



Allergy, Genes and Environment Network
Le réseau des allergies, des gènes et de l'environnement

The Allergy, Genes and Environment (AllerGen) Network

Final Network Report

2004-
2020



NCE RCE

Networks of Centres | Réseaux de centres
of Excellence of Canada | d'excellence du Canada



Jovan, 8 years (CHILD participant in Burnaby, BC):

"My poster is about a CHILD Study visit. I learned about allergies at home and outside. It is good to know what you are allergic to!"

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Executive Summary

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he Allergy, Genes and Environment Network (AllerGen) was established in 2004 to unite Canada's allergic and respiratory disease communities with the overall goal of improving the lives of Canadians living with asthma, allergies, anaphylaxis and related immune diseases.

Over 15 years as a national Networks of Centres of Excellence, AllerGen invested over \$51M in 220 research projects; trained 1,763 Highly Qualified Personnel (HQP) students and trainees; partnered with 651 organizations across sectors to leverage \$128.6M; generated 6,730 scientific publications; and has had its research featured in major national and international media over 4,000 times.

Through the formation of partnered, trans-disciplinary, multi-sectoral teams, sharing a drive for unmitigated research excellence, AllerGen has created valuable new knowledge, products and tools; enabled knowledge and technology uptake and application by receptor and stakeholder communities in Canada and beyond; and built much needed national clinical capacity in allergic/asthmatic disease prevention and management.

Through its strategic research investments, AllerGen catalyzed three ongoing, self-sustaining Legacy Initiatives that benefit those living with—and caring for people affected by—allergy, asthma and related immune diseases.

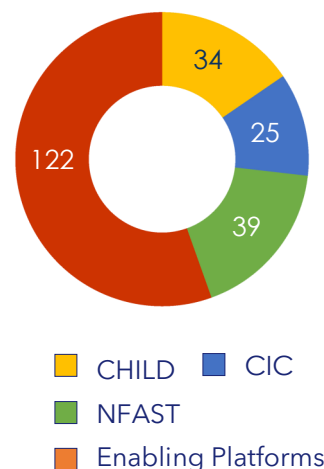
CHILD Cohort Study (CHILD)

In 2008, AllerGen launched CHILD as a national discovery platform. This pan-Canadian, general population-based longitudinal birth cohort study is one of only a few global initiatives that enable investigation of the early-life origins of asthma, allergy, and other chronic, non-communicable diseases (NCDs).

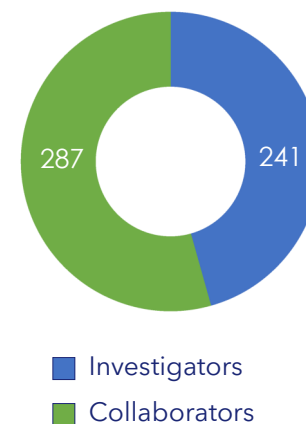


Mikaela, 8 years (CHILD participant in Vancouver, BC): "My poster is about all the good things the CHILD Cohort Study has done."

Research Projects (n=220)



Researchers (n=528)



The CHILD team has generated over 100 scientific publications, and delivered breakthrough findings on the impact of early-life exposures (e.g., mode of delivery, breastfeeding, antibiotics, air pollution, pets, household cleaning products, sleep, screen-time, food and nutrition) on the development of childhood allergies, asthma, obesity, cognitive capacity, the immune system and the internal microbiome.

Impactful CHILD results have been reported over 2,000 times by global media outlets (*TIME Magazine, People, CNN, New York Times, CBC, Globe & Mail, Maclean's*, and many others), informing policy, practice and the advocacy efforts of organizations such as UNICEF Canada and The Sandbox Project, healthcare professionals, and dozens of grassroots maternal/child health organizations and stakeholders.

CHILD has produced data critical to hypothesis-generation and novel basic and applied research initiatives in the field of maternal-child health. CHILD data will also fuel novel research opportunities for decades to come.

Clinical Investigator Collaborative (CIC)

To accelerate drug development for the treatment of asthma and other inflammatory airways diseases, AllerGen established the CIC, a multisite Phase II clinical trials consortium operating as an academic clinical research organization (A-CRO) at six Canadian universities and one international site—the Karolinska Institute in Stockholm, Sweden.

Led by world-renowned scientists, the CIC has conducted 29 clinical trials with 19 industry partners, including global pharmaceutical enterprises AstraZeneca, Genentech, Novartis and Pfizer, and new Canadian biotechnology companies Asmacure and AIM Therapeutics. CIC trials have attracted nearly \$30 million in R&D investment to Canada and created over 41 jobs for scientists, trainees and research associates, positioning Canada as a global leader in the development of allergic asthma therapeutics.

For example, the CIC identified new biologicals Ligelizumab (anti-IgE, Novartis), Quilizumab (anti-IgE, Genentech Inc.) and Mepolizumab (anti-IL-5, GlaxoSmithKline), as effective new molecules for future investment to treat various forms of asthma.

In 2014, the CIC studied the biologic drug Tezepelumab (anti-TSLP, Amgen) and first identified the drug's significant therapeutic potential to treat allergic asthma. The findings were published in *The New England Journal of Medicine*, reported broadly in major media outlets, and set the stage for rapid clinical development of the molecule hailed as a "blockbuster drug."

National Food Allergy Strategic Team (NFAST)

To improve the quality of life of Canadians affected by food allergies, AllerGen established a unique translational research program focused on understanding the causes, prevalence, treatment and consequences of food allergy and anaphylaxis. NFAST—comprising clinical, natural and social scientists working in trans-disciplinary, inter-institutional teams—has enabled better clinical management strategies, created innovative educational tools, and advanced policy and public health measures addressing food allergy.

With 138 refereed publications since 2007, NFAST teams and their partners across sectors have:

- produced Canada's first food allergy prevalence data, informing Health Canada's food allergen labelling reform initiative in 2012 and contributing to provincial legislation that protects students at risk of anaphylaxis;

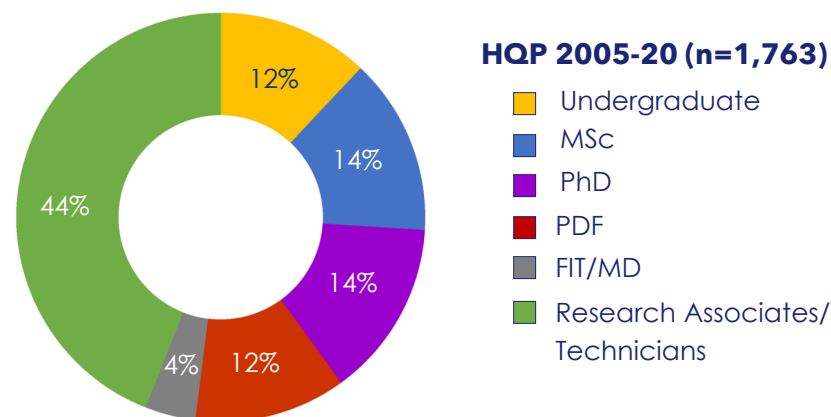
- created the first national anaphylaxis surveillance database that provides critical information on what causes anaphylaxis, how often it occurs, whom it affects, and how it is being treated across provinces;
- supported emerging clinical therapies such as food allergy oral immunotherapy (OIT) and produced new findings on the genetic basis of food allergy; and
- created innovative, award-winning educational tools, food allergy apps and peer-to-peer mentoring programs for kids with food allergies.

Enabling Platforms

AllerGen's Legacy Initiatives have been complemented by three Enabling Platforms that have produced investigative breakthroughs in biomarkers, bioinformatics, gene-environment interactions and personalized health, and enabled improved policies and clinical care/management practices in asthma and allergies. The Platforms have provided a strategic connection to research technologies and methods, ensuring that AllerGen discoveries continue to be both novel and relevant to industry, clinicians and policymakers.

Highly Qualified Personnel (HQP) Program

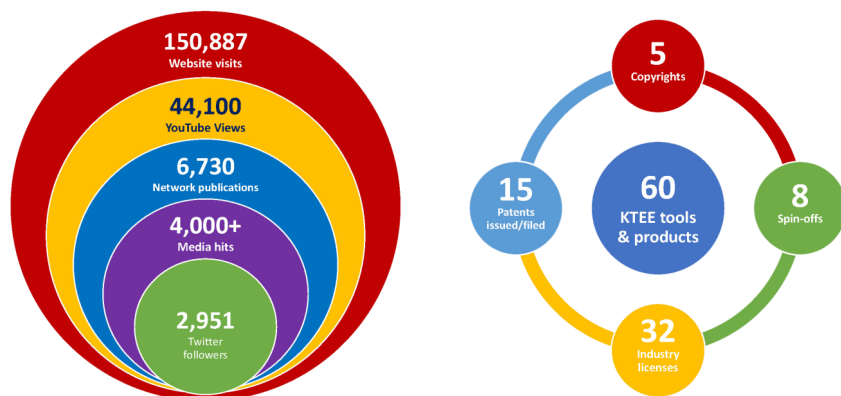
AllerGen's HQP program has been one of the Network's most impactful and transformational achievements. From 2005 to 2019, AllerGen invested \$26.4 million in HQP programming (\$22.3 million in research support and \$4.1 million in specialized awards, grants and Fellowships) to provide advanced education, training and capacity-building opportunities to 1,763 trainees, research staff and early-career professionals.



Of the Network's HQP graduates, at least 328 are now employed across sectors including industry, policy development, healthcare and academe; 14 advanced to become Network investigators; and 74 (4.2%) secured faculty positions in Canada and abroad.

In addition to value-added HQP awards, studentships and training opportunities, AllerGen established a prestigious, two-year *Emerging Clinician-Scientist (ECS) Fellowship* to support the development of the next generation of Canadian clinical immunologists and allergists in their pursuit of research training and a combined career as clinicians and academic researchers. Through this program, AllerGen invested \$1.25 million in support of five outstanding clinician-scientists, who are now ideally positioned to translate and transform research knowledge into improved patient care and health for the benefit of Canadians.

KTEE 'at-a-glance' 2005-20



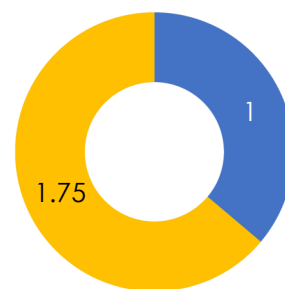
Knowledge & Technology Exchange & Exploitation

AllerGen's knowledge mobilization and commercialization activities have accelerated the uptake and application of Network research outputs by partners, stakeholders and receptor communities in Canada and abroad.

Partnerships

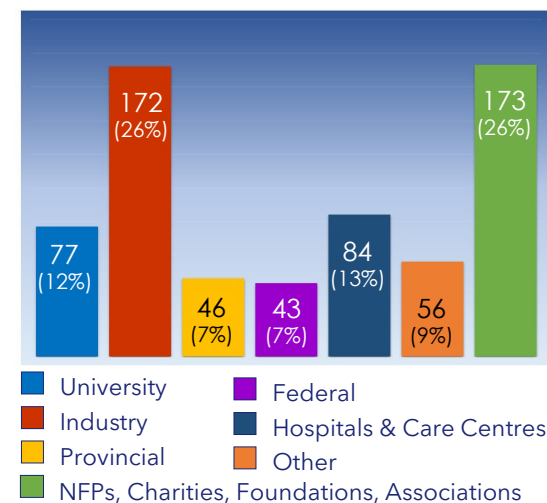
Network partners have played a vital role in shaping AllerGen's research outcomes, and in translating and commercializing findings that bridge the gap between the lab and Canadians living with allergic and asthmatic disease. Since 2005, Network-wide partner cash and in-kind investments total more than \$128.6M, representing an NCE to non-NCE leveraging of \$1 : \$1.75.

Leveraging Ratio (1 : 1.75)



■ Total non-NCE \$
■ Total NCE \$

Partners 2005-20 (n=651)



Poised to address new health priorities

AllerGen's 15-year commitment to networked, collaborative research across disciplines has positioned its pan-Canadian teams to contribute to global efforts to address new and evolving health priorities across the entire span of immune/inflammatory disorders and responses. Currently, AllerGen investigators are leveraging the network structure to mount rapid responses to address the COVID-19 pandemic and CHILD is conducting an important add-on study to measure the direct impacts of COVID-19 infection, as well as the indirect emotional and socioeconomic impacts of public health containment strategies on Canadian families.

AllerGen NCE wishes to thank the Government of Canada for the opportunity to build this Networks of Centres of Excellence over the past 15 years and is proud to confirm that AllerGen has had a significant and lasting impact on the Canadian landscape of discovery, innovation and translation that will endure for generations to come.

As of April 1, 2020, AllerGen's Administrative Centre continues to operate as a not-for-profit organization supporting two of the Network's three Legacy Initiatives - CHILD and the CIC. AllerGen partner organizations the Canadian Society of Allergy and Clinical Immunology (CSACI) and Food Allergy Canada are providing leadership and continuity to AllerGen's third Legacy Initiative, founded on the Network's food allergy research investments, towards establishing a national food allergy strategy for Canada.

Kylie, 9 years (CHILD participant in Osterwick, MB):

"My poster is about learning which things or places could be better for our body."



AllerGen Network Final Report

The Canadian allergic & related immune disease landscape transformed

Since 2004, the Allergy, Genes and Environment Network's (AllerGen's) investments in research, capacity building, knowledge mobilization, and commercialization have permanently transformed the Canadian landscape in the field of allergic and related immune disease.

Allergic disease has a profound impact on both the individual and economic health of Canadians:

- 1 in 3 Canadians live with allergic disease
- Asthma is the third-most prevalent chronic disease, affecting nearly 3 million Canadians
- Between 2010 and 2011, direct and indirect costs associated with treating asthma topped \$1 billion in Canada
- 50% of Canadian households are directly or indirectly affected by food allergy



AllerGen's VISION: To create an enduring network of allergy and immune disease experts whose discovery and development efforts contribute to reducing the impact of allergic and related immune diseases nationally and globally.



AllerGen's MISSION: To catalyze and support discovery, development, networking, capacity building, commercialization and knowledge translation to reduce the morbidity, mortality and socioeconomic burden of allergy, asthma and anaphylaxis for the benefit of Canadians and the global community.

In the 15 years following its creation, AllerGen invested over \$51M in 220 research and knowledge mobilization projects; trained 1,763 Highly Qualified Personnel; partnered with 651 organizations across sectors to leverage \$128.6M; generated 6,730 scientific publications; and had its research featured in major national and international media over 4,000 times.

Through these investments and a constant drive for research excellence, AllerGen's vision to help Canadians address the challenges of living with allergy, asthma and related immune diseases has been realized.

AllerGen's Integrated Research Strategy

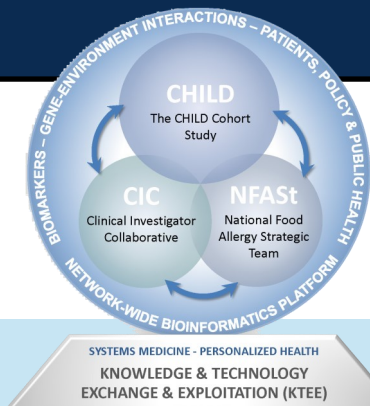
An evolution to lasting legacies

From AllerGen's initial, broad research program launched in 2005, three focused, cross-disciplinary national research programs evolved, and continue as lasting legacies for Canada.

DISCOVERY LEGACY

CHILD Cohort Study (CHILD)

A world leader in maternal, newborn & child health research



CHILD was launched in 2008 with foundational funding from CIHR and initial and ongoing financial support from AllerGen. CHILD is the largest multidisciplinary, longitudinal, general population-based birth cohort study in Canada, following the lives of nearly 3,500 children (and their parents) over time as they grow and develop—from mid-pregnancy into childhood, adolescence and beyond.

CHILD is one of only a few studies in the world that has investigated the early-life origins of asthma, allergy, and other NCDs including obesity, diabetes and metabolic disorders, as well as neurodevelopment and mental health.

CHILD Cohort Study Platform Investors	
AllerGen	\$16,931,480
Canadian Institutes of Health Research (CIHR / Tri-Agency)	\$29,962,294
Other partners	\$21,035,197
TOTAL since 2007	\$67,928,971

KEY IMPACTS

Delivering breakthrough findings

CHILD has published over 100 articles in peer-reviewed academic journals worldwide. Global media outlets—including *New York Times*, *TIME Magazine*, *Wall Street Journal*, *CNN*, *Boston Globe*, *Washington Post*, *People*, *Vogue*, *Cosmopolitan*, *Newsweek*, *The Economist*, *CBC*, *Globe & Mail*, and *Macleans*—have featured CHILD findings over 2,000 times.

Informing policy and practice

CHILD is a trusted source of child health knowledge for a wide range of stakeholders, providing parents, clinicians, not-for-profit organizations, policymakers and communities with information to make more informed decisions.

For example, UNICEF Canada, the world's leading child-focused humanitarian organization, featured CHILD results in its 2018 campaign to improve parental leave policies in Canada; and *MD Magazine* featured CHILD research results on breastfeeding to help primary-care physicians provide optimal patient care.

The Sandbox Project—a national charity working to improve the health and well-being of Canadian children through collaboration and public education—has highlighted CHILD as the one major success story stemming from five key recommendations made in its 2007 foundational report: *Reaching for the Top: A Report by the Advisor on Healthy Children and Youth*, which documented Canada's relatively poor performance vis-à-vis peer countries in terms of key health indicators for children and youth. Since 2007, The Sandbox Project has enabled the uptake of CHILD findings by dozens of grassroots maternal/child health organizations and stakeholders.

"CHILD research is informing UNICEF's efforts to advocate for better child and family policies, including improved parental leave take-up that will help mothers continue breastfeeding and keep more babies healthy."

Lisa Wolff
Director, Policy & Research,
UNICEF Canada

Building a powerful discovery platform

CHILD has collected over 40 million data points, 600,000 questionnaire responses and 500,000 biological samples. Its vast datasets are housed in *CHILD db*, a unique, interactive platform under development that will soon be available to researchers worldwide, enabling future discoveries.

The Study's value as a platform for studies of development increases exponentially as data collection continues. In recognition of the value of CHILD's discovery platform:

- in 2018, Genome Canada and partners awarded the Study over \$9 million to study the microbes involved in the development of asthma and to investigate ways to replace these microbes as a preventive treatment.
- in 2019, the Canadian Microbiome Initiative 2 (CMI2) program awarded CHILD \$2 million to uncover the mechanisms by which gut bacteria influence asthma development and the role that early-life exposures, such as breastfeeding, play in modifying those bacteria.
- in 2020, the Bill & Melinda Gates Foundation awarded \$6.5 million to a study, of which CHILD is a part, exploring the components of human milk that influence infant growth and resilience.

Addressing emerging global health threats

CHILD's access to, and knowledge about families and family health, immunity, inflammation and immune responses, and the microbiome provides the building blocks and essential tools to tackle global diseases and threats, and their amelioration or eradication. AllerGen's foundational investments in CHILD have enabled it to rapidly launch a unique add-on study to measure the direct impacts of COVID-19 infection susceptibility and severity among Study

Breakthrough CHILD Findings

- Delayed introduction of allergenic foods increases food allergy risk—by 4x with peanut
- Gut bacteria during infancy may influence development of food allergies
- Owning a cat or dog may protect babies from allergies & obesity
- Air pollution exposure during pregnancy & infancy could increase risk of allergies
- Asthma & allergies are predictable by one year of age
- Breastfeeding protects babies from wheezing & lowers asthma & obesity risk
- Four gut bacteria protect children against asthma; the first 100 days are critical
- Household cleaners may cause asthma & obesity in young children
- Screen time linked to behavioural problems in preschoolers
- Fruit consumption in pregnancy boosts babies' cognitive development
- Artificial sweetener intake in pregnancy may increase babies' risk of obesity
- Mom's depression in pregnancy may impact baby's immune system
- Cesarean deliveries & formula feeding alter the microbiome



CHILD Cohort Study family

participants, as well as identify the indirect impacts on Canadian families caused by the social and economic upheaval accompanying the pandemic. This research will generate real-time data informing Canada's COVID-19 response, including strategies to prevent or control subsequent waves of transmission.

The next five years...

In 2018, CHILD achieved a major milestone with the completion of its originally-planned endpoint: all 5-year-old participants' clinical visits and a participant retention rate of 93.3%.

CHILD is now progressing into a longer-term study, conducting clinical assessments at ages eight, 12 and 15 to identify critical disease intervention "windows" from preconception to adolescence. Data collection for the 8/9-year visit will be completed in early 2021.

By 2025, CHILD anticipates fueling significant new child health advances, including:

- discovery of precise biomarkers to predict persistent asthma, with translation into novel therapeutics;
- tracking lung function growth from infancy to adolescence and discovery of factors promoting lung health;
- understanding the gender switch in asthma to female predominance during puberty;
- identifying the role of the early-life environment in the development of obesity and cardiovascular /metabolic syndrome risk and disease factors ; and
- informing the new field of epigenetics.

With its now-embedded science and scientists in biomarkers, bioinformatics, genetics, epigenetics, the microbiome and exposome, CHILD will continue to contribute in a novel way to the intersection of the biological and social determinants of health, in Canada and globally.

The AllerGen Administrative Centre continues to act as CHILD's business office, facilitating national and international research collaborations.

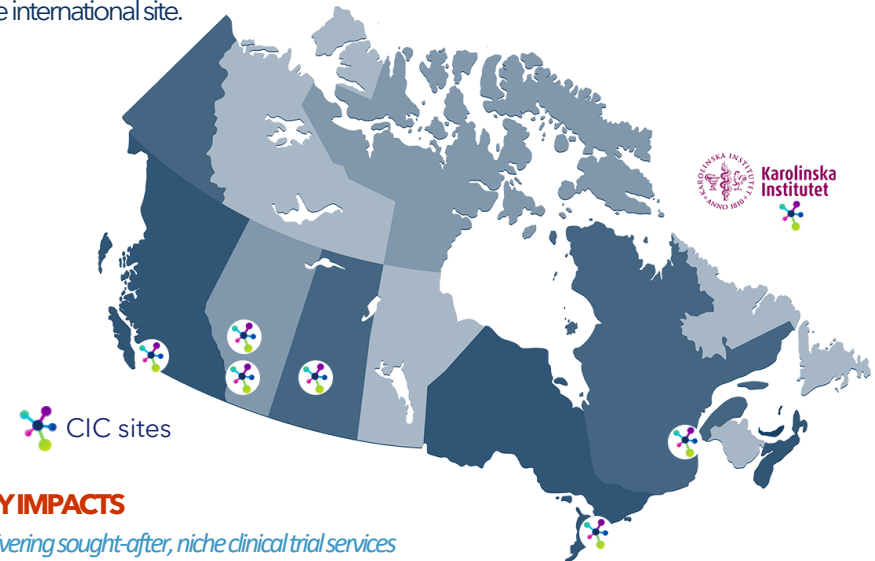
COMMERCIALIZATION ACCELERATOR LEGACY

Clinical Investigator Collaborative (CIC)

International leader in airways diseases clinical trials

Launched by AllerGen in 2005, the CIC is a pan-Canadian Phase II clinical trials consortium that fast-tracks new drug candidates for the treatment of inflammatory airways diseases, including allergic and severe asthma.

The CIC has attracted nearly \$30 million in R&D investment to Canada and created over 41 jobs for scientists, trainees and research associates. Led by renowned experts at McMaster University, the CIC operates at six Canadian universities and one international site.



KEY IMPACTS

Delivering sought-after, niche clinical trial services

The CIC has conducted 29 "proof-of-concept" clinical trials that determine pharmacological activity, pharmacokinetics, target engagement, and efficacy of new molecules and compounds for airways diseases, and it has licensed 23 Standardized Operating Practices (SOPs) to industry partners since 2005.

"There is nowhere else in the world you can go to do a multicentre allergen challenge except at the AllerGen CIC. It is unique."

Dr. Paul Newbold

Senior Medical Affairs Leader,
Respiratory Global Group, AstraZeneca

Breakthrough CIC Findings

- Identified Ligelizumab (anti-IgE, Novartis), Quilizumab (anti-IgE, Genentech Inc.) & Mepolizumab (anti-IL-5, GlaxoSmithKline) as effective new molecule candidates for future investment
- Tested Tezepelumab (Amgen), a new anti-TSLP treatment for allergic asthma, & published results in *New England Journal of Medicine*. The study demonstrated significant anti-inflammatory effects in airways & circulation, captured media attention, & set the stage for rapid clinical development of the molecule.
- Evaluated a wide range of other novel molecules including monoclonal antibodies, antisense oligonucleotides, small molecule inhibitors, & steroid receptor agonists.
- Developed predictive biomarker panels to discriminate between early- & late-phase allergic asthma responders.

investments with small, effective studies, and validated models that are 100% accurate for making “no go” decisions.

Publishing novel data

The CIC has produced over 130 peer-reviewed publications sharing novel data on efficacy and mechanism of action, including in high-impact scientific journals such as *New England Journal of Medicine*, *Science Translational Medicine* and *The Lancet*.

The next five years...

Beyond 2020, the CIC will continue testing new compounds, maintaining Canada as a leader in the discovery, development and commercialization of new tests and treatments for the benefit of individuals suffering from airway diseases.

The AllerGen Administrative Centre continues to act as the CIC business office, facilitating its industry research collaborations.

The CIC has partnered with 19 companies, including global bio-pharmaceutical companies Amgen, AstraZeneca, Genentech, Novartis, Pfizer, Schering Plough, and Wyeth. CIC has also provided new Canadian bio-technology companies (Asmacure, AIM Therapeutics) with business and commercialization insights on which they based strategic investment decisions, facilitating Canadian small and medium enterprise (SME) development.

AllerGen has invested over \$6.3M in the CIC, for a combined overall NCE to non-NCE leveraging ratio of \$1 : \$4.74.

Generating breakthrough findings that accelerate the development of promising new therapies

The CIC has put Canada on the map as a leader in research and drug development for asthma and other airways diseases. CIC trials have allowed companies to prioritize their discovery

PATIENTS, POLICY AND PUBLIC HEALTH LEGACY

National Food Allergy Strategic Team (NFAST)

Improving the health of Canadians living with food allergies

With 138 refereed publications since 2007, AllerGen's transdisciplinary NFAST research teams have made significant contributions to understanding the causes, prevalence, treatment and consequences of food allergy and anaphylaxis. This team has also informed important new national regulatory changes with respect to food labelling and the development of food industry guidelines for allergen thresholds.

KEY IMPACTS

Produced Canada's first food allergy prevalence data

Prior to AllerGen's investments in food allergy research, Canadian data on food allergy and anaphylaxis were sparse and based on imprecise estimates using US data.

Since 2005, AllerGen's NFAST team has published three nationwide surveys (2009, 2011 and 2016), in partnership with Health Canada, producing the first *Canadian* data on food allergy prevalence, management, and disease burden, including data for vulnerable populations and changes in food allergy prevalence over time.

Prevalence Highlights

- 6.1% of Canadians (2.1M people) have a probable food allergy: 1.7M adults and 470,000 children (0-17 yrs)
- The overall prevalence of food allergy in Canada remained relatively stable from 2010 to 2016
- Between 2011 and 2017, the rate of peanut allergy anaphylaxis in children declined in Canada
- 50% of Canadian households are affected, directly or indirectly, by food allergies
- Canadians with lower education and immigrants within 10 years of arrival have fewer food allergies than the general population
- Allergies to peanut, tree nut, and sesame are more common in children while allergies to fish and shellfish are more common in adults

“It is essential for Health Canada to understand food allergy prevalence in order to assess the effectiveness of its policies and programs. AllerGen research has given us that and will continue to inform our priorities well into the future.”

Dr. Sébastien La Vieille

Senior Scientific Advisor, Health Canada Food Directorate

In 2010, AllerGen established the Cross-Canada Anaphylaxis REgistry (C-CARE) to investigate anaphylaxis rates, triggers and management Canada-wide.

C-CARE Database Highlights

- Peanut is the most common anaphylactic trigger in children
- Anaphylaxis cases among children doubled between 2011 and 2015
- Annual incidence of recurrent anaphylaxis in children is 29%; food is the primary trigger
- 25% of anaphylactic events in children are due to accidental exposure to a known allergen
- Children with severe and milk-induced anaphylaxis have elevated levels of tryptase, an enzyme released by immune cells for up to 24 hours after the event
- Only 41% of adults and children experiencing food-induced anaphylaxis use their epinephrine autoinjector (EAI) before being treated at a hospital emergency room

C-CARE is the first registry in the world to track episodes of anaphylaxis prospectively. The registry collects data from thousands of adults and children treated by EMS or in hospital emergency departments in 5 provinces, providing critical information on what causes anaphylaxis, how often it occurs, whom it affects, and how it is being treated.

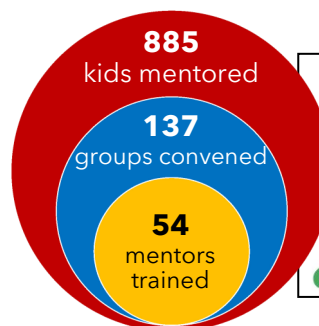
C-CARE is a powerful tool that is generating critical knowledge on trends in anaphylaxis diagnosis, treatment and care to inform policies, programs and clinical care paths.

Health Canada, a C-CARE partner, will use the data to evaluate the role of health policies, particularly those related to food labelling, in the prevention of anaphylaxis in Canada.

Created innovative educational tools

AllerGen's food allergy research has been effectively translated from the academic setting to on-the-ground community organizations and into Canadian households. In 2014, AllerGen's partner organization Food Allergy Canada licensed materials from an AllerGen-supported project at the University of Alberta to create [Allergy Pals](#) – an online peer mentoring program to help kids with food allergies learn from each other. Asthma Canada licensed the materials for a similar program, Asthma Pals, in 2016.

NFAST teams also developed [Kung Food](#), a mobile educational food allergy “app” that improves the knowledge and coping skills of children and teens. The app, available from the Mac App Store and Google Play, features a quick reference allergy guide, an allergy attack simulator and allergy trivia games.



Supported policy development & emerging clinical therapies

With partners in government, industry, clinical practice and patient/ community organizations, NFAST research has contributed to policy developments across all levels of government and advanced the development of new clinical therapies for food allergies.

Advanced food allergy prevention, diagnosis, treatment & care

Through transdisciplinary collaborations, NFAST teams have advanced knowledge contributing to improved prevention, diagnosis, treatment and care for individuals living with food allergies. With AllerGen's support, these teams have reached beyond Canada to contribute to the efforts of international researchers and patient advocacy groups in the United States (Food Allergy Research and Education) and Europe (European Academy of Allergy and Clinical Immunology).

Policy Highlights

- Contributed to Sabrina's Law – groundbreaking legislation that protects students at risk of anaphylaxis
- Informed Health Canada's food allergen labelling reforms
- Developed evidence-based guidelines for the management of food allergies in schools
- Provided a legal opinion on food allergy as a disability
- Supported “food free” policy implementation at Ontario library
- Advanced development of a safe, effective protocol for treating cow's milk allergy with oral immunotherapy (OIT)
- Supported development of clinical practice guidelines for OIT in Canada
- Conducted innovative studies on peanut thresholds
- Created the foundation of the Food Allergy Canada-CSACI National Food Allergy Action Plan

New Knowledge Highlights

- Generated new findings on the genetic basis of peanut allergy
- Established a pan-Canadian pediatric Peanut Allergy Registry (CanPAR)
- In mice, identified mechanisms involved in the development of sensitization or tolerance to food and how the immune system “remembers” food allergens to cause lifelong allergies
- Revealed lived experiences of those living with food allergies: financial barriers; overlapping stigmas of food allergy and poverty; challenges of students transitioning to post-secondary environments

release findings on the factors that contribute to a safer environment for students at post-secondary institutions in Canada and produce a genetic/epigenetic risk index for peanut and other food allergies.

Finally, AllerGen research has laid the foundation for the development and implementation of a coordinated, comprehensive national food allergy strategy. AllerGen’s clinical and community partner organizations, the CSACI and Food Allergy Canada, are leveraging AllerGen’s research results to develop the *National Food Allergy Action Plan*, with the goal of guiding future food allergy research investments and informing evidence-based policy frameworks to minimize the risks and adverse impacts of food allergy for the 50% of households directly and indirectly affected by the condition.

ENABLING PLATFORMS

Strengthening research technologies & methods

AllerGen’s Legacy Projects have been complemented by three Enabling Platforms that provided strategic, research-enhancing technologies and methods, helping to ensure that AllerGen research has been novel and relevant to industry, clinicians and policymakers.

The next five years...

AllerGen’s food allergy investments and collaborations from 2005-2020 continue to deliver new research, products and tools to improve the health and lives of Canadians living with food allergies.

In 2020-2021, NFAST researchers will publish new data on the economic impact of food allergy in Canada; issue guidance to industry to assist in managing allergen precautionary labelling (i.e. food products with a “may contain” statement); and update food allergen exposure data along with recommendations for practical allergen sentinel levels. They will also

These Enabling Platforms have enabled significant advances in understanding epigenetic mechanisms, the microbiome, and psychosocial factors in early life and their impacts on wellbeing and health. Together, the Enabling Platforms have provided further evidence to inform the Developmental Origins of Health and Disease (DOHaD) hypothesis that the environment before birth and in the early years of life, including nutrition, exposure to toxic stress and environmental chemicals, impacts lifelong risk for chronic diseases like obesity, hypertension and diabetes.

Gene-Environment Interactions (GxE) Enabling Platform

The GxE Enabling Platform generated important discoveries about the contribution of genes, gene-environment interactions and environmental exposures to allergic diseases and asthma. GxE findings also aided the development of novel therapies, diagnostics and public health interventions for these conditions. GxE researchers have:

- developed and commercialized, with Health Canada and Environment Canada, an inexpensive portable monitor (AirSENCE) that measures air pollution using the air quality health index (AQHI) scale. AirSENCE was used at the 2015 Pan Am Games and in the City of Toronto’s King St. Pilot to study how urban design affects health.
- generated new evidence confirming the harmful impacts of traffic-related air pollution (TRAP), showing that diesel exhaust can alter gene expression through epigenetic changes in airway cells and worsen allergic responses as well as lung function.
- developed new methodologies that allow scientists to measure cellular and epigenetic changes in an infant’s cord blood which are associated with an increased risk of asthma, allergy and other immune diseases.

Biomarkers and Bioinformatics (B&B) Enabling Platform

B&B Enabling Platform research helped advance the era of “personalized health” by identifying and developing biomarkers to predict and monitor allergy/asthma, and by leveraging bioinformatics technology to link vast datasets from across the Network, facilitating global studies of allergic disease. B&B researchers have:

- launched a spin-off company (Respirlyte Inc. ©) that created a simple, non-invasive urine test to diagnose lung diseases such as asthma using biomarkers excreted in urine.
- identified a blood-based biomarker to diagnose Western red cedar asthma—an occupational disease associated with employment in BC’s forestry industry.

- developed a simple blood test, using NanoString technology, that predicts which individuals with asthma will develop a “late-phase” asthmatic response.
- developed a new immunotherapy technique that modifies dendritic cells to reduce symptoms of food allergies in mice and holds promise for translation into human trials.
- integrated AllerGen’s vast datasets to create globally accessible databases (e.g., GENAPHA, Innate DB, Allergy and Asthma Portal, CHILd db) that continue to facilitate allergy and asthma research and discovery worldwide.

Patients, Policy and Public Health (PPP) Enabling Platform

Research undertaken by PPP Enabling Platform investigators facilitated development of public health interventions and enabled evidence-informed policies, lifestyle choices and disease management practices in the areas of asthma and allergies. PPP researchers have:

- developed diverse educational and social support tools and resources, including culturally-tailored interventions for Aboriginal Canadian children and youth with allergies and asthma; and web-based asthma, allergy, and other support tools and education programs, such as Allergy Pals (Food Allergy Canada) and Asthma Pals (Asthma Canada).
- measured the economic burden of asthma and the association between uncontrolled asthma and productivity loss in the workplace, and produced tools that allow family physicians to diagnose work-related asthma sooner.
- established an asthma clinic in El Salvador, which helped reduce the national asthma burden and death rate by providing expertise and resources for diagnosis, treatment, management, and education in a centralized and specialized hospital setting.

Highly Qualified Personnel (HQP)

A legacy of learning and new Canadian capacity

Since 2005, AllerGen has invested in Canada’s young allergic disease researchers in fields spanning over 46 disciplines and 23 institutions, providing them with value-added learning opportunities to accelerate their professional development and strengthen their ability to contribute to the Canadian economy.

AllerGen’s Highly Qualified Personnel (HQP) program was one of the Network’s most impactful and transformational achievements. In total, AllerGen invested \$26.4

million in HQP programming, including \$22.3 million in research support and \$4.1 million in specialized awards, grants and Fellowships.

KEY IMPACTS

Boosted Canada’s research capacity and scientific productivity

AllerGen provided advanced education, training and capacity-building opportunities to 1,763 trainees, research staff and early-career professionals.

By embedding HQP into multi-disciplinary, multisectoral training environments at over 20 sites across Canada, AllerGen provided mentorship and capacity-building opportunities to its trainees far beyond those available in traditional academic and laboratory settings.

Over 82% of AllerGen’s trainees worked directly on AllerGen-funded projects; 53% of the Network’s 6,730 scientific publications have a trainee as first author; and Network HQP have delivered 762 oral, poster and conference/scientific meeting presentations.

AllerGen’s HQP awards, studentships and training opportunities supported the development of value-added professional, personal and career-related skills not typically available in an academic/research environment.

AllerGen HQP were given access to unique datasets, including from the CHILD Cohort Study, resulting in unique research opportunities, elevated publication rates/impacts, and access to national/international awards and opportunities.

Produced highly employable graduates working in diverse sectors

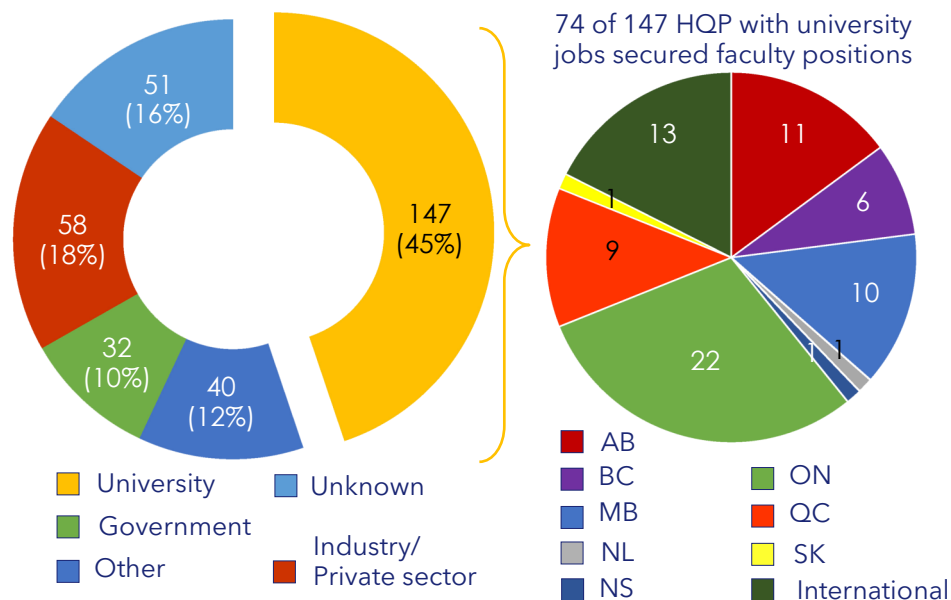
AllerGen HQP have benefitted from unparalleled cross-university connections and exposure to highly collaborative partnered research projects, as well as mentoring and networking events that connected them with leading research, policy and healthcare experts, and industry and community partners.

Of AllerGen’s HQP graduates, at least 328 are now employed across sectors

HQP Highlights

- 573 trainee participants in AllerGen’s Annual Trainee Symposia
- 962 abstracts presented in adjudicated poster competitions
- 350 partnered *Travel Awards* issued
- 74 *Summer Studentships* awarded
- 45 HQP served on the ASNPN Executive Committee
- 32 *Research Skills* awards issued
- 11 *International Research Visit* awards issued

HQP Employment 2005-20 (n=328)



including industry, policy development, healthcare and academe.

Launched Canada's "best and brightest" scientists

AllerGen's HQP program launched the careers of numerous exceptional investigators. Among the program's graduates, 14 advanced to become Network investigators and 74 (4.2%) secured faculty positions in Canada and abroad.

AllerGen's emphasis on knowledge exchange, collaboration and relationship-building, within and beyond the Network, allowed these trainees to establish independent research programs and achieve the research and publication productivity necessary to obtain major funding awards.

AllerGen's *network way of working* broke down academic and institutional silos and fostered a cultural transformation among its trainees, who continue to seek out cross-disciplinary networking and partnership opportunities. The Network also seeded the careers of high-performing investigators during the early phase of their careers, including: Dr. Mark Larché (McMaster University); Dr. Chris Carlsten, Dr. Stuart Turvey, Dr. Scott Tebbutt and Dr. Kelly McNagny (UBC); Dr. Piush Mandhane and Dr. Anita Kozyrskyj (UAlberta); Dr. Meghan Azad (UManitoba); and Dr. Padmaja Subbarao, Dr. Theo Moraes, and Dr. Thomas Eiwegger (SickKids Hospital).

Addressed the shortage of allergy disease expertise

Upon AllerGen's inception in 2004, novel, patient-oriented diagnostic and treatment protocols for allergic diseases were urgently needed in Canada, as was a strategy to address the dire shortage of allergy and clinical immunology expertise.

In 2011, AllerGen established its prestigious, two-year \$250,000 *Emerging Clinician-Scientist Fellowship* to fill this gap and support the development of the next generation of Canadian clinical immunologists and allergists in their pursuit of a combined career as clinicians and academic researchers/clinician scientists.

AllerGen invested \$1.25 million in support of five outstanding clinician-scientists who are ideally positioned to translate research knowledge into improved patient care and health.

AllerGen's Emerging Clinician-Scientist Recipients

- 2011** **Dr. Moshe Ben-Shoshan**, Assistant Professor (Clinical) of Pediatrics, McGill University, Montreal Children's Hospital
- 2013** **Dr. Philippe Bégin**, Associate Professor, Université de Montréal, Centre hospitalier de l'Université-Sainte Justine
- 2014** **Dr. Marilyn Desjardins**, Assistant Professor of Pediatrics, McGill University, Montreal Children's Hospital
- 2016** **Dr. Catherine Biggs**, Assistant Professor (Clinical) of Pediatrics, The University of British Columbia, BC Children's Hospital
- 2019** **Dr. Derek Chu**, Clinical Immunology and Allergy Fellow, McMaster University, McMaster University Medical Centre

Partnered to enrich training and development opportunities

Through innovative collaborations, AllerGen and its partners have provided advanced training to the next generation of Canadian innovators, leaders and entrepreneurs, who are making significant scientific, technological, socioeconomic and cultural advances for Canadians affected by allergic diseases.

Established unique program to nurture mentoring expertise

In 2018, AllerGen created the Michelle Harkness Mentorship Awards (MHMA) program in memory of Michelle Harkness, AllerGen's former HQP Manager (2011-2017). Uniquely, the awards not only recognize demonstrated mentorship excellence, they also build mentorship skills and capacity among scientists,

Partnered Awards Issued

- Asthma Canada/AllerGen Graduate Student Research Award – 7 awards/\$120,000
- Fonds de recherche Santé Québec (FRQS)/AllerGen Clinical Research Scholars – 3 awards/\$514,324
- Canadian Respiratory Research Network (CRRN)/AllerGen/Heart & Stroke Foundation/Canadian Lung Association Emerging Research Leaders Initiative (ERLI) – 2 awards/\$ 570,000
- Michael Smith Foundation for Health Research (MSFHR)/AllerGen Trainee Research Awards – 6 awards/\$249,260
- The Canadian Asthma, Allergy and Immunology Foundation (CAAIF)/AllerGen Research Fellowships in Clinical Immunology and Allergy – 4 awards/\$720,000

researchers, healthcare professionals and community partners through the awarding of *Mentorship Development Grants*.

The MHMA program is having an impact across Canada. The 15 awardees to date are leading efforts to advance the uptake and use of evidence-informed decision making within Canada's public health sector; overseeing a Young Canadians Roundtable on Health; establishing a network of academic women mentors; and providing individual and group mentoring for Canadian research trainees, among other activities.

The next five years...

Upon completion of its NCE mandate in 2019, AllerGen will continue to manage the Annual MHMA awards competition, which promotes mentorship and a collaborative way of working across sectors and disciplines Canada-wide.

In addition, it has vested several of its major HQP award programs with Legacy Partners to ensure their continued availability. These include:

- *Emerging Clinician-Scientist Fellowship* awards, jointly carried forward by three of AllerGen's national partners, spanning clinical (CSACI), government (CIHR) and industry (AstraZeneca) sectors, to support Canadian allergists, clinical immunologists, MD clinician-scientists and basic scientists undertaking translational academic research in allergic asthma.
- *Graduate Student Research Awards*, carried forward by CAAIF and Asthma Canada to support the training, education and professional development of graduate students, and to promote the search for a cure for asthma.

- *Summer Studentships*, offered by CSACI, an AllerGen Legacy Partner, to enable undergraduate trainees and medical students to conduct research in asthma, allergic rhinitis, atopic dermatitis, chronic urticaria, food allergy, anaphylaxis, immunodeficiency and other immunological diseases.

Knowledge & Technology Exchange & Exploitation (KTEE)

Converting research into socioeconomic benefits

AllerGen research has produced over 6,700 scientific publications and been featured over 4,000 times in international media stories.

AllerGen's knowledge mobilization and commercialization activities have accelerated the uptake and application of Network research outputs by partners, stakeholders and receptor communities in Canada and abroad.

AllerGen Innovation Products

- 32 industry licenses
- 15 patents issued/filed
- 8 spin-off companies, enterprises & networks
- 5 copyrights

KEY IMPACTS

Improving diagnoses, care and quality of life for Canadians with allergic diseases

AllerGen research investments have generated 60 novel KTEE products and tools in four key areas supporting patients, clinicians, educators, policymakers, advocacy groups and the general public.

Community Engagement/Policy Tools: School asthma KT strategy; food allergy school guidelines; food-free public library policy; traffic-related air pollution position statement; and food allergy prevalence tables widely used by clinical organizations, policymakers (e.g., Health Canada) and national food allergy organizations (e.g., Food Allergy Canada).

Databases: *CHILD db*—a database with 40 million data points; Allergy and Asthma Portal; global Innate Immunity Database; GENAPHA asthma genetics database; and AllerGen lay language research summaries database.

Diagnostic/Assessment Tools: OIT clinical practice guidelines; and a home assessment training tool.

E-learning Tools: peer-to-peer online mentoring programs; interactive food allergy app for kids and teens; asthma education materials including toolkits, workbooks and brochures; and webinar videos on topics such as *Knowledge Mobilization*, *Bioinformatics and Innovative Technology*, and *Planning for Research Success*.



The Legend of Tahnee, the Wolf: My Asthma Journey asthma education program was developed by AllerGen researchers at the University of Alberta in partnership with First Nations, Inuit and Métis communities. The interactive educational program for children offers accessible, appropriate and culturally relevant resources to optimize asthma management and control and improve quality of life.



AllerGen's CIHR award-winning video series (2016-1st place; 2019-2nd place) delivers actionable "knowledge nuggets" from the CHILD Cohort Study about how early-life exposures, such as breastfeeding, cesarean-section delivery, and the use of antibiotics and cleaning products can influence a child's gut microbiome, health and wellbeing.

Strengthening Canada's global scientific and economic leadership position

The Network's strategic focus on intellectual property (IP) identification, support and management has helped AllerGen researchers better understand and protect their IP and leverage it to innovate and achieve commercial success.

AllerGen researchers have generated 85 Canadian innovations – including numerous patents, spin-off companies, industry licenses, and resources – that are achieving research impact through commercialization.

Global dissemination of AllerGen research

- 6,730 Network publications | 858 peer reviewed
- 1,863 conference presentations in 41 countries
- 1,325 posters in 22 countries
- 103 national Network press releases
- 150,887 website visitors
- 2,951 Twitter followers | 6,928 tweets
- 185 YouTube videos | 44,100 views
- 103 workshops | 6 Cafés Scientifiques
- 15 capacity-building webinars | 495 attendees
- 12 Success Stories magazine issues
- 10 Research SKETCHES lay summaries

Boosting KTEE capacity among Canadian researchers

AllerGen's investments in building KTEE literacy and skills among its researchers and trainees have helped make Network outputs accessible to diverse audiences and helped improve the communication of scientific and clinical research results to diverse Canadian audiences and stakeholders.

- Strategic Initiative funding – a rapid response strategy within AllerGen's research program – devoted \$3.7M to support 83 KMb and commercialization project teams to mobilize, translate and protect intellectual property.

Spin-offs: Companies, Commercial Enterprises and Networks

Adiga Life Sciences (Biomarkers & Bioinformatics)

Respirlyte Inc © (Biomarkers & Bioinformatics)

AirSENCE (Gene-Environment Interactions)

TAG (Traffic Pollution, Asthma and Genetics) Consortium (Gene-Environment Interactions)

CANUE (Gene-Environment Interactions, CHILD Cohort Study)

GET-FACTS (National Food Allergy Strategic Team)

SyMBIOTA (CHILD Cohort Study)

InFAC – International Food Allergy Consortium (National Food Allergy Strategic Team, CHILD Cohort Study)

- AllerGen's Network-Supported Intellectual Property (NSIP) Advisory Committee and unique KTEE/Commercialization Mentorship Program provided support, coordination, and technical advice to facilitate research commercialization in collaboration with the university industry liaison offices (UILOs) at Network Member institutions.
- AllerGen's *Knowledge Translation Planning Toolkit* offers researchers and partner organizations a comprehensive KMb strategy, and a "co-produced pathway from research to impact" framework to advance the uptake of research results.
- Advanced training in presentations and communications was provided annually to all Network participants, from trainees to researchers to partner organizations.

Facilitating long-term impacts through stakeholder engagement

AllerGen used a three-pronged approach to engage stakeholders in Network research.

"Hub and spoke" model: Key stakeholders in asthma research, clinical care, and advocacy (e.g., CSACI, Canadian Pediatric Society, Asthma Canada, Food Allergy Canada, the Canadian Thoracic Society, The Sandbox Project, Health Nexus Santé, and UNICEF, among many others) have leveraged their networks to amplify the breadth and reach of AllerGen's research results.

Multidisciplinary Stakeholder Advisory Committees: AllerGen's Legacy Projects have established knowledge user teams from government, industry, clinical practice, and the community to support the rapid and effective uptake, implementation and continuation of Network research.

Participant Engagement Committees: CHILD has established regional and national participant committees involving children and parents, to bring their voices, experiences and perspectives into the setting of research and KMb priorities.

Networking and Partnerships

The power of partnership

A network way of working has been Allergen's hallmark. The 103 workshops and meetings held since the Network's inception, with multidisciplinary and multisectoral participation, have built a strong global allergic disease network.

Since 2005, Allergen's Network-wide partner cash and in-kind investments total more than \$128.6M, representing an NCE to non-NCE leveraging ratio of \$1 : \$1.75

KEY IMPACTS

Leveraged strong partnerships to generate and disseminate new knowledge, therapies, clinical guidelines and KTEE outputs

Allergen has worked with an average of 137 key partners per year from industry, government, clinical practice, not-for-profit and community organizations, and other research receptor groups across sectors.

These partners have played a vital role in shaping Allergen's research outcomes, and in translating and commercializing findings that bridge the gap between the lab and Canadians living with allergic diseases.

- A partnership with the CANadian Urban Environmental (CANUE) Health Research Consortium – an Allergen GxE spin-off organization – links data from CHILd and the GxE Platform with CANUE's urban form and environmental data, helping policy- and decision-makers to design healthier cities.
- The GxE Platform partnered with six birth cohorts around the world in the TAG Study of 15,000 children, discovering that children with a specific genetic profile may be at increased risk of developing asthma when exposed to air pollution.
- Over a five-year period, CHILd partnered with the federal government's Chemicals Management Plan (CMP) – co-managed by Environment Canada and Health Canada – to measure Canadian children's exposure to phthalates.

Built capacity for Canada to tackle new global health priorities

Allergen's 15-year commitment to cooperative research across disciplines has positioned its pan-Canadian teams to contribute to global efforts to address new health priorities, including the COVID-19 pandemic. Numerous Allergen researchers and teams are involved in Canada's Rapid Responses to COVID-19 research.

Partnership Highlights

- 651 total partners | 3 partners (avg) per research project
- 148 international partners
- 45 international HQP collaborations
- 7 international Memoranda of Understanding to support collaborative research, student exchange and training
- \$128.6M partner investments
- Allergen-Partner funding leveraging: \$1 NCE : \$1.75 non-NCE investment

United researchers into transdisciplinary teams

Allergen promoted national and international networking across disciplines, institutions and sectors through project funding conditional on a networked approach and on equity, inclusion, diversity and excellence.

The result has been a remarkable transdisciplinary collaborative spirit, the relentless quest for new knowledge benefitting Canadians affected by allergy, asthma and related immune disease, and a deep commitment to capacity building, mentorship and excellence – these will be among Allergen's many enduring legacies arising from this fruitful and productive NCE adventure, 2004-2020.

"When I joined Allergen in 2007, I had published 3 papers on allergy-related topics in 7 years. Since 2012, I have published 50 such papers with Allergen colleagues in journals across several disciplines. I could not have achieved that depth and breadth of collaborative productivity without Allergen. It was career changing."

Dr. Kelly McNaghy
The University of British Columbia
Allergen Associate Scientific Director, GxE leader

Acknowledgements

Glossary of acronyms

AllerGen extends its sincere appreciation to the Network's investigators, trainees, partners, Board of Directors, Research Management Committee (RMC), Advisory Committee members, and the Network's leadership and administrative team. The accomplishments of the past 15 years are a testament to their ongoing commitment and contributions to the successful fulfillment of AllerGen's NCE mandate and mission.

AllerGen also thanks the NCE Secretariat and the Network's host institution, McMaster University, for their continued championing of AllerGen's vision, mission and goals since 2005.

Glossary of acronyms

A-CRO	Academic clinical research organization
AQHI	Air quality health index
AllerGen	Allergy, Genes and Environment Network
ASNPN	AllerGen Students and New Professionals Network
B&B	Biomarkers and Bioinformatics Enabling Platform
CAAIF	Canadian Asthma, Allergy and Immunology Foundation
CANUE	CANadian Urban Environmental Health Research Consortium
C-CARE	Cross-Canada Anaphylaxis REgistry
CanPAR	Canadian pediatric Peanut Allergy Registry
CHILD	CHILD Cohort Study
CHILD db	CHILD Cohort Study database
CIC	Clinical Investigator Collaborative
CIHR	Canadian Institutes of Health Research
CMi2	Canadian Microbiome Initiative 2
CMP	Chemicals Management Plan
COPD	Chronic Obstructive Pulmonary Disease
COVID-19	Coronavirus disease; caused by SARS-CoV-2 infection
CRRN	Canadian Respiratory Research Network
CSACI	Canadian Society of Allergy and Clinical Immunology

CyTOF	Mass cytometry by time-of-flight
DOHaD	Developmental origins of health and disease
EAI	Epinephrine auto-injector
EMS	Emergency medical services
FRSQ	Fonds de Recherche Santé Québec
GxE	Gene-Environment Interactions Enabling Platform
GENAPHA	Genomic Applications for Humanity
GET-FACTS	Genetics, Environment and Therapies: Food Allergy Clinical Tolerance Studies
HQP	Highly Qualified Personnel
InFAC	International Food Allergy Consortium
Innate DB	Innate Immunity Database
IP	Intellectual property
KMb	Knowledge mobilization
KT	Knowledge translation
KTEE	Knowledge Transfer Exploitation and Exchange
MHMA	Michelle Harkness Mentorship Awards
MSFHR	Michael Smith Foundation for Health Research
NCD	Non-communicable disease
NCE	Networks of Centres of Excellence
NFAST	National Food Allergy Strategic Team
NSIP	Network Supported Intellectual Property Advisory Committee
OIT	Oral immunotherapy
PPP	Patients, Policy and Public Health Enabling Platform
R & D	Research and development
SOP	Standardized Operating Practices
SyMBIOTA	Synergy in Microbiota Research
TAG	Traffic Pollution, Asthma and Genetics Consortium
TSLP	Thymic stromal lymphopoietin
UILO	University industry liaison offices





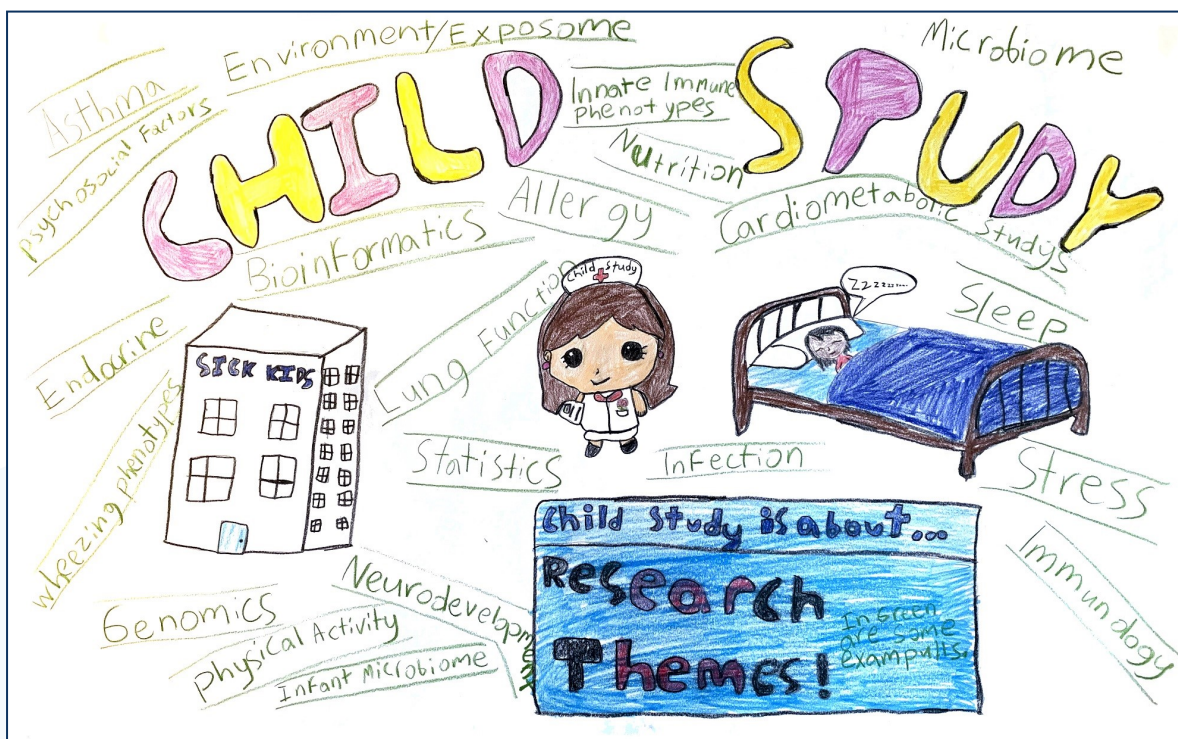
Members of AllerGen's **Research Management Committee** at AllerGen's 2019 Research Conference.



Members of the **Executive Committee of AllerGen's HQP Network** at AllerGen's 2019 Research Conference.



CHILD Cohort Study research leaders, staff, and participating family members at AllerGen's 2019 Research Conference.



Maya, 9 years (CHILD participant in Mississauga, ON):

"My Poster is about all the kinds of knowledge the CHILD Study will bring to be used to make children's lives better."



Allergy, Genes and Environment Network
Le réseau des allergies, des gènes et de l'environnement

2004-
2020



NCE RCE

Networks of Centres | Réseaux de centres
of Excellence of Canada | d'excellence du Canada