer, 1990). There are also stark, albeit shrinking, differences in emergency department (ED) visits with Black[1] children depicting more severe symptoms and higher ED visit frequency (Akinbami, Moorman, Simon, & Schoendorf, 2014). A similar trend is observed in asthma-related mortality across races and ethnicities, with non-Hispanic Black, American Indian/Alaska Natives/Puerto Rican and Black Hispanic children faring the worst (Akinbami et al., 2009).

Risk Factors for Asthma

The risk factors for asthma among children can be divided into three broad categories; environmental, psychological and physiological. Earlier research on the environmental predictors of asthma is summarized by a review article by Walker, Stokes, and Warren, (2003). They list exposure to toxic and flammable chemicals, proximity to waste incinerators, ambient air pollution, exposure to second hand tobacco smoke and indoor allergens such as dust mites and cockroaches as the most commonly cited risk factors for childhood asthma (Walker et al., 2003). While numerous research studies and review articles have identified the most commonly cited risk factors for asthma, their relative importance in determining asthma incidence, severity or mortality continues to be evasive and widely debated (Mayo Clinic, 2015; Asthma and Allergy Foundation of America, 2011).

Urban or inner city children appear to be at an increased risk of asthma, regardless of race or family income, indicating the presence of a wide range of social and environmental factors that act as risk factors for asthma (Aligne et al., 2000; Schwartz et al., 1990; Vangeepuram, Galvez, Teitelbaum, Brenner, & Wolff, 2012). Bowatte et al. (2015), in a systematic review and meta-analysis of birth cohort

[1] The authors of this report are sensitive to the use of labels to describe people. However, when making comparisons it is useful to categorize individuals (e.g. by race or ethnicity, sexual orientation, income, etc.). According to the American Psychological Association, both the terms "Black" and "African American" are widely accepted. For consistency, we use the term "Black" (except where citing a source that uses a different term).

studies, found a significant positive association between exposure to traffic related air pollution (TRAP) and asthma prevalence. Newman et al. (2014), in a longitudinal cohort study, established a significant association between TRAP and increased hospital readmission rates for asthma among White children, with a high overall hospital admission rate, but no clear association with TRAP among African American children (Newman et al., 2014).

Consistent with research by Bellin et al. (2014), Newman et al. (2014) draw attention to the social and environmental factors, other than TRAP, that play a major role in determining asthma severity among minority populations. Stevenson et al. (2001) used the National Health and Nutrition Examination Survey (1988 – 1994) to analyze the racial differences in asthma prevalence in relation to allergen sensitivity. Their findings indicate that similar to the trends found in asthma morbidity, African American and Mexican American children are significantly more sensitized to asthma inducing allergens as compared to White children (Stevenson et al., 2001). Holt, Theall, & Rabito (2013) explored the impact of environmental exposures at the individual and neighborhood levels using the Fragile Families and Child wellbeing (longitudinal) study data in a multilevel logistic regression (Holt et al., 2013). Their findings indicate that in addition to the widely established correlates of asthma prevalence such as low parental educational attainment, low socioeconomic status and exposure to tobacco smoke, a significant correlation exists between asthma prevalence and deteriorating interior and exterior housing, vacant lots or nearby homes in poor condition, cockroach and mice allergen presence and lack of health insurance (Holt et al., 2013).

Caregiver's psychological health cuts across the social, environmental and psychological dimensions of asthma management and has been increasingly identified as a key factor in asthma-related morbidity (Weil et al., 1999). Weil et al. (1999) found that not only is caregiver's mental health highly correlated with the mental health of the child, caregiver's psychological factors and life stress are directly associated with child hospitalizations and asthma morbidity (Weil et al., 1999). Koinis-mitchell et al. (2014) expanded on the significance of psychological stressors and claimed that children with high neighborhood and family stress have poorer asthma control (Koinis-mitchell et al., 2014). Adding to the wide array of existing literature on psychological determinants of asthma, Wing, Gjelsvik, Nocera, and McQuaid (2015) explored the relationship between 'Adverse Childhood Experiences' (ACEs) and parent reported asthma prevalence among children (Wing et al., 2015). In addition to a direct correlation between the number of ACEs and asthma prevalence, Koinis-mitchell et al. (2014) also identified culturally specific stressors such as discrimination and acculturative stress that lead to asthma-related mortality among children belonging to racial minorities (Koinis-mitchell et al., 2014). Conversely, Exley, Norman and Hyland, in a systematic review of twelve studies addressing the impact of ACE's on asthma incidence, found that in the absence of environmental risk factors, ACE's have no independent impact on asthma (Exley, Norman, & Hyland, 2015).

More recently, researchers have sought to adopt a more holistic approach by combining the impact of psychological and environmental factors. Subramanian and Kennedy (2009) used the National Survey of Children's Health (2003-2004) data to confirm a strong negative relationship between parents' perception of neighborhood safety and reported lifetime asthma among children. These findings were

replicated by Kopel et al. (2015) using data from an ongoing asthma study School Inner City Asthma Study (SICAS). Similarly, Quinn, Kaufman, Siddiqi, and Yeatts (2010) identified housing security, mobility, comfort, safety, finances, dynamic household membership, and relationships with neighbors and landlords as 'social pollutants' that influence immunological and behavioral pathways to health for children. Sato et al. (2013) complemented this research by highlighting the importance of home environment in asthma management, and the role of a structured family systems in care provision (Sato et al., 2013).

Physiological risk factors and their correlation with asthma have received significant attention over the years leading to the emergence of a variety of research findings. A range of studies have explored the association between obesity and asthma; however, the large number of confounding variables has led to skepticism on the validity of the association (Chinn, 2003). Schachter, Salome, Peat, & Woolcock, (2001) in a study exploring the association between obesity and asthma found that obese people with symptoms of dyspnea and wheeze were often misdiagnosed and prescribed medication for asthma, which in itself could create adverse health consequences (Schachter et al., 2001). Conversely, high intake of excess free fructose found in non-diet soda and other artificially sweetened beverages has been shown to increase the likelihood of asthma among children, while the high consumption of fructose and sweetened drinks has been widely linked to the high rates of obesity (Bray, Nielsen, & Popkin, 2004; DeChristopher, Uribarri, & Tucker, 2015; Ludwig, Peterson, & Gortmaker, 2001). Asthma among children with cognitive disability was examined by Kotey, Ertel and Whitcomb (2014) in a study analyzing children diagnosed with Autism Spectrum Disorder (ASD). Their findings reflected that children with ASD were more likely to develop asthma, however, a dearth of research on this linkage precludes the possibility of confirming it with certainty (Kotey et al., 2014).

A widely studied physiological risk factor for asthma is prenatal exposures, preterm birth and low birth weight. A meta-analysis exploring the association between environmental and lifestyle exposures in utero and subsequent asthma prevalence in children found a positive association between maternal obesity, gestational weight gain during pregnancy and asthma in children (Forno, Young, Kumar, Simhan, & Celedon, 2014). Schwartz et al. (1990) identified young maternal age at the time of birth, low birth weight and lack of breast feeding as strong predictors of subsequent childhood asthma. A meta-analysis conducted by Li, Peat, Xuan and Berry (1999) concluded that children whose parents smoke are approximately twice as likely to develop a serious respiratory infection, a significant known factor leading up to potential exacerbation of asthma symptoms (Li et al., 1999; WebMD, 2015). Maternal environmental chemical exposures during pregnancy, prenatal and post natal exposure to (maternal) tobacco smoke have also been identified as prominent risk factors for asthma development in children at various stages of life (Alati, Al Mamun, O'Callaghan, Najman, & Williams, 2006; Burke et al., 2012; Smit et al., 2015).

Due to the high concentration of low income racial minorities in urban areas, inner cities comprise concentrated pockets of children with issues related to routine access to health care, and consequently higher ED visits (Sato et al., 2013). Akinbami et al. (2014) analyzed asthma care provision trends between 2000 and 2010 and found that Black children had higher rates of ED visits than White children,

and were more likely to have more severe asthma symptoms upon hospitalization (Lara J. Akinbami et al., 2014; Bai, Hillemeier, & Lengerich, 2007). Kit, Simon, Ogden and Akinbami (2012) associated decreased childhood asthma morbidity and better asthma management to more prevalent use of controller medication. In this context, stark differences persist in the use of controller medication (such as Inhaled Cortico-Steroids (ICSs)) along racial lines with children belonging to minority groups faring significantly worse in asthma management than White children (Crocker et al., 2009; Kit et al., 2012).

Community Health Workers

The American Public Health Association (APHA) defines community health workers (CHWs) as:

> frontline public health workers who are trusted members of and/or have an unusually close understanding of the community served. This trusting relationship enables CHWs to serve as a liaison/link/intermediary between health/social services and the community to facilitate access to services and improve the quality and cultural competence of service delivery. CHWs also build individual and community capacity by increasing health knowledge and self-sufficiency through a range of activities such as outreach, community education, informal counseling, social support and advocacy (APHA, 2014. pp. 1).

In addition to this broad deifintion, individuals who do similar work as CHWs are often also labeled as promotores, lay health advisors, and community health educators, to name a few (Alvillar, Quinlan, Rush, & Dudley, 2011).

The lack of a standardized definition for CHWs in the United States precludes the possibility of conclusively determining their total number (Kash, May, & Tai-Seale, 2007). Furthermore, while a wide range of training and certification programs exist in a number of states across the country, no standard certification has been developed to ensure acquisition of streamlined caregiver skills, and several states do not have formal training or cerification program in place (Kash et al., 2007). Community health workers have been found to be effective across a range of health outcomes, leading to improved access to care, appropriate use of services, and improved knowledge and behavior of patiants (Zuvekas, Nolan, Tumaylle, & Griffin, 1999). CHWs have been most engaged and successful in health promotion, prevention measures, health education and chronic disease management (Whitley, Everhart, & Wright, 2006). CHWs reduce overall health care costs by preventing conditions from exacerbating to the point where emergency care is needed, and can also act in the capacity of health system navigators for patients (Alvillar et al., 2011; Zuvekas et al., 1999). However, ambiguity regarding the roles and functions for CHWs, absence of streamlined training and certification programs, and lack of formal, sustainable funding mechanisms leaves this resource largely untapped (Whitley et al., 2006). While efforts to incorporate CHWs into formal public health interventions and health care delivery processes have been underway for over a decade, challenges persist in determining the overall impact of CHWs on improving overall health outcomes in the country (Kash et al., 2007)

Community Health Worker based Interventions in relation to Asthma

A range of literature in relation to public health has explored and advocated for the benefits of employing CHWs in large scale community health initiatives, particularly asthma management

(Friedman et al., 2006; Thyne, Rising, Legion, & Love, 2006). A review of literature on CHW-based asthma management shows that these interventions are almost always geared towards low income communities, employ a variety of lay or semi-skilled health workers to act as intervention agents, and singularly define specific roles and functions for CHWs based on pre-existing asthma management models (Evans et al., 1999; Fisher et al., 2009; Parker et al., 2007; Thyne et al., 2006). The wide variety of intervention techniques, instruments, populations and loosely defined role of CHWs precludes the possibility of a systematic, comparative review of the interventions identified. For the purposes of this report, the studies and interventions identified met the following criteria:

> Randomized control trials or randomized crossover studies analyzing the overall impact of CHWs[2] on asthma-related morbidity, severity of symptoms (asthma) or asthma-related hospitalizations among children and adolescents.

Krieger, Takaro, Song and Weaver (2005), in a widely cited randomized control trial 'Seattle-King County Healthy Homes Project' tested the hypothesis that a high intensity (up to eight visits per year) home based intervention using CHWs would be more impactful in controlling asthma among children between four to fourteen years of age, as compared to a low intensity intervention (one visit per year). The design of the intervention included support from the CHWs in the form of resources[3], educational material and counselling with the high intensity group receiving significantly more of each as compared to the low intensity group. The most significant outcomes of the intervention were described as substantially greater benefits to the high intensity group in terms of improved caregiver quality of life, declining use of urgent health care services, and decrease in the number of (asthma) symptom days. This study design was replicated by Celano, Holsey and Kobrynski, (2012) using home based family interventions with a higher frequency of visits in high intensity groups and lower frequency in the low intensity group, both implemented through trained asthma counsellors. This study produced similar outcomes as Krieger et al. (2005), with most significant results in improved asthma management and reduced caregiver stress (Celano et al., 2012).

Adapting the basic framework of the Seattle-King County Healthy Homes Project discussed above, Parker et al., (2007) reported the outcomes of 'Community Action Against Asthma; a one year household intervention targeted towards children (7-11 years) with persistent asthma, residing in eastside and southwest Detroit, Michigan (Parker et al., 2007). This intervention aimed to improve children's asthma-related health by reducing household environmental triggers. The CHWs were trained on behavior change models, "[..] clinical aspects of asthma; allergens (dust mites, cockroaches, pets,

[2] The term 'community health worker' was not deconstructed in the analysis. Interventions studied in this review included CHW's who were masters level social workers, nurses, psychiatrists as well as lay health workers with some basic training.

[3] The resources provided to high intensity groups included allergy control pillow and mattress encasements, low-emission vacuums, commercial-quality door mats, cleaning kits. The counseling and education resources included; referral to smoking cessation counseling, roach bait, rodent traps, assistance with roach and rodent eradication, encouragement for improved housing conditions and free skin-prick allergy testing at multiple clinic sites. The low intensity group only received a home environmental assessment, an action plan, limited education, and bedding encasements

rodents, mold and mildew) and their relationship to asthma; ETS, risks and strategies to reduce exposure; household chemicals and their risks and uses; strategies for reducing environmental triggers (both ETS and allergens) for asthma; tenants' rights; accessing the medical care system; and provision of referrals for a range of issues, such as enrollment in medical care, tenants' rights, food banks, and help with paying electricity bills" (Parker et al., 2007. pp. 379). Evaluation showed that the program reduced two out of eight reported asthma outcomes ("cough that won't go away," "coughing with exercise") and had a discreet effect on reducing unscheduled health care utilization, improving medication use and decreasing depressive symptoms among caregivers (Parker et al., 2007). However, it was unsuccessful in creating consistent environmental effects such as reducing indoor asthma allergens (Parker et al., 2007).

Bryant-Stephens, Kurian, Guo and Zhao (2009) used a randomized crossover design to examine the impact of an intervention targeting family empowerment through education and environmental resources, on asthma symptom control and emergency health service utilization among children between two to sixteen years of age residing in west or southwest Philadelphia. Lay health workers were trained on asthma symptom management, environmental asthma trigger removal and adult learning styles, and were expected to educate families on asthma pathophysiology and environmental risk factors in a total of five sessions (Bryant-Stephens et al., 2009). The intervention groups were further provided with a basic set of supplies, similar to ones provided by the interventions discussed above (Bryant-Stephens et al., 2009; J. W. Krieger et al., 2005). In the six-month post intervention follow up period, the intervention had a clear positive impact on reducing certain environmental triggers such as dust antigen, better management of asthma symptoms and complemented the results of earlier studies by also reducing ED visits (Bryant-Stephens et al., 2009; Parker et al., 2007). This study also found that the relationships the lay health educators were able to establish with the caregivers positively impacted asthma outcomes in this disadvantaged population (Bryant-Stephens et al., 2009).

Fisher et al., (2009) evaluated the effectiveness of CHWs in being able to reach low-income parents of African American children (two to eight years of age), who were Medicaid enrollees hospitalized for asthma. The focus of this intervention was to reduce re-hospitalization among the targeted population. A randomized control study design was used to isolate the impact of this two-year asthma coach intervention in an urban children's hospital in St. Louis City and County (Fisher et al., 2009). The CHWs used in this intervention were expected to reinforce basic asthma education among the targeted communities and were African American women with high school education, residing in the same area as the target population (Fisher et al., 2009). The CHWs conducted home visits and made phone calls tailored to parent's need and willingness to adopt asthma management practices, providing a broad framework of support and expertise (Fisher et al., 2009). The study concluded that an asthma coach can reach low-income parents of African American children hospitalized for asthma and reduce re-hospitalization significantly among children from targeted families (Fisher et al., 2009).

A body of research also exists on the impact of home based asthma interventions with clinical specialists, nurses, psychiatrists or a combination of two as the intervening agents instead of lay health workers. Brown et al. (2002) used a sample of primarily African American children, ages one to three, recruited from asthma specialty clinics and primary care pediatricians serving low income populations in

Atlanta (Brown et al., 2002). Registered nurses delivered the package of home based interventions which comprised of educational materials tailored to meet the culturally specific needs of the African American families, over eight, 90-minute sessions (Brown et al., 2002). From among the outcome measures analyzed, families in the intervention group were more likely to have decreased asthma morbidity and improved caregiver quality of life (Brown et al., 2002). The study also drew attention to the role trained home based nurse educators can play as liaisons between the family and the physician to enhance communication regarding asthma-related control practices and disease management (Brown et al., 2002).

The impact of CHWs in settings where children have access to asthma education through nurses as well as community resources was analyzed by Krieger, Takaro, Song, Beaudet and Edwards (2009) in a randomized control trial. Children recruited into the sample were between three and eleven years of age, residents of King County, Washington, and Medicaid enrollees. CHWs provided educational resources, psychological counselling for caretakers as well as bedding encasements, vacuum bags, cleaning kits and a vacuum cleaner (J. Krieger et al., 2009). Consistent with the findings of earlier randomized control trials, Krieger et al. (2009) found that support from CHWs in home based self-management, in addition to in-clinic nurse education, improved asthma control as well caretakers' reported quality of life (Krieger et al., 2009).

Three pre-post studies also confirmed the positive impact of culturally competent CHW interventions on decreasing ED visits (Margellos-Anast, Gutierrez, & Whitman, 2012). Thyne et al. (2006) outlined the design and implementation of the 'Yes We Can' Urban Asthma partnership and documented the implementation of a CHW intervention in San Francisco, with structured training from the Francisco State University and the City College of San Francisco (Thyne et al., 2006). Primomo, Johnston, DiBiase, Nodolf, & Noren, (2006) observed similar patterns in a pre-post intervention study design and concluded that CHWs play a defining role in providing key information to families regarding asthma management that in turn enables them to communicate with providers more effectively (Primomo et al., 2006).

Primary Care Practice Enhancements and Community Health Worker Interventions

Practice Enhancement in primary care settings, particularly in pediatrics is designed to provide a "medical home" model of care by fostering partnerships among patients, physicians and available community resources (Patient Centered Primary Care Collaborative (PCPCC), 2014). The goal of this approach is to provide coordinated care to patients by improving awareness of and access to available community resources, while also increasing patients understanding of the healthcare delivery system (PCPCC, 2014). Community Health Workers are ideally placed to fulfil this function and act as liaisons between clinicians and patients. CHWs can potentially facilitate patient self-management, particularly in instances of chronic conditions such as asthma (Blackman & Scotti, 2015). They can also assist patients in accessing appropriate clinical services while also decreasing costly and unnecessary hospitalizations. Furthermore, CHWs are known to strengthen care provider's understanding of communities. This can have important implications for creating culturally competent clinical environments for patients and improve communication between patients and providers (Blackman & Scotti, 2015).

Practice enhancement through CHWs occurs by providing patients the information they need to navigate the health care system as well as by providing the providers with relevant information about the communities they cater to. Research pertaining to the effectiveness of both of these phenomena is present, however only recently have the services provided by CHWs been incorporated into care delivery protocols through streamlined funding mechanisms such as Medicaid (CDC, 2011). CHWs have played the role of navigators in multiple childhood asthma-related interventions, dating as far back as 1994, by helping connect caregivers with appropriate providers and health services. Butz et al (1994) document a widely successful home visit program conducted by CHWs to provide basic asthma education to caregivers with respect to environmental triggers and asthma control. A major component of this intervention was CHW facilitation of patient access to primary health care professionals. One in four cases (families) of the target population lacked access to a primary care practitioner and required a CHW to arrange an appointment (Butz et al., 1994). Furthermore, CHWs kept the primary care provider of the respective patient informed of the child's symptoms, medication use and number of ER visits and hospitalizations by communicating a summary report of the home visit (Butz et al., 1994). Friedman et al. (2006) also document 'Care Coordination' as a major component of the Allies CHW programs in addition to asthma education, home visits and environmental trigger reduction (Friedman et al., 2006). Facilitating appointments with care providers and connecting families with external services and resources were described as some of the major roles undertaken by CHWs (Friedman et al., 2006).

More recently an intervention using the CHW model targeting African American children in Chicago also comprised of two main components; home visits for asthma education and CHW facilitation of a relationship between patient and provider (Margellos-Anast, Gutierrez, & Whitman, 2012). The CHW assessed if the participant children had an appropriate level of interaction with their physicians and if not, CHWs offered assistance toward doing so. Furthermore, the CHW, in consultation with the appropriate care provision staff, also provided basic case management services when needed.

The increasing importance of CHWs to address health disparities in pediatric asthma has been well established in literature. However, integration of CHWs into different modes of formal care delivery system has been a slow process. A case study conducted by Matiz et al. (2014) investigates the potential of integration of CHWs into Patient Centered Medical Homes (PCMH) for the delivery of comprehensive asthma care among Latino children (Matiz et al., 2014). The study uses results from the assignment of CHWs for two sessions a week, to families receiving care at five different PCMHs, over a course of two years (2011 – 2013) (Matiz et al., 2014). CHWs documented the encounter with the family, as well as the information collected on an interactive form (shared in real time with the PCMH healthcare team) (Matiz et al., 2014). The results of the study support earlier postulations of increased support and comprehensive care delivery for asthma patients through CHWs (Matiz et al., 2014). Adherence to asthma management plans by patients and caregivers increased from five percent at baseline to 39 percent at the end of the intervention. The study proposes that CHWs, when integrated into healthcare delivery systems, have immense potential in terms of being able to assess and identify high-risk populations for care coordination, and share this information directly with the provider (Matiz et al., 2014). The authors also refer to the resistance to recognizing the role of CHWs from the medical personnel in the PCMH, and the significance of understanding the strengths and weaknesses of CHWs as

being essential to the process of integration (Matiz et al., 2014). Finally, the study points to an important aspect of provider incentive in the establishment of an integrated care delivery system; CHWs act as advocates for the patients and their families and by the nature of their relationship with patients, earn their trust. This relationship can be used to establish the legitimacy of the care provider among the population it aims to serve.

Summary

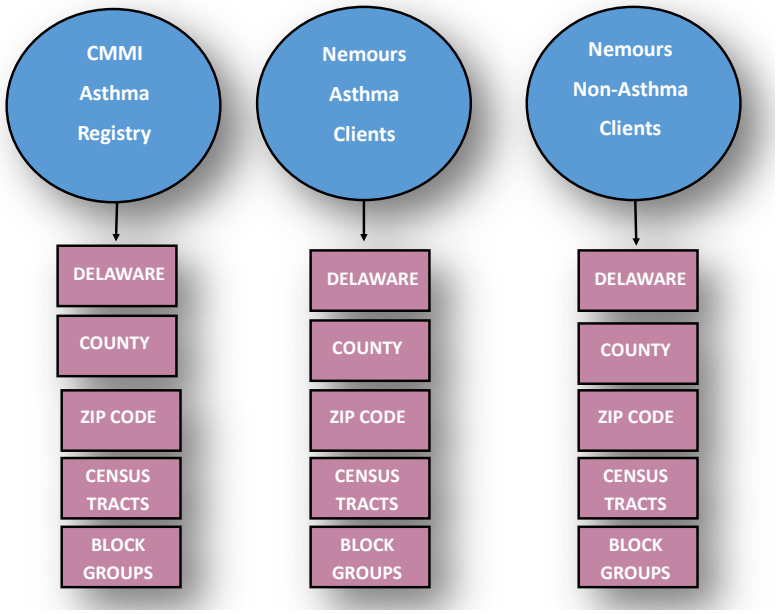
Asthma-related morbidity is one the most prevalent chronic conditions among children in the United States. It is also the third leading cause of hospitalizations among children and costs up to $56 billion in direct costs through healthcare use and indirect costs through missed school days and loss of productivity (Barnett & Nurmagambetov, 2011; Hall, DeFrances, Williams, Golosinskiy, & Schwartzman, 2010). While the causes of asthma are multifaceted, certain known risk factors have proven to be amenable to intervention to reduce asthma-related mortality and morbidity. A review of literature in the field suggests that the most common and effective avenues for intervention are reducing environmental triggers (such as cockroaches and dust mites) and asthma management (use of controller medication). The rising costs of hospitalizations and ED visits, particularly among children, has brought the effectiveness of CHW-based interventions to manage asthma-related morbidity and severity of disease into the limelight.

Given the disparities in asthma prevalence rates among children belonging to minority groups, certain localities and population groups have increasingly been identified as high-risk for negative asthma outcomes. The utility of CHWs in reducing health care costs has been increasingly recognized, with multiple states establishing formal training and certification programs. However, in order to incorporate CHWs into the formal healthcare system for asthma management and treatment, sustainable funding mechanisms in the form of federal and state funded programs (Medicaid and CHIP) as well as private health insurance providers must be established. CHW-based interventions, appropriately tailored to address the needs of the community, are shown to be effective in producing positive asthma outcomes. The components, mode of delivery and duration of these interventions vary widely, and are shown to have varying degrees of effectiveness in improving outcomes. There exists an ample amount of literature in the field of public health to design consolidated asthma-related intervention programs including CHW training for future programs.

Methodology

We analyzed health services utilization data for children, ages 2 through 18, covered by Medicaid and receiving care with the Nemours pediatric health system between 2010 and 2014. Client data provided by Nemours were aggregated into three exclusive groups: (1) children on the CMMI asthma registry; (2) children not on the registry but who had received at least one asthma diagnosis; (3) children who were Nemours clients but had not received an asthma diagnosis (Figure 1).

Figure 1. CMMI Study Groups

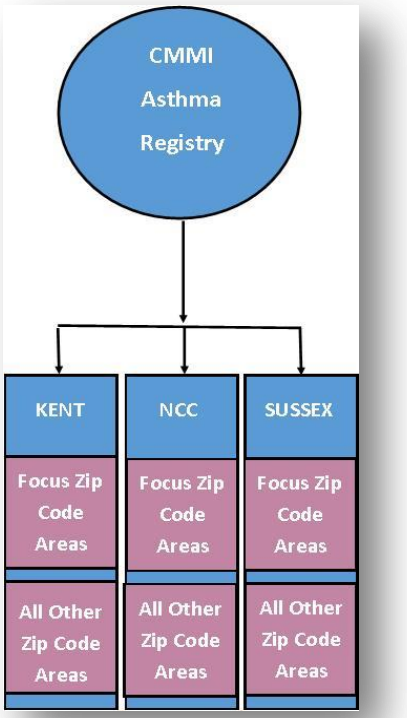


The following variables were provided for each group: (1) Medicaid Identification Number or Subscriber Number, (2) Child's name, (3) Child's address, (3) Managed Care Organization, and (4) Client birth date. For those children on the Asthma Registry additional variables about number of community health worker visits were also provided.

Health utilization variables were generated for each of the three groups and broken down by county, zip code, census tracts and block groups. For geographic areas where there were too few individuals in the breakdowns, numbers were suppressed according to confidentiality rules for the use of medical claim data. In order to provide census tract and block group information, addresses were geo-coded using ArcMap and then aggregated to the census tract and block group level. The success rate of geocoding was 87% for the registry clients and 92% for the other two groups.

In order to match the Nemours clients to the Medicaid data, a common field needed to be present. The variable Medicaid Identification number (MID) was used to link the two data sets. For the registry clients, a small number of MIDs (52) were missing and were able to be identified by searching the Medicaid client data by name. For the Nemours asthma clients not on the registry, 49% did not have MIDs and instead had only subscriber numbers. One of the larger managed care organizations tracks their clients through subscriber numbers rather than MIDS. The majority of the clients with missing MIDS were able to be identified and only 1.6% was not found. The Nemours non-asthma clients had 42% of the clients with missing MIDs; after matching, only 1.9% were left as unidentified. Those labelled as "unidentified" resulted from not being able to link a client name and birth date with the Medicaid client files.

Figure 2. CMMI Registry Analysis Areas



Preliminary data generated for the registry clients by zip code indicated that many of the counts per zip code would have to be suppressed due to the small number of clients residing there. Because of the small populations in certain zip code areas, Nemours decided that the areas would be divided into focus zip code areas, which would then be compared to other zip code areas in the county. More specifically, the CMMI project focused its efforts, according to need, on the following aggregated zip code areas:

Aggregate zip codes 19801 and 19802; compared to the rest of New Castle County

Aggregate zip codes 19901 and 19904; compared to the rest of Kent County

Aggregate zip codes 19956 and 19973; compared to the rest of Sussex County

We generated zip code, census tracts, and block group counts for the registry clients, but it was agreed that most of the analysis would focus on the aggregations and comparisons outlined above and in Figure 2. Location of the zip code areas are shown in Figure 3.

Using the MID, we were able to link the three different groups with Medicaid prescription and medical claims data in order to measure the health utilization of these groups. We examined the following variables for each population group:

(1) Number of and billed amount for medical visits
(2) Number of and billed amount for medical visits – asthma-related
(3) Number of and billed amount for ED visits
(4) Number of and billed amount for ED visits – asthma-related
(5) Number of and billed amount for hospitalizations
(6) Number of and billed amount for hospitalizations – asthma-related
(7) Number of and billed amount for urgent care/outpatient visits
(8) Number of and billed amount for urgent care/outpatient visits – asthma-related
(9) Number of and billed amount for physician visits
(10) Number of and billed amount for physician visits – asthma-related
(11) Number of and billed amount for prescriptions
(12) Number of and billed amount for prescriptions – asthma-related
(13) Total billed amount
(14) Total billed amount – asthma-related

For the emergency department and hospital utilization analysis that follows, paired t-tests were performed comparing the means between the baseline and in the intervention period and between the years 2013 and 2014. In addition, a preliminary regression analysis was performed. Although utilization

appeared to differ in many instances, the preliminary statistical analysis did not show any statistical significance.

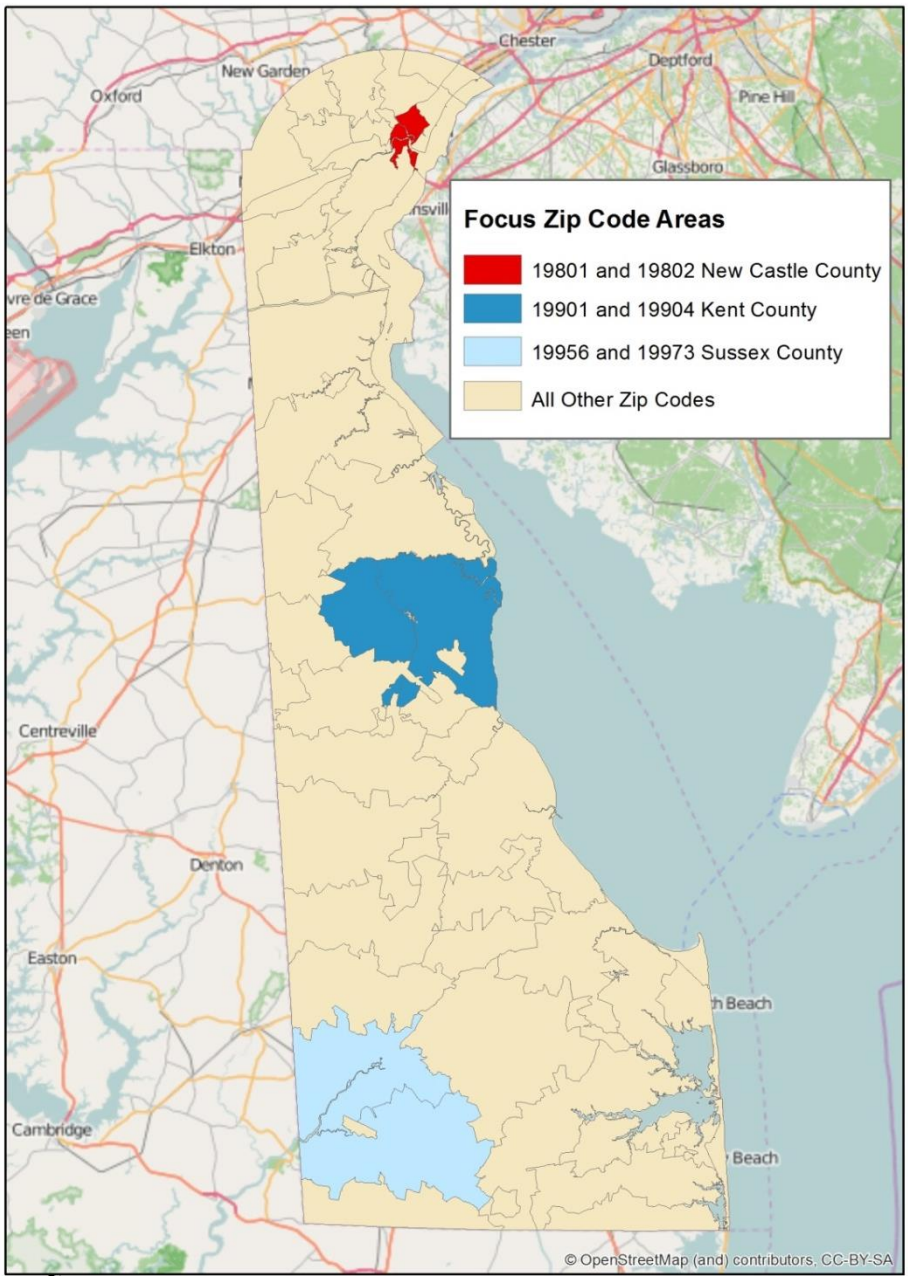


Figure 3. Registry Focus Zip Code Areas

Our analysis produced summary tables for the different geographic areas according to these variables. For the registry clients, breakdowns by gender, age group, and race were also provided. Finally, we generated utilization tables according to the number of community health worker visits. Where appropriate, we present utilization and cost across two distinct time periods, meant to represent baseline and the intervention period. A summary of empirical findings follows. (More detailed reports,

including data describing monthly utilization on each of the variables described above, were shared with Nemours on a regular basis throughout the study period.)

Summary of Empirical Findings

This section presents highlights of our analysis of the patterns of healthcare utilization and related costs for children with asthma in the Nemours health system between 2010 and 2014 focusing on emergency department use and hospitalization. Figures and charts in this section are drawn from a more comprehensive set of data tables which have been submitted to NHPS under separate cover in excel format.

Demographic Description

Table 1 shows the demographic characteristics of Nemours clients on the asthma registry. Approximately 60% of the registry clients lived in one of the focus areas, with almost one-fourth residing in the Sussex focus area. As seen in this table, the majority of clients with severe asthma in the Nemours system are male, five years or older, Black or African American and non-Hispanic. When examining the demographic breakdown by focus areas, the age distribution is relatively consistent; however, the proportion of males and Black or African Americans varies more by region. The Kent focus and non-focus areas have a larger proportion of males; the New Castle (NC) areas have a high proportion of Black/African Americans; the Sussex areas are the only areas with a countable Hispanic population. While not all clients participated in Medicaid (as indicated by the existence of a medical claim for the year) in all years of our study period, the demographic profile remains constant.

Table 1. Demographic characteristics of asthma registry clients

Demographic Grouping	Total N=731 (100%)	Kent Focus (18.5%)	NC Focus (17.3%)	Sussex Focus (23.9%)	Kent Non-Focus (11.6%)	NC Non-Focus (12.9%)	Sussex Non-Focus (15.9%)
Age Group							
2 -4 year olds	20.4%	26.1%	24.0%	14.5%	26.2%	17.2%	17.4%
5-9 year olds	45.3%	39.6%	44.0%	52.6%	38.1%	47.3%	46.1%
10 - 17 year olds	34.3%	34.3%	32.0%	32.9%	35.7%	35.5%	36.5%
Gender							
Males	64.0%	70.1%	55.2%	60.1%	71.4%	66.7%	64.3%
Females	36.0%	29.9%	44.8%	39.9%	28.6%	33.3%	35.7%
Race							
Black	63.5%	75.4%	>=90%	48.0%	34.5%	>=85%	36.5%
White	22.9%	11.9%	n/d	31.8%	48.8%	n/d	38.3%
Other	13.6%	12.7%	n/d	20.2%	16.7%	n/d	25.2%
Ethnicity							
Hispanic	7.3%	n/d	0.0%	8.7%	n/d	n/d	18.3%
Not Hispanic	91.4%	>=90%	100.0%	87.3%	>=90%	>=90%	80.0%

n/d = not disclosed due to confidentiality.
Source: Raw data provided by Nemours Health and Prevention Services (NHPS). Center for Community

Research & Service, 2015.

Figure 4 shows asthma registry clients by zip code. As seen on this map, the dark shaded regions indicate particularly high prevalence of severe asthma as reflected by participation on the registry and coincide with the focus zip code areas shown in Figure 3 above.

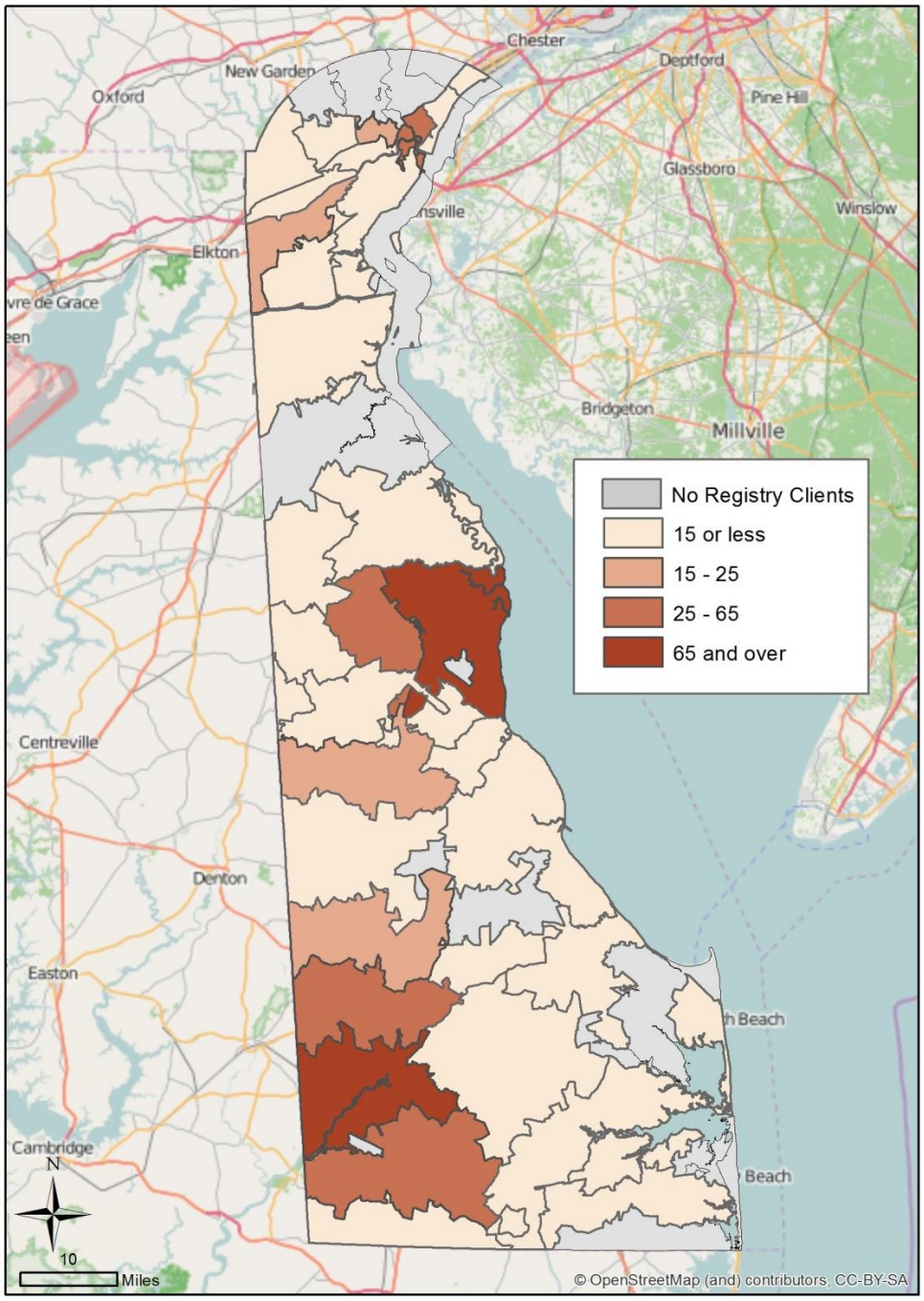


Figure 4. Registry clients by zip code

Table 2 shows the demographic characteristics of Nemours clients with asthma, but not included in the registry, as well as all other Nemours clients covered by Medicaid. As seen in this table, the majority of clients in both non-registry groups are Black or African American, though the percentages are not as high as those on the registry.

Table 2. Demographic characteristics of non-registry clients, 2011-2014

Demographic Grouping	Nemours Clients with Asthma Diagnosis (not on registry) N=4,876	All other Nemours Clients (non-Asthma, non-registry) N=13,191
Age Group		
2 -4 year olds	27.4%	22.2%
5-9 year olds	38.9%	37.3%
10 - 17 year olds	33.6%	40.6%
Gender		
Males	54.2%	48.5%
Females	45.8%	51.5%
Race		
Black	57.2%	51.2%
White	21.8%	26.8%
Hispanic	18.7%	19.4%
Other	2.3%	2.6%
The ethnicity variable was not provided separately by NHPS. In the Medicaid data, ethnicity is merged with the race variable. *Source: Raw data provided by Nemours Health and Prevention Services (NHPS). Center for Community Research & Service, 2015.*		

Healthcare Utilization and Costs of Asthma Registry Clients and Comparison Groups

Analysis of Registry Clients Only

Our analysis of the utilization and associated costs of care for children with asthma focused on claims for services provided in the emergency department (ED), as well as inpatient hospitalizations, as these where the services most likely to be impacted by the intervention. Table 3 shows the average (or mean) billed amount for three different service categories for asthma registry clients between 2010 and 2014. As seen in this table, across most regions, the mean billed amount for asthma-related ED utilization appeared to decrease in 2014 even as the mean for all asthma-related utilization, including inpatient hospital utilization, increased each year. However, upon further analysis, we found that the difference between the mean billed amounts for both ED utilization and inpatient utilization in the baseline period (2010-2012) compared with the intervention period (2013-2014) was not statistically significant (for any of the geographic regions).[4]

[4] Because the mean billed amount appeared to change between 2013 and 2014 for some categories, we also conducted paired-t test analyses on these years and found no statistical difference there either.

Table 3. Mean billed amounts for asthma-related utilization across select services, among asthma registry clients, 2010-2014, adjusted to 2014 dollars

	All Medical Utilization		ED Utilization		Inpatient Utilization	
DELAWARE						
2010	878.4		127.9		253.1	
2011	1,286.6		128.0		357.0	
2012	1,830.8		120.0		591.4	
2013	1,834.5		135.4		610.5	
2014	1,957.3		108.9		657.7	
KENT						
	Focus area	**Non-focus area**	**Focus area**	**Non-focus area**	**Focus area**	**Non-focus area**
2010	780.1	814.0	91.9	80.6	222.4	376.9
2011	1,356.6	544.9	115.4	52.8	303.6	64.2
2012	1,474.4	728.9	122.5	25.0	480.8	270.0
2013	1,951.8	1,006.7	133.3	86.7	857.6	457.5
2014	1,672.3	2,155.7	88.2	63.5	801.3	209.3
NEW CASTLE						
	Focus area	**Non-focus area**	**Focus area**	**Non-focus area**	**Focus area**	**Non-focus area**
2010	1,450.9	921.1	251.0	224.5	623.7	245.2
2011	2,672.5	1,707.2	242.5	241.2	1,214.3	464.7
2012	3,219.7	3,251.3	221.7	209.0	1,153.9	1,605.1
2013	2,396.5	3,735.1	223.5	217.4	723.1	1,314.9
2014	4,186.1	2,244.0	250.8	144.2	1,423.4	1,238.0
SUSSEX						
	Focus area	**Non-focus area**	**Focus area**	**Non-focus area**	**Focus area**	**Non-focus area**
2010	570.6	853.0	62.8	82.1	74.8	98.1
2011	843.2	689.5	84.5	45.9	140.2	22.2
2012	1,346.1	1,276.4	59.4	105.3	161.9	236.6
2013	928.4	1,072.1	76.9	82.8	185.7	406.0
2014	625.6	1,490.7	63.0	53.6	18.3	492.6

Mean amounts adjusted for inflation using the CPI for medical services. Amounts in 2014 dollars.
Source: Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences

Figures 5-9 illustrate the overall trends in utilization (as reflected in the mean billed amount) across geographic regions and over time. As seen in these figures, which correspond with the data in Table 3, there were some fluctuations in the mean billed amount that deviated from the overall trends. This variability may be due to issues related to pent-up demand, small sample sizes and natural variability. Additional analysis may help to identify and explain apparent anomalies in the data. Further, although none of the reductions in mean billed amount between the baseline and intervention time periods was statistically significant, a longer period of analysis (based upon a longer time period for the intervention) may reveal positive outcomes.

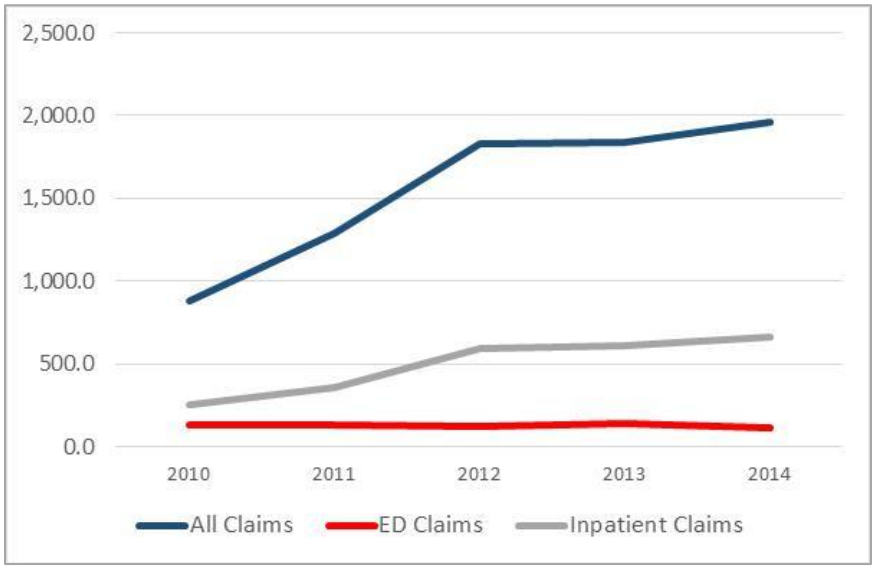


Figure 5. Mean billed amount for asthma-related utilization across select services among asthma registry clients, 2010-2014, adjusted to 2014 dollars

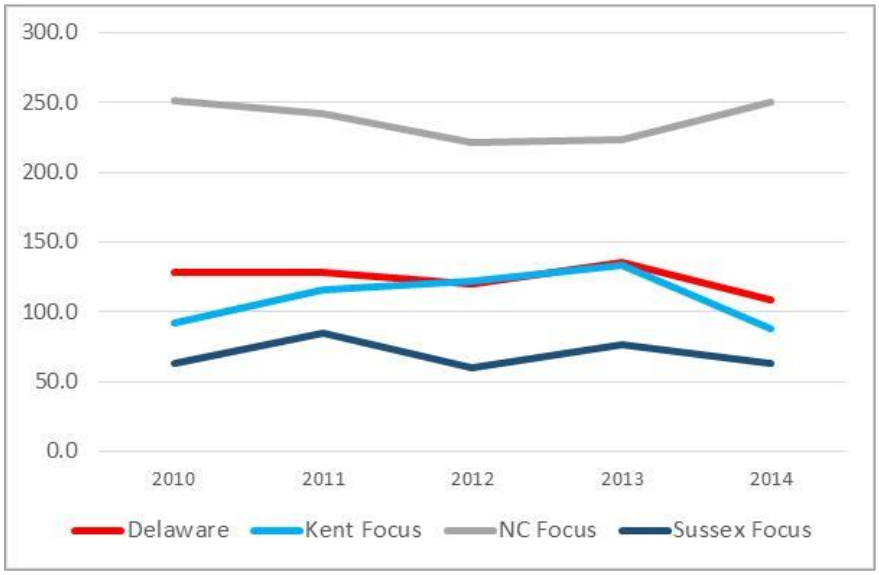


Figure 6. Mean billed amount for asthma-related ED utilization among asthma registry clients, across regional focus areas, 2010-2014, adjusted to 2014 dollars

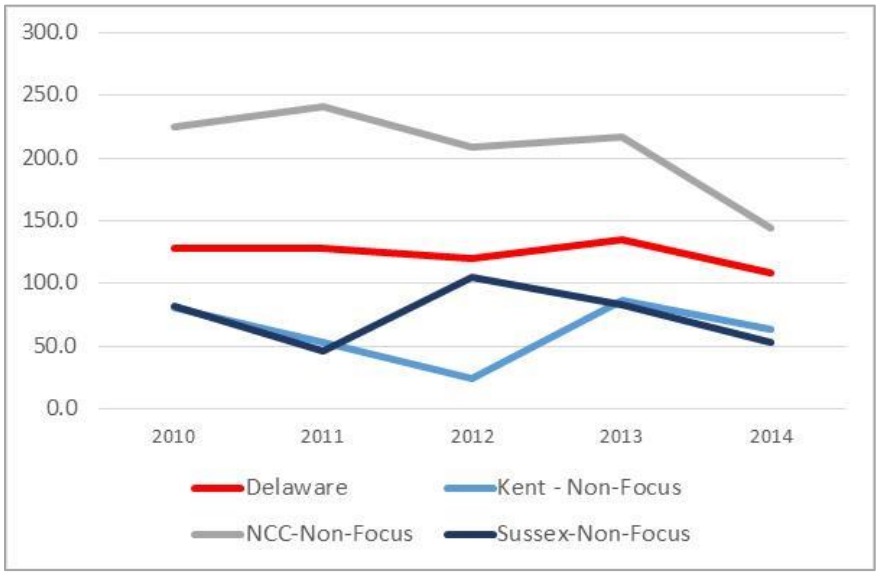


Figure 7. Mean billed amount for asthma-related ED utilization among asthma registry clients, outside of regional focus areas, 2010-2014, adjusted to 2014 dollars

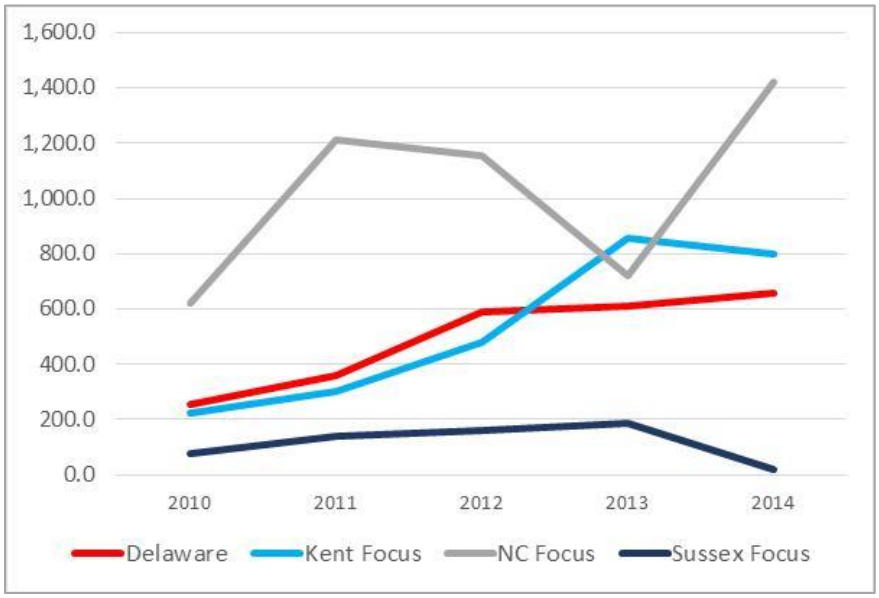


Figure 8. Mean billed amount for asthma-related inpatient hospitalizations among asthma registry clients, across regional focus areas, 2010-2014, adjusted to 2014 dollars

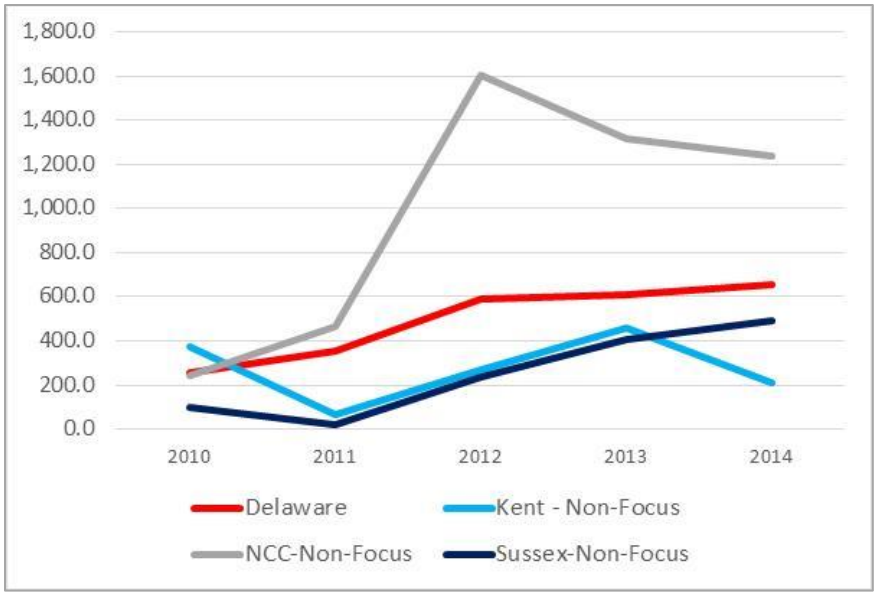


Figure 9. Mean billed amount for asthma-related inpatient hospitalizations among asthma registry clients, outside of regional focus areas, 2010-2014, adjusted to 2014 dollars

Table 4 compares the mean billed amount for asthma-related ED visits and inpatient hospitalizations between the baseline period (2010-2012) and the intervention period (2013-2014) for children on the registry. As seen in this table and Figure 10 that follows, the mean billed amount for ED visits appeared to decline, while the mean billed amount for inpatient hospitalizations appeared to increase. Table 4 also shows the mean number of claims per child during both time periods. As indicated in the table and in the figure, the mean number of claims decreased for both categories of service. Given that the mean billed amount for inpatient hospitalizations increased while the mean number of claims for these services decreased, this indicates that some children had particularly costly inpatient stays even while the average number of stays went down. Further analysis might omit the outliers in the data.

Table 4. Mean billed amount and mean number of claims for selected categories of service at baseline and during the intervention period, among all registry clients

Service Category	**Baseline (2010-2012)**	**Intervention (2013-2014)**
Mean billed amount per child		
ED	$127	$122
Inpatient	$377	$645
Mean number of claims per child		
ED	0.154	0.149
Inpatient	0.161	0.132
Amounts adjusted to 2014 dollars. *Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences*		

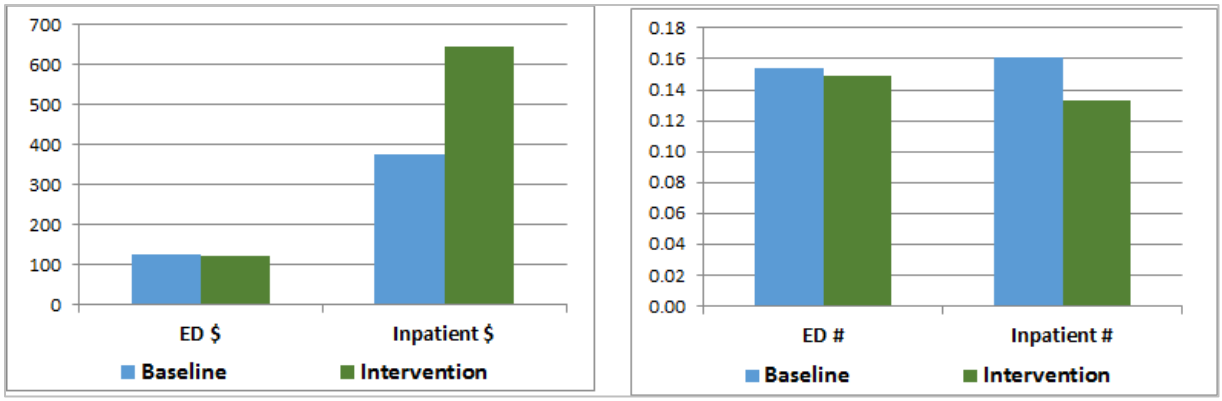


Figure 10. Mean billed amount and mean number of claims at baseline and during the intervention period, among all registry clients

Table 5 shows the mean billed amount and mean number of claims for the selected services among registry clients according to geographic area. As seen in this table and in Figure 11, the mean billed amount for asthma-related ED visits appeared to decrease in the Kent County focus areas, while increasing in the non-focus areas of Kent County, however, this difference was not statistically significant (nor was any other differences by region).

Table 5. Mean billed amount and mean number of claims for the selected services among registry clients according to geographic area, baseline compared with intervention period

Kent Focus				**Kent Non-Focus**		
Billed	Baseline	Intervention		Billed	Baseline	Intervention
Mean billed amount per child						
ED	118.0	104.1		ED	46.6	77.4
Inpatient	348.5	792.2		Inpatient	194.5	343.3
Mean number of claims per child						
ED	0.2	0.1		ED	0.1	0.1
Inpatient	0.3	0.1		Inpatient	0.2	0.1
NC Focus				**NC Non-Focus**		
Billed	Baseline	Intervention		Billed	Baseline	Intervention
Mean billed amount per child						
ED	245.4	242.1		ED	232.2	183.3
Inpatient	987.7	1,120.2		Inpatient	715.6	1,338.7
Mean number of claims per child						
ED	0.2	0.3		ED	0.2	0.2
Inpatient	0.2	0.2		Inpatient	0.2	0.2
Sussex Focus				**Sussex Non-Focus**		
Billed	Baseline	Intervention		Billed	Baseline	Intervention
Mean billed amount per child						

ED	72.6	72.1		ED	67.5	66.5
Inpatient	114.0	104.7		Inpatient	72.1	459.6
Mean number of claims per child						
ED	0.1	0.1		ED	0.1	0.1
Inpatient	0.1	0.0		Inpatient	0.1	0.1

Amounts adjusted to 2014 dollars.
Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences

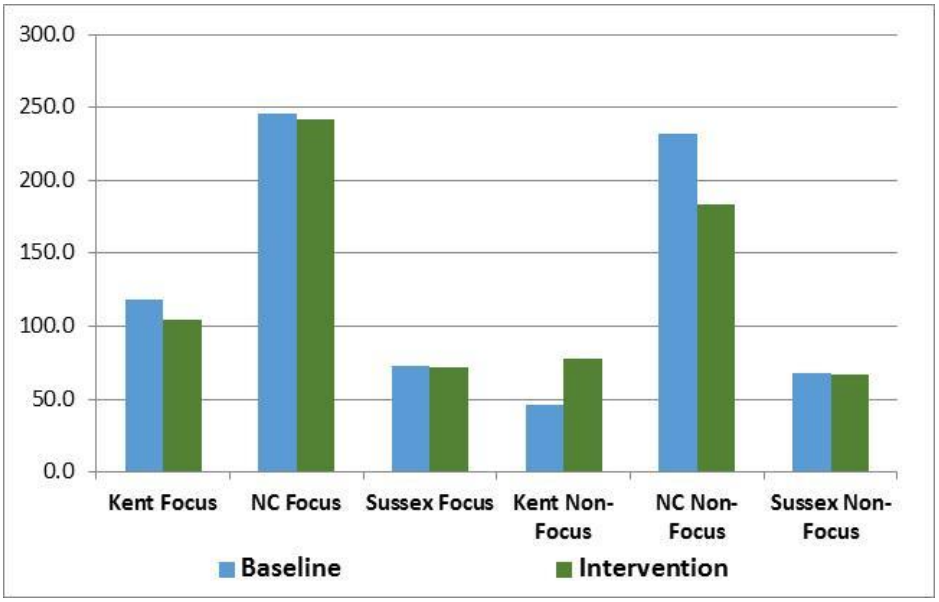


Figure 11. Mean billed amount for asthma-related ED visits at baseline and during the intervention period, among registry clients, according to geographic area, adjusted to 2014 dollars

In order to try to better understand characteristics of ED utilization among registry clients, we analyzed major categories of diagnoses for ED visits (as indicated by ICD 9 diagnoses grouping). Table 6 shows diagnoses for ED visits for the registry clients between 2010 and 2014 (by percent). Asthma diagnoses are included within the respiratory system category. The slight decrease in the proportion of ED visits attributed to the "respiratory system" category may indicate that the intervention is having a positive impact on children with severe asthma.

Table 6. Diagnoses groupings for ED visits among registry clients, Percent, 2010-2014.

ICD 9 Diagnoses Grouping	2010	2011	2012	2013	2014
Digestive System	2.8	2.8	2.5	3.0	3.2
Genitourinary System	1.3	1.3	2.3	2.6	2.0
Infections/Parastic Diseases	2.5	2.4	2.0	2.2	2.3
Injury & Poisoning	23.0	24.6	28.0	29.4	24.3
Musculoskeletal System	2.1	2.1	4.8	2.7	3.3
Nervous System & Sense Organs	5.3	3.7	5.2	4.1	4.7
Respiratory System	25.8	26.6	22.2	23.3	22.4
Skin and Subcutaneous Tissue	1.8	0.1	3.2	1.5	3.0
Symptoms, Signs, Ill-defined conditions	32.3	28.0	25.8	28.3	27.4
Sub-total	96.8	91.5	95.8	96.9	92.6
All Other Classifications	3.2	8.5	4.2	3.1	7.4
Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences					

Table 7 provides information on the mean number of community health worker (CHW) visits for children on the registry according to geographic area. As seen in this table, more than three quarters of the children on the asthma registry living in Kent and New Castle Counties received four or more visits during the intervention period, regardless of whether or not they lived in the focus area zip codes. In contrast, among registry clients in Sussex County, the majority had fewer than four visits.

Table 7. Mean number of community health worker visits among registry clients, across geographic regions, during the intervention period

Number of Visits	Delaware	Kent Focus	NC Focus	Sussex Focus	Kent Non-Focus	NC Non-Focus	Sussex Non-Focus
None	22.1%	6.0%	12.1%	40.6%	2.4%	12.0%	45.6%
One - Three	12.4%	14.2%	12.1%	14.7%	9.5%	10.9%	11.4%
Four or more	65.5%	79.9%	75.8%	44.7%	88.1%	77.2%	43.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences							

Given the evidence that suggests that more visits with a community health worker are associated with reductions in ED and inpatient hospitalizations, we analyzed mean billed amounts for asthma-related claims according to the number of CHW visits. Table 7 shows mean billed amounts for all asthma-related claims, ED claims and inpatient hospital claims by year according to the number of CHW visits. Importantly, the data on CHW visits do not include the exact dates of visits; however, we know that the visits occurred during 2013 and 2014.

Table 8. Mean billed amounts for asthma-related claims across service types, among registry clients, according to the number of CHW visits, 2010-2014

Mean Asthma-related Claims - Billed Amount					
Number of Visits	**2010**	**2011**	**2012**	**2013**	**2014**
None	610.1	847.1	1,026.5	1,021.3	1,461.1
One - Three	1,021.7	1,251.5	2,122.0	828.1	1,756.4
Four or more	941.4	1,451.1	2,062.1	2,283.5	2,152.3
Total	878.4	1,286.6	1,830.8	1,834.5	1,957.3
Mean Asthma-related ED Claims - Billed Amount					
Number of Visits	**2010**	**2011**	**2012**	**2013**	**2014**
None	75.9	60.0	36.3	63.5	70.6
One - Three	84.3	101.5	131.0	74.1	92.4
Four or more	153.8	157.4	147.8	169.7	124.1
Total	127.9	128.0	120.0	135.4	108.9
Mean Asthma-related Inpatient Claims - Billed Amount					
Number of Visits	**2010**	**2011**	**2012**	**2013**	**2014**
None	138.6	385.6	57.1	62.1	177.7
One - Three	311.6	429.3	344.1	43.7	913.3
Four or more	280.4	333.5	831.4	891.8	767.9
Total	253.1	357.0	591.4	610.5	657.7

Amounts adjusted to 2014 dollars.
Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences

Figures 12-14 correspond with the data in Table 8. As seen in Figure 12, the mean billed amount for all asthma-related claims has generally increased over time for all categories of frequency of CHW visits. The figure shows a dip in the mean billed amount in 2013 among registry clients who received between one and three visits, but further analysis is needed to determine if this change meaningful. Figures 13 and 14 show the mean billed amounts for ED visits and inpatient hospitalizations (respectively) over time, according to the number of CHW visits. While the trends for ED visits appear to be relatively flat, it is difficult to draw any conclusions from these data. Similarly, the trend lines for mean billed amounts for inpatient hospitalizations show variability across time and number of CHW visits that is difficult to interpret without further analysis.

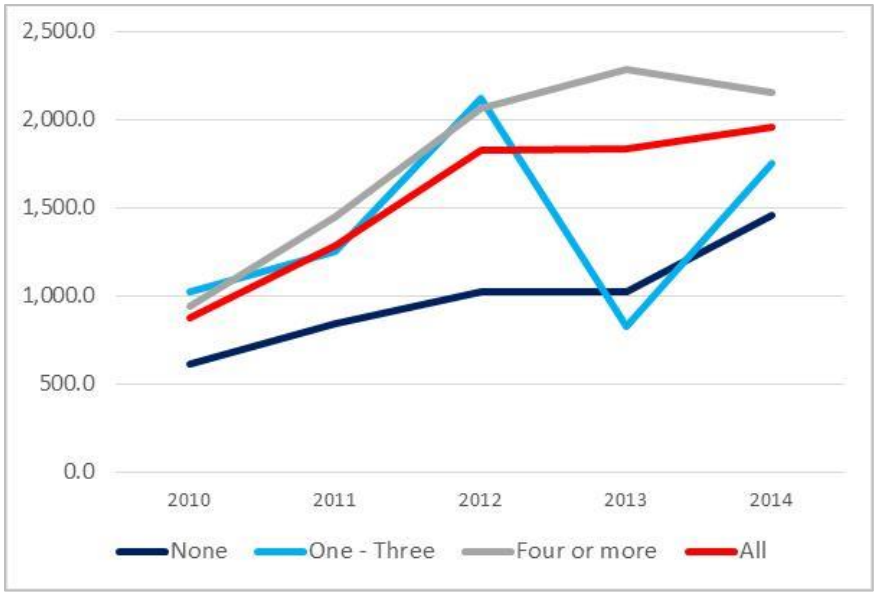


Figure 12. Mean billed amount for all asthma-related claims, among registry clients, according to number of CHW visits, 2010-2014, adjusted to 2014 dollars

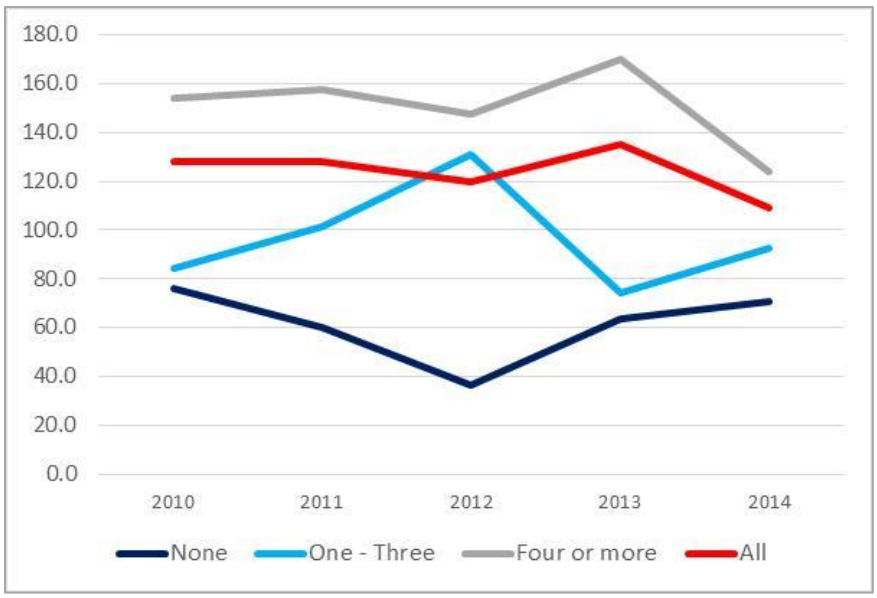


Figure 13. Mean billed amount for asthma-related ED claims, among registry clients, according to number of CHW visits, 2010-2014, adjusted to 2014 dollars

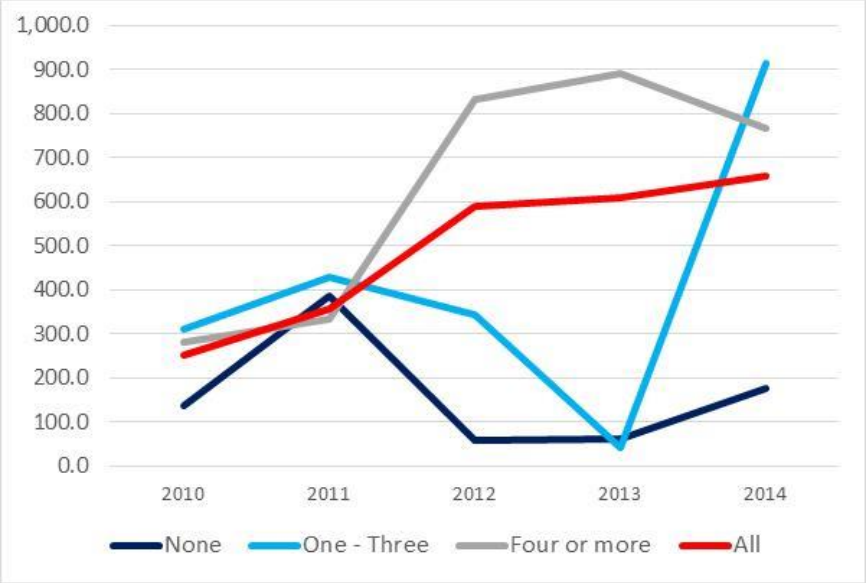


Figure 14. Mean billed amount for asthma-related inpatient hospitalization claims, among registry clients, according to number of CHW visits, 2010-2014, adjusted to 2014 dollars

In Table 9 we have compared the mean billed amounts and mean number of claims during the baseline time period (2010-2012) with the intervention period (2013-2014) according to the number of CHW visits. As seen in this table, costs for ED visits appeared to decline among children with multiple CHW visits, while inpatient hospitalizations went up. Again, the mean number of claims for inpatient services also went done, indicating a number of particularly costly cases. Although the changes in mean billed amount for ED visits were not statistically significant, the data indicated a positive trend.

Table 9. Mean billed amount of asthma-related claims for ED and inpatient utilization at baseline and during the intervention period, according to the number of CHW visits

Type of Claim	Mean Billed Amount		Mean Number of Claims	
	Baseline	intervention	Baseline	intervention
Community Health Worker Visits = 0				
ED	56.25	66.00	0.10	0.08
Inpatient	178.75	126.00	0.06	0.08
Community Health Worker Visits = 1 - 3				
ED	178.75	126.00	0.11	0.10
Inpatient	317.02	493.00	0.12	0.08
Community Health Worker Visits = 4 or more				
ED	156.88	147.11	0.18	0.18
Inpatient	458.92	836.09	0.21	0.16

Amounts adjusted to 2014 dollars. Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences

Figure 15 illustrates these data graphically, specifically for asthma-related ED claims. As seen in this figure there appears to be a meaningful drop in the mean billed amount for ED claims between the two time periods among those with just one to three visits with a CHW; however, this should be interpreted with caution, particularly as the difference was not statistically significant.

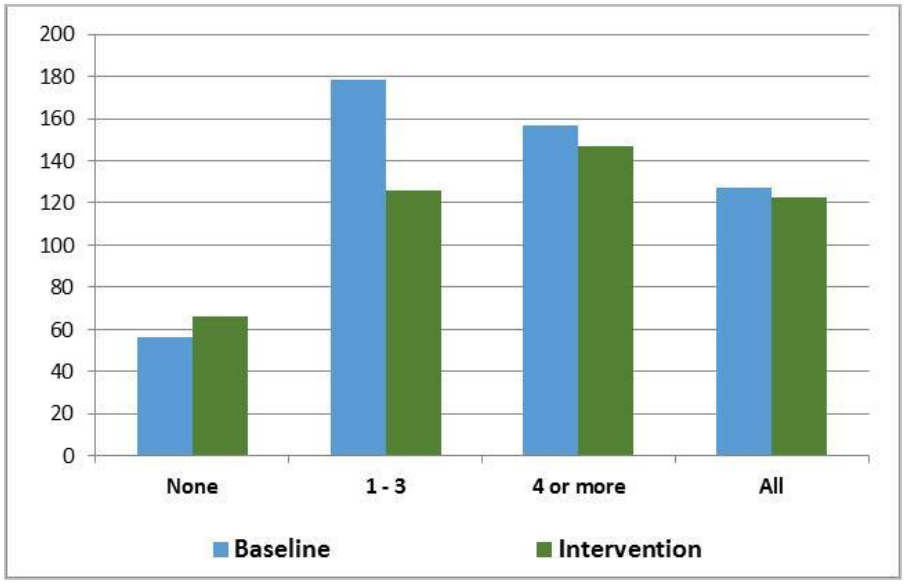


Figure 15. Mean billed amount of asthma-related ED claims, baseline compared with the intervention period, according to number of CHW visits

Table 10 shows the mean billed amounts for asthma-related claims according to the number of CHW visits and geographic areas over time. We analyzed differences in the mean billed amount for ED visits and total claims between 2013 and 2014 for each region and found no statistically significant differences. We did not analyze the mean differences for inpatient claims because there were too many clients with no inpatient claims during the study period.)

Table 10. Mean Billed Amounts, Asthma-related Claims, Total, ED, and Inpatient

Kent Focus Area						Kent Non-Focus Area				
Mean asthma-related billed amount - All Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	57.6	235.2	387.8	152.7	364.6	165.9	88.6	189.4	0.0	98.5
One - Three	839.2	418.7	2,034.9	1,552.4	1,552.8	1,259.7	0.0	133.5	226.4	26.7
Four or more	820.2	1,613.4	1,459.6	2,151.6	1,781.9	778.6	608.7	816.1	1,112.0	2,387.0
Mean asthma-related billed amount - ED Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One - Three	75.1	58.4	179.0	152.6	211.0	0.0	0.0	0.0	0.0	0.0

Kent Focus Area						Kent Non-Focus Area				
Four or more	101.1	134.5	122.1	138.9	73.8	93.2	59.3	28.7	97.7	70.4
Mean asthma-related billed amount - Inpatient Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One - Three	463.6	0.0	1,127.5	44.9	7.9	716.8	0.0	0.0	0.0	0.0
Four or more	197.2	382.3	398.7	1,070.0	988.6	346.2	72.0	310.2	515.5	232.3
NC Focus Area						**NC Non-Focus Area**				
Mean asthma-related billed amount - All Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	683.4	4,494.4	142.4	1,241.1	8,236.3	950.5	1,170.7	536.4	339.0	233.3
One - Three	1,302.2	3,801.5	3,470.2	471.2	1,642.5	678.0	2,808.6	1,053.3	1,445.4	36.1
Four or more	1,580.7	2,199.4	3,684.5	2,862.9	3,885.2	953.0	1,649.8	4,048.8	4,533.1	2,799.4
Mean asthma-related billed amount - ED Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	99.0	143.8	31.0	84.7	253.8	207.5	221.5	152.5	114.4	0.0
One - Three	219.0	317.0	201.0	0.0	81.2	102.4	290.6	208.0	0.0	0.0
Four or more	277.1	245.2	257.4	278.3	274.2	245.3	237.9	218.7	263.6	182.3
Mean asthma-related billed amount - Inpatient Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	484.0	3,877.6	0.0	0.0	1,607.8	280.6	560.9	0.0	0.0	0.0
One - Three	614.6	1,985.7	0.0	210.8	1,479.6	299.7	724.3	0.0	0.0	0.0
Four or more	644.4	671.2	1,568.1	907.2	1,385.4	231.7	414.0	2,123.6	1,687.8	1,565.7
Sussex Focus Area						**Sussex Non-Focus Area**				
Mean asthma-related billed amount - All Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	604.3	570.6	1,904.0	816.0	1,095.2	611.5	345.6	309.0	487.8	360.8
One - Three	899.3	417.8	987.3	479.6	246.1	1,352.8	401.8	5,412.0	660.0	7,200.6
Four or more	424.5	1,226.4	932.7	1,177.5	342.5	987.7	1,134.0	1,432.4	1,757.4	1,199.3
Mean asthma-related billed amount - ED Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	58.5	59.3	27.2	50.6	103.8	72.7	4.9	25.0	27.3	0.0
One - Three	17.7	0.0	70.0	142.0	67.0	116.9	0.0	101.2	0.0	95.3
Four or more	82.4	134.2	86.4	76.9	26.4	83.8	101.1	195.5	158.5	95.9
Mean asthma-related billed amount - Inpatient Claims										
Number of CHW Visits	**2010**	**2011**	**2012**	**2013**	**2014**	**2010**	**2011**	**2012**	**2013**	**2014**
None	137.2	57.8	131.5	8.5	34.2	60.9	15.8	0.0	170.6	0.0
One - Three	39.8	0.0	360.5	0.0	0.0	0.0	0.0	33.4	0.0	4,474.4
Four or more	28.1	259.7	128.1	399.8	10.5	159.7	34.0	544.7	741.0	0.0

Amounts adjusted to 2014 dollars.

Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the

Kent Focus Area		Kent Non-Focus Area
Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences		

Analysis of Utilization among Registry Clients and Comparison Groups

In this section, we present data for children in the asthma registry, along with data for other Nemours clients with an asthma diagnosis covered by Medicaid (not on the registry), and other Nemours clients covered by Medicaid (without an asthma diagnosis). Claims data for these later two comparison groups are meant to provide context for the registry claims and to serve as a sort of control for changes in utilization and costs over time.

Table 11 shows the mean billed amounts and mean number of claims for each of these comparison groups over time. The table highlights mean billed claims for all services, as well as for ED visits; however, unlike the previous section, the billed amounts in this analysis reflect *all* utilization (not just asthma-related utilization). This is because, by definition, the comparison group without asthma should not have any asthma-related claims.

Table 11. Mean billed amount and mean number of claims across comparison groups, 2010-2014

Mean billed amount per child – all claims			
	Registry	Other Clients with Asthma	Other Clients - No Asthma
2010	10,823.0	4,460.0	2,714.4
2011	15,612.9	5,352.2	3,487.2
2012	18,281.0	7,830.1	5,108.2
2013	15,947.7	8,909.9	5,366.7
2014	15,363.0	8,808.7	7,226.6
Total number claims per child			
	Registry	Other Clients with Asthma	Other Clients - No Asthma
2010	22.9	11.5	8.3
2011	21.4	10.6	7.6
2012	20.4	9.1	6.6
2013	18.6	9.1	6.5
2014	18.4	9.0	6.6
Mean billed amount per child – all ED claims			
	Registry	Other Clients with Asthma	Other Clients - No Asthma
2010	645.7	313.7	215.3
2011	691.4	350.6	228.4
2012	632.3	391.2	220.3
2013	667.5	434.3	248.7
2014	599.6	461.2	273.3
Total number of ED claims per child			
	Registry	Other Clients with Asthma	Other Clients - No Asthma
2010	1.3	0.6	0.4
2011	1.2	0.7	0.4
2012	1.2	0.7	0.4
2013	1.1	0.7	0.4
2014	1.2	0.7	0.5
Amounts adjusted to2014 dollars.			

Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences

Figure 16 illustrates the trend in mean billed amount per child for all claims across the three comparison groups between 2010 and 2014, and Figure 17 shows similar data for ED claims. As seen in these figures the mean billed amounts appear to be increasing steadily for the non-registry comparison groups; while the mean billed amounts for the children on the asthma registry level off (and even appear to decrease) after 2012.

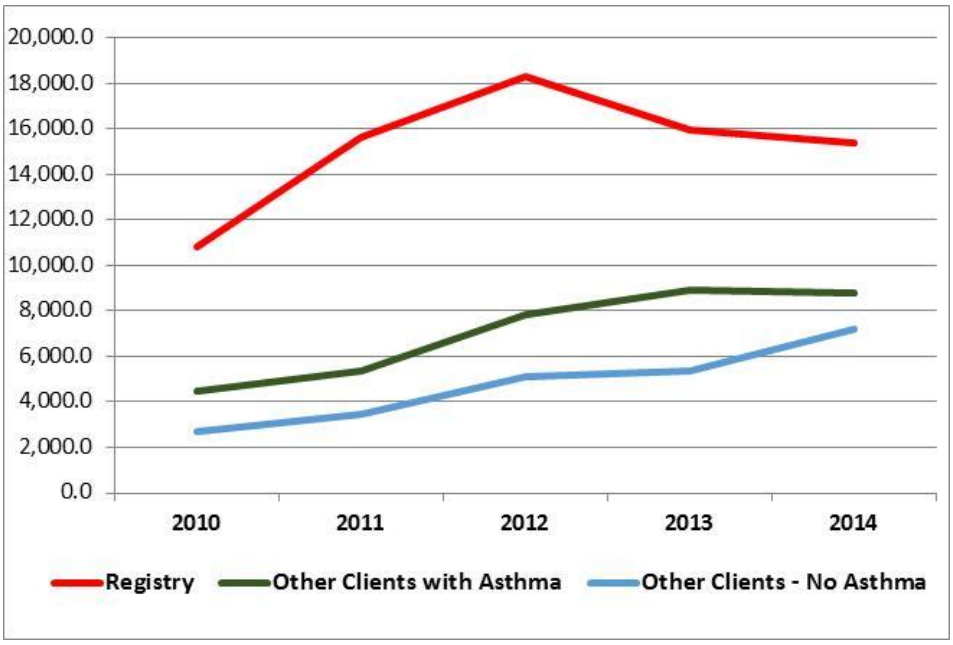


Figure 16. Mean billed amounts per child for all claims across comparison groups, 2010-2014, adjusted to 2014 dollars

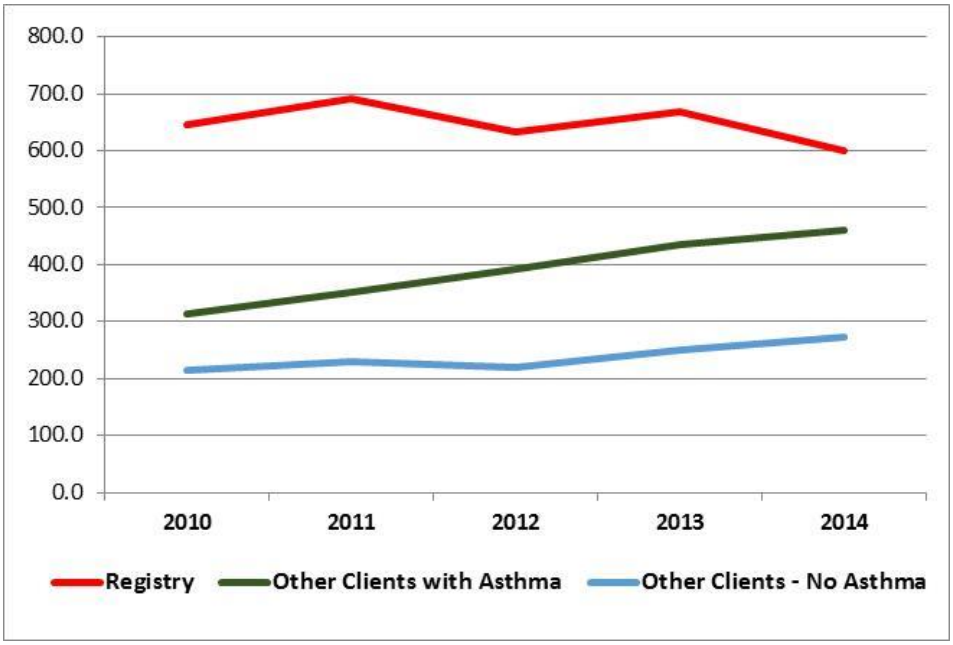


Figure 17. Mean billed amounts per child for all ED claims across comparison groups, 2010-2014, adjusted to 2014 dollars

Table 12 shows the mean billed amounts and mean number of claims per child across each of the three comparison groups; and compares the baseline period (2010-2012) with the intervention period (2103-2013). As seen in this table, and in Figure 18 which corresponds with this table, the mean billed amount for ED visits appears to have increased for both of the non-registry comparison groups, while the mean billed amount for ED visits appears to have decreased for registry clients during the intervention period.

Table 12. Mean billed amounts and mean number of claims per child across comparison groups, baseline compared with the intervention period, 2014 Dollars

	Registry		Other Clients with Asthma		Other Clients - No Asthma	
	Baseline	**Intervention Period**	**Baseline**	**Intervention Period**	**Baseline**	**Intervention Period**
Mean billed amount – all claims	14,905.6	15,655.3	5,880.8	8,859.3	3,769.9	6,296.6
Mean number of all claims per child	21.5	18.5	10.4	9.1	7.5	6.6
Mean billed amount – ED claims	656.5	633.5	351.8	447.8	221.3	261.0
Mean number of ED claims per child	1.2	1.2	0.7	0.7	0.4	0.4

Amounts adjusted to2014 dollars.
Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences

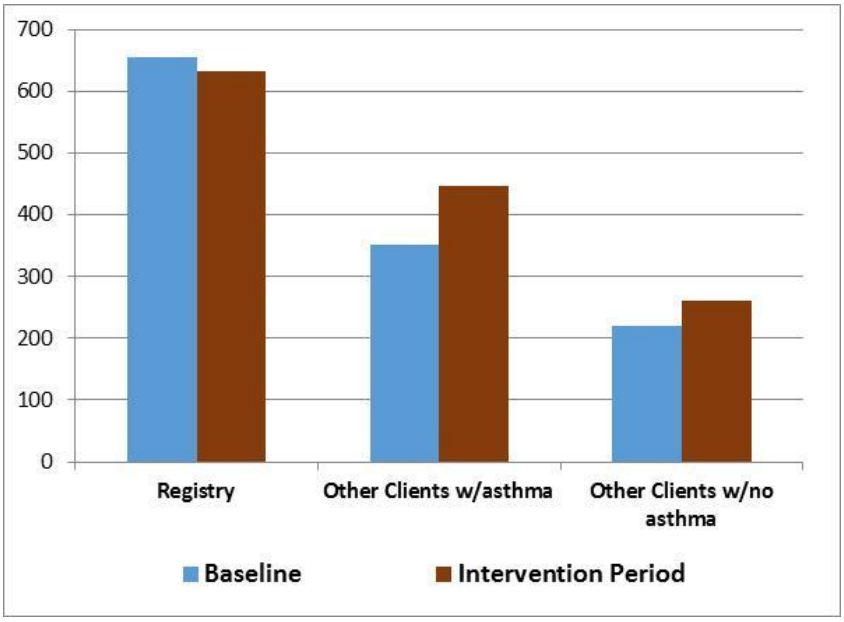


Figure 18. Mean billed amount for all ED visits according to patient group, baseline compared with intervention period, adjusted to 2014 dollars

Finally, although we were not able to compare asthma-related utilization across all three groups, we were able to make comparisons between children on the asthma registry and other children in Nemours with less severe asthma (i.e. those with an asthma diagnosis but not on the registry). Table 13 shows the mean billed amount per child for asthma-related ED claims for children in the registry and for children with asthma but not in the registry between 2010 and 2014. The mean billed amount for asthma-related ED claims appears to jump in 2013 for both groups. However, it falls again in 2014 for children on the registry, while it continues to increase for children with less severe asthma. These trends are also illustrated in Figure 19.

Table 13. Mean billed amount for asthma-related ED claims for registry clients and non-registry clients with an asthma diagnosis, 2010-2014, adjusted to 2014 dollars

	Registry Clients	Other Clients with Asthma
2010	127.9	33.9
2011	128.0	37.8
2012	120.0	37.8
2013	135.4	53.4
2014	108.9	60.5

Amounts adjusted to2014 dollars.
Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences

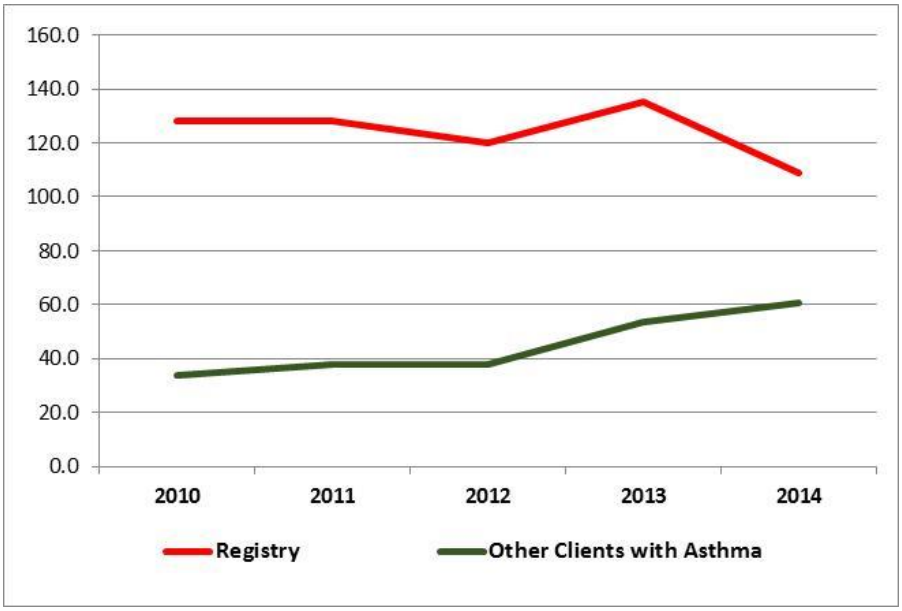


Figure 19. Mean billed amount for asthma-related ED claims for registry clients and non-registry clients with an asthma diagnosis, 2010-2014, adjusted to 2014 dollars

In Table 14, we compared the mean billed amount for asthma-related ED claims for registry clients and non-registry clients with an asthma diagnoses in the baseline period and the intervention period. Figure 20, which corresponds with this table, shows an increase in the mean billed amount across time periods for non-registry clients, and a corresponding decrease in the mean billed amount across time periods for registry clients. While the differences were not statistically significant, we cautiously interpret these trends as an indication that the intervention may be having a positive impact that could become more apparent over time and with additional analyses.

Table 14. Mean billed amount for asthma-related ED claims for registry clients and non-registry clients with an asthma diagnosis, baseline compared with the intervention period, 2014 dollars

	Baseline	**Intervention Period**
Registry Clients	125.3	122.12
Other Clients with Asthma	36.5	56.9

Amounts adjusted to 2014 dollars.
Source: Center for Community Research & Service, University of Delaware, 2015. Compiled with data provided by the Delaware Division of Medicaid & Medical Assistance through a partnership with the University's Colleges of Health Sciences and Arts & Sciences

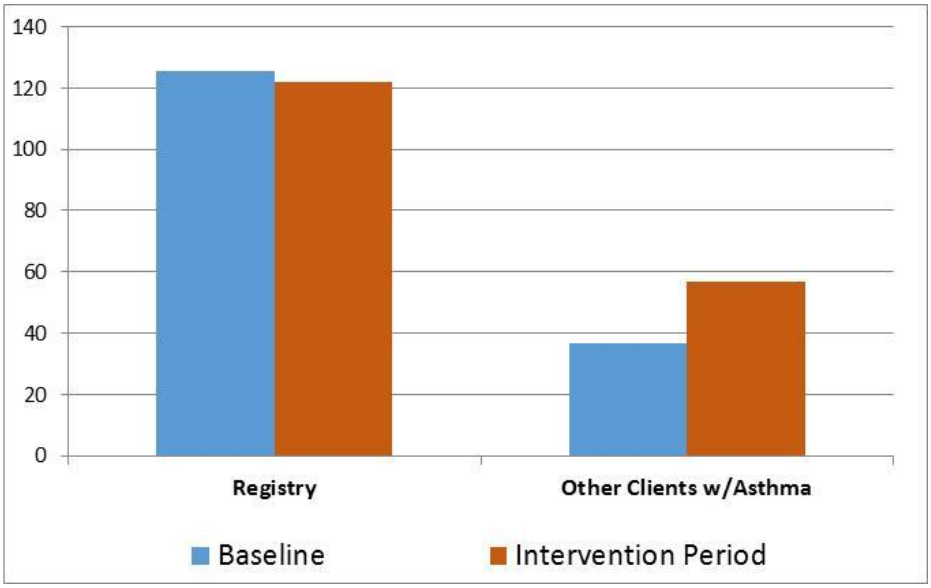


Figure 20. Mean billed amount for asthma-related ED claims for registry clients and non-registry clients with an asthma diagnosis, baseline compared with the intervention period

Conclusion

The literature suggests that well-designed CHW interventions can have a positive impact on the health outcomes and healthcare costs for low income children with asthma. Accordingly, the Nemours asthma intervention aimed to increase the quality of care for Delaware children with asthma, improve outcomes of care for this population, and reduce the cost of asthma care over time. This analysis was conducted to help Nemours begin to assess the extent to which the initiative was meeting its goals. Specifically, this study was designed to provide data on healthcare utilization among children served by the intervention. It was not designed to be a rigorous evaluation of the initiative, nor should it be interpreted as such. However, the comparisons that were made between utilization of ED and inpatient hospital services at baseline and utilization during the intervention period may provide an indication of how the initiative is affecting children with severe asthma. Further, while our comparison between children on the registry and other children served by Nemours should not be viewed as an ideal control group design, the comparison groups were useful in putting the trend data into context. For instance, the comparisons revealed that the average per child cost of ED visits has remained constant or declined among children with severe asthma served by the intervention, even as average costs have increased for other children with asthma. Though not statistically significant, the data show trends moving in the right direction.

This analysis was limited in scope by practical resource constraints (e.g. money and time), and revealed many additional questions that could be explored in more detail in future studies. For instance, it would be valuable to examine utilization patterns over a longer period of time. Similarly, the study was constrained by the nature of the Medicaid data used in the analysis. As an administrative data set intended for billing purposes, we did not have access to actual health outcome-related data, nor could we examine issues related to quality of care. Finally, the analysis did not account for the amount of time that children were exposed to the intervention. Specifically, we were not able to distinguish between children who may have been connected with the registry at the outset of the intervention and those who may have been enrolled much later. Our analysis of the mean number of CHW visits per child was meant to assess, at least in part, the intensity of the intervention. However, our inability to track entry and exit into the program limits the interpretation of its potential impact.

Given the importance of asthma care to the wellbeing of child and their families, the disproportionate burden of asthma on low-income and minority children, and the growing healthcare costs associated with treating childhood asthma, a more rigorous evaluation of the Nemours CMMI asthma initiative may be warranted. Future evaluation studies may benefit from a more purposeful design such that the exact nature of the intervention is well-defined, activities are clearly documented, and implementation is assessed at multiple levels, and across place and time, in order to make stronger inferences regarding its impact. Similarly, an evaluation approach that focuses more directly on individual children served by the intervention would provide important insights regarding its impact. Children with severe asthma are often characterized as having multiple risk factors, face numerous barriers to quality healthcare, and require personalized interventions. While CHWs are ideally suited to meet the intense and diverse needs of high risk children, an evaluation of their efforts must account for this individualized approach. For this reason, different analytical approaches, such as qualitative interviews or more detailed chart reviews, could complement the quantitative analyses and contribute to a more holistic understanding of the

needs of children with asthma in Delaware and the potential impact of interventions designed to meet those needs.

In summary, we believe this analysis contributes important information to assist Nemours in understanding the potential impact of the CMMI asthma intervention. While more rigorous evaluation is needed to identify areas of improvement and to potentially validate the overall approach, the data provided in this report offer a useful starting point and framework for future studies. Similarly, we encourage Nemours leaders to review the more comprehensive set of data tables which have been shared separately. These too may offer valuable insights and a springboard for ongoing evaluation. Finally, we refer readers to the literature reviewed earlier in this report (and cited below) for evaluation approaches and sources for comparison. As Nemours providers are keenly aware, asthma is the most common cause of chronic illness in children and has a profound effect on their quality of life. The health impacts, combined with the economic impacts associated with treating childhood asthma, call for continued efforts to identify and implement effective strategies to improve quality of care, reduce costs, and ultimately improve outcomes for low income children and their families.

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