
PRO BONO
ANALYTICS
interns

What is INFORMS?

With 12,500 members from nearly 90 countries, INFORMS is the largest international association of operations research (O.R.) and analytics professionals and students. INFORMS provides unique networking and learning opportunities for individual professionals, and organizations of all types and sizes, to better understand and use O.R. and analytics tools and methods to transform strategic visions and achieve better outcomes. O.R. and analytics enable organizations to turn complex challenges into substantial opportunities by transforming data into information, and information into insights for making better decisions and improving results.

What is Pro Bono Analytics?

Pro Bono Analytics is a program created by INFORMS to link operations research/analytics professionals who are willing to volunteer their skills with nonprofit organizations, working in underserved areas or with underserved populations, that could benefit from analytics. We currently have 600 volunteers who are looking to give back to their communities.

How do our awards demonstrate measurable impact?

INFORMS' most prestigous application prize, the Franz Edelman competition attests to the contributions of operations research and analytics in both the profit and nonprofit sectors. Since its inception, cumulative benefits from Edelman finalist projects have topped the $257 billion mark. Edelman finalist teams have improved organizational efficiency, increased profits, brought better products to consumers, helped foster peace negotiations, and saved lives. Our student competition "Doing Good With Good O.R." features the most exciting work performed by students in partnership with public and private organizations that yields tangible and beneficial outcomes for individuals, communities, and organizations.

What types of business problems can be solved by partnering with Pro Bono Analytics?

- How to improve operational efficiency
- How to better utilize limited people resources
- How to develop a strategic plan, with goals of sustainability and equity rather than profit
- How to measure and communicate impact
- How to expand a successful program
- How to best launch a new program

PRO BONO ANALYTICS

Pro Bono Analytics (PBA) helps nonprofits use data to make better decisions & stretch limited resources.

	NASHVILLE ZOO	LawNY	GOODWILL	FAMILY SERVICES	MEALS-ON-WHEELS
PROBLEM	How can you best measure and report the impact of youth education programs?	How can the different in-take processes at multiple pro bono law offices be streamlined and made consistent, with goals of speeding up the decision and being consistent in the cases accepted?	Goodwill of Grand Rapids faced with declining foot traffic in stores, how should limited marketing funds be allocated?	How can Family Service of Greater Boston (FSGB) best coordinate care for at-risk urban children and their families across programs?	What changes can be made to the supply chain to improve the timing and accuracy of hot meal deliveries?
SOLUTION	PBA volunteers consulted with the Nashville Zoo on the appropriate metrics, collected and organized data, and created visualizations quantifying the effectiveness of their education programs on animal conservation.	PBA volunteers worked with 7 different offices of LawNY: interviewing personnel and identifying processes, and then developing a business process map of the various in-take approaches.	PBA volunteers analyzed data on ad campaigns (TV, radio, social media, Pandora, print, billboards) along with store customer counters and donation levels, to help Goodwill understand the various relationships.	A data collection and management strategy to standardize information across their various outpatient and in-home programs was designed and developed by PBA volunteers.	Working with an INFORMS Student Chapter from the University at Buffalo, a new inventory control system was designed for the Meals-on-Wheels warehouse.
IMPACT	Provided the Nashville Zoo with enhanced capability to measure current program effectiveness, thus improving future curriculum development and fund raising efforts.	Recommendations for improvements enhances efficiency and effectiveness for clients, intake workers, and advocates.	Allowed the Grand Rapids branch of Goodwill to tailor marketing spend to the most effective campaigns strategies.	Created the ability to provide evidence-based decisions regarding program changes, allowing FSGB to better serve their clients.	The improved warehouse design increased the accuracy of deliveries, and led to a follow on project with the student chapter to optimize warehouse storage space.

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APPENDIX

Analytics helps companies use data to make better decisions and impact bottom lines.

EDUCATION	MIT's "An Analytics Approach to the Clock Drawing Test for Cognitive Impairment," shows a better approach for doctors to dectect early indicators of dementia and Alzheimer's.	Routing special-education students in urban environments requires structure, special sequencing restrictions, and route duration limitations. Heuristics can achieve significant savings for both route distance and route duration, and a shuttle system is also found to be effective.	"Improving Access to Science and Math Ed in Western PA" proposed strategies for cooperation between school districts that included moving students to multiple centers for advanced math and science courses & moving teachers between schools.	"Information Technologies in Business: A Blueprint for Education and Research" helps define a natural path for future research about IT in business & society that will lead to stronger intellectual foundations for the field & define future education that is grounded in concepts & theories that emerge from research.	"Guiding School-Choice Reform through O.R." views reform as an optimization problem of finding school-choice menus and priorities that induce the best combination of equity of access, proximity to home, predictability, and community cohesion.
ARTS & CULTURE	Federal Communications Commission (FCC) conducted the world's first major two-sided auction, during which the FCC purchased spectrum from TV broadcasters to sell to wireless providers. In addition to raising nearly $20 billion in revenue, the FCC contributed $7 billion toward reducing the federal deficit.	Turner Broadcasting developed audience targeting solutions that simultaneously created advertiser and sales efficiencies. These solutions, TargetingNOW and AudienceNOW, use integrated forecasting and optimization models to revolutionize media industry standards and processes.	Are Super Bowl ads worth it? New research indicates sales benefits persist well into the year. For advertisers who may question the value of Super Bowl ads, which can cost upwards of $4 million for a 30 second spot, new research shows the value of these ads can persist into basketball and baseball seasons.	Pennsylvania Shakespeare Festival: "Analytics to identify potential season donors and high-value patrons and subscribers."	Imitation is the most sincere form of flattery, unless you are an app developer. New research shows that a copycat app's ability to either detract from or enhance the success of the original depends on the quality of the copycat.
HUMAN SERVICES	U.S. Centers for Disease Control's project with KidRisk, Inc., "Eradicating Polio Using Better Decision Models" eliminated polio in India.	"UPS On-Road Integrated Optimization and Navigation (ORION) Project" not only realizes hundreds of millions in cost savings and effieceny gains, but saves tons of $C0_2$ output.	Syngenta applied O.R. methods to breeding decisions for crop production, reducing the time and cost required to develop crops with higher productivity to meet the needs of a growing world population.	"Let the Needles Do the Talking! Evaluating the New Haven Needle Exchange" reduced the rate of HIV infection rate of program participants by 33%.	The NYPD created a network of sensors, databases, devices, software & infrastructure that delivers tailored information to both NYPD desktop and mobile devices, enabling the NYPD to use data to inform officer decision making and save lives with O.R. and analytics.

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Does your organization need help finding analytical answers to complex questions?

What is analytics, how can it help your nonprofit organization, and how can you get started?

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Nonprofit Client: UN HABITAT

UN HABITAT
FOR A BETTER URBAN FUTURE

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Measuring the state of Cities

Not everything that counts can be counted.

Cities are the home of prosperity, yet they are complex by nature - they are melting pots of culture and ideas and for those tasked with the responsibility of governing them, it is no easy feat to gather information that truly represents their status and allows them to measure progress against peer cities. Designing and enacting policies that will fairly affect all residents relies on the reporting of accurate information, but with so many aspects of society to indicate a city's health, where do you begin to measure and evaluate? Our partner, the **Global Urban Observatory (GUO)** team at **UN HABITAT**, brought this problem to us seeking volunteer analytics help.

The **Global Urban Observatory (GUO)** team at **UN HABITAT** is responsible for the data collection and dissemination of information for the *State of World Cities Report* . They measure and report on numerous indicators by city, such as income inequality, poverty rates, clean water access, healthcare access, school enrollments, women in the workforce, etc., to evaluate a city and its population. These reports are used to compute the *City Prosperity Index* in the *State of World Cities Report* for 100 cities globally helping to provide an innovative approach to urban environments and assisting decision makers to design clear policy interventions that are based on facts.

GUO was interested in adding a new KPI for reporting on city health; they needed to define a measure of human vulnerability that could be added to an existing *City Prosperity Index*. Human vulnerability for the purposes of this project effort focused on the following:

- The degree to which a population can absorb an event or series of events with minimal physical, mental, and emotional harm. Event(s) in this context include both shocks (sudden and often unpredictable) and stresses (continuous, cumulative, and often predictable).

- *World Health Organization* data on life expectancy can be used to calibrate a model to estimate a human vulnerability index.

After extensive analysis for generating how human vulnerability would be literally defined, our volunteers researched, modeled, and developed a city-based *Human Vulnerability Index* (HVI) that could be added as a new dimension to the *City Prosperity Index* . **They determined that the HVI could be divided into three primary components: susceptibility, lack of coping capacity, and lack of adaptability capacity** with each comprised of many subcomponents.

Result of the Project

The three primary components are important because they help to give insight into how a population would use its own resources to manage emergencies (in short-term and long-term), how they would be affected by harm/damage of a potential hazard and how they would adapt to this change in environment. Furthermore, this information helps a city compare itself against other cities, and identify areas where additional resources would have the greatest impact in reducing the vulnerability of their citizens. The PBA volunteers then finalized and published their model in Microsoft Excel and populated it with selected data fields provided by the Humanitarian Data Exchange (HDX). The model will help enable the **Global Urban Observatory (GUO)** team at **UN HABITAT** to accurately calculate a city-based *Human-Vulnerability Index* for use in their current and future *City Prosperity Index* publications.

PRO BONO ANALYTICS

Do you have a concern assessing the impact of decisions within your organization?

What is analytics, how can it help your nonprofit organization, and how can you get started?

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Nonprofit Client: AMTA

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Evaluating the Impact of Decisions

Not everything that counts can be counted.

Every nonprofit organization faces difficult decisions and, regardless of their nature, it is vital to assess all possible outcomes to the fullest extent. An analytical and calculated approach to evaluating decision impact is vastly important, assuming that the organization has the staff to implement such an analysis. Since the majority of nonprofit organizations do not have the bandwidth, they are left to their own devices and methods based on their experiences. the **American Music Therapy Association** was having this exact issue when they approached us for volunteer analytics help evaluating a paramount decision.

Music therapy is the clinical and evidence-based use of music interventions (instruments and music in general) to accomplish individualized goals within a therapeutic relationship. Credentialed professionals who have completed an approved music therapy program provide therapeutical benefits for healthcare goals to individuals of all ages.

Our partner, **American Music Therapy Association (AMTA)**, is an organization dedicated to the progressive development and public awareness of the therapeutic use of music in rehabilitation, special education, and community settings. They are committed to the advancement of education, training, professional standards, credentials, and research in support of the music therapy profession.

Professionalism is crucial for **AMTA** and the music therapy profession as a whole; they strive to uphold the highest level of excellence and credentialing for therapists and practitioners. To maintain this reputation of excellence, **AMTA** was interested in raising the bar for their minimum education level requirement to become a credentialed music therapist. They were seeking assistance in determining the impact of this decision to require a master's level education: impact on current practitioners, students, up-and-coming practitioners, future of the profession, therapy patients, and any unintended consequences that this new requirement might yield. *How do you measure and determine the potential ramifications of this decision?*

Our volunteers worked with **AMTA** to implement the Multiple-Objective Decision Analysis method for measuring and defining the different outcomes of the decision at various sections. Utilizing this approach was most beneficial for providing a thorough analysis that outlines the ideal characteristics of a successful education program (at the master's level) and its impact on music therapy professionals and clients. They built models with data based around characteristics of education programs, musical/clinical skills competencies, financial burden (to professionals and clients), etc, to help make their recommendations.

Result of the Project

After modeling various outcomes of the decision and completing the seven-steps of the Multiple-Objective Decision Analysis, it was determined that requiring the Master Level Entry (MLE) standard offered the most value to **AMTA.** It revealed that making this decision did not have any adverse impacts or unintended consequences on music therapy professionals, students, or patients – in fact, it would help continue the reputation of professionalism as desired by **AMTA**. Our volunteers helped them to fully evaluate all outcomes of a difficult decision that would impact the organization and profession as a whole allowing them to confidently change their minimum education requirement.

PRO BONO ANALYTICS

Do you have an issue identifying key performance data within your organization?

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Nonprofit Client: On the Rise

ON THE RISE

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Making Better Decisions with your Data

Not everything that can be counted, counts - One of the most difficult challenges faced by nonprofit organizations is to effectively communicate performance metrics and successes to board members, partners, and funders. Each organization is unique and there is not a one-size-fits-all combination of metrics that will accurately report current statuses and areas for potential improvement.

Effective communication can be compounded further by the plethora of data often collected by nonprofit organizations – not everything that can be counted is important, so how do you determine what metrics are necessary for telling the most powerful story? This is the exact issue our partner, **On the Rise**, was facing when they wanted to make better decisions with their data and approached us for volunteer analytics help.

On the Rise is a women's homeless shelter and community dedicated to their mission of providing the relationships, safety, and resources needed to get out and stay out of homelessness. Their primary offerings are day shelter services, housing, health services, legal services, financial advice, etc. while focusing on relationships as the foundation for staff advocacy within the program.

On the Rise collects a vast amount of data about its programs and clients, but its staff was overwhelmed identifying what information needed to be the focal point of their funder and partner reports. There were a few ideas for performance metrics they'd like to see, but no clear path for how to accurately identify or report them.

On the Rise needed to develop a tool for data aggregation and reporting to better explore some specific aspects of the organization's performance: relationships between program participants' engagement and other attributes (risk factors, tenure, housing status), how the organization is functioning as a whole, and gathering information about descriptive and diagnostic analytics reporting. Building a tool to easily identify and draw conclusions for these outcomes would help them achieve their main goal of identifying data to better communicate program effectiveness with funders and human service provider partners.

Our volunteers got together and started the process of sifting through **On the Rise's** data to identify what would be the most helpful for achieving their outcomes. They determined that they would compare participant demographic data, risk factors, and contact data (how the participant interacted with the organization) to identify a quantitative analysis with potential impact on the overall program design. Since this was one of the initial attempts at identifying choice information for performance reporting, our volunteers built a few analytics models as tools for a more accurate graphic depiction of the data. The models were set up and populated with engagement data measuring consistency (number of visits per month) and involvement (time spent per month) from participants.

Result of the Project

Identifying this preferred engagement and building the preliminary models laid the groundwork for **On the Rise** to further investigate phases of analysis for their policy makers and funders. Our volunteers helped them to realize the potential for using analytics to help identify program performances. They are inspired to continue collecting and identifying key data on program participants to complete a well-rounded, quantitative analysis of their organization and more accurately tell the story of their successes.

PRO BONO ANALYTICS

Do you have a concern measuring the impact of your marketing and advertising?

What is analytics, how can it help your nonprofit organization, and how can you get started?

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Nonprofit Client: Goodwill

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How do you effectively measure the success of your marketing and advertising?

Impactful marketing and advertising is one of the keys to success for every organization, especially nonprofits. The only way to determine marketing and advertising impact is by measuring and analyzing the various channels in which ads are delivered in addition to the message of the advertising. For most organizations lacking the bandwidth for such an analysis, this is much easier said than done. Raising awareness, increasing participation, soliciting funding, driving foot traffic, promoting the mission – whatever the reason for marketing and advertising -- a nonprofit organization is doing itself a disservice if there are no measurements for success and no analysis to provide recommendations for improving marketing and advertising efforts.

Our partner, **Goodwill of Greater Grand Rapids**, came to Pro Bono Analytics seeking volunteer help to get a better understanding of the effectiveness of their media advertising campaigns and the impact their campaigns had on driving foot traffic to their stores. **Goodwill Industries International Inc.** provides job training, employment placement services, and other community-based programs for people who have barriers preventing them from otherwise obtaining a job. In addition, **Goodwill Industries** may hire veterans and individuals who lack education or job experience or face employment challenges. **Goodwill** is funded by a massive network of franchised retail thrift stores that also operate as nonprofits. As with most other retailers, store traffic for franchisee **Goodwill of Greater Grand Rapids**, had been declining and there was no clear direction as to which media campaigns were more effective than others.

Goodwill of the Grand Rapids, Michigan Region had used a variety of both paid and unpaid advertising channels (radio, print, and television) and it was important to understand the difference across the ad channels and whether or not they were a paid service. They wanted volunteer help identifying which channels/payment status would yield a statistically significant effect on the transactions. Additionally, they wanted help identifying the effectiveness of their various coupon and discount offerings included in their advertising.

Our volunteer team got together and began working through **Goodwill's** advertising and sales data from 2014 to 2017 to identify relationship trends between advertising channel and spend and in-store foot traffic and sales. They determined that building linear regression models in R would be the best, most powerful approach for showing relationship trends and recommendations and analysis.

Result of the Project

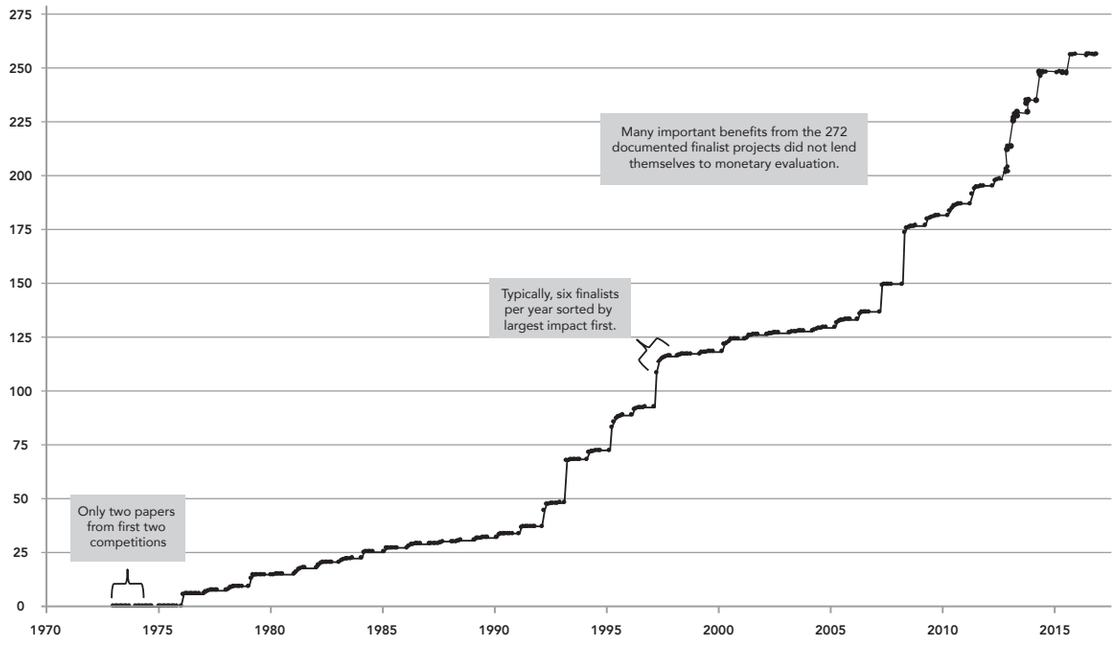
Having Pro Bono Analytics volunteers review their data proved successful for **Goodwill of the Grand Rapids, Michigan Region**. Our volunteers were able to determine that paying for printed advertising (magazines, newspapers, etc.) had the most positive impact on increasing in-store foot traffic and recommended that **Goodwill** consider investing more advertising budget into this channel in general. They also proposed decreasing some advertising spend on underperforming channels in addition to creating a survey to inquire with in-store customers to see which media channels they utilize. This project served as an excellent first step towards more efficiently using marketing and advertising to support **Goodwill's** efforts.

Operations Research: Billions and Billions of Benefits!

By Jeffrey M. Alden,
Technical Fellow, GM, R&D Operations Research

Benefits over 250 Billion from Edelman Finalist Projects 1972 through 2017

(Conservatively quantified benefits, realized plus at most two years anticipated, in 2018 U.S. dollars)



Over 257 billion U.S. dollars of impact! That's impressive! How were they estimated? How broad is the impact? Is there more?

Since 1974, the Edelman finalists published their project accomplishments in the INFORMS journal *Interfaces*. Reviewing all 272 articles, their monetary impact was estimated under these guidelines:

- Be objective and conservative.
- Include only one year of enormous impact (10s of billions) to downplay the huge size and budget of some organizations.
- Include reported impact and at most two more years of anticipated impact.
- Ignore relative impacts even though saving $10 million for a small company may be more impressive than saving $100 million for a large company.

These conservative guidelines do not include many important yet difficult-to-quantify benefits like better legal dispute resolution, cancer treatments, airline security, hazardous material deposition, budget allocation, epidemic disease control, organizational structure, on-time railway performance, and space shuttle heat shielding performance. For example, there are more than 20 finalist papers with significant life and health benefits. Most are very difficult to quantify, however, a CDC project on (future) U.S. epidemics expects annual savings of 6,000 lives valued at $12B[1] and a U.S. Army project prevented 4,500 casualties by reducing requirements for helicopter and ground-convoy movements[2]. Almost all finalist papers report non-monetary benefits and frequently tout them as most important and longer lasting by establishing, for example, ongoing practices and organizational changes that improve health, safety, cooperation, decision making, and job satisfaction. Great! Clearly, the reported monetary benefits greatly understate the full impact of the Edelman finalist projects.

Another important indication of the influence of operations research (O.R.) is the impressive breadth of applications. The Edelman finalists represent more than 130 different application areas including: air traffic, banking, canal operations, communications (broadband, broadcasting), consumer products, crowd control, delivery (express, truck), defense (air force, army), education, financial (pension, investment, credit card, settlement), fire protection, forestry, healthcare (blood collection, cancer, hospital, diagnosis, disease control, elderly, medical displays, pharmaceutical), hotel management, energy production and distribution (coal, gas, electric, oil, nuclear), land use, manufacturing (electronics, food, paper, seeds, steel, tires, vehicles, wood), marketing, mining, printing, sanitation, security (airport, police), senior housing, social networks, sports, tax collection, transportation (airline, highway, railway, space), treasure hunting, waste management, water (resources, quality, flow, flood), and weapons dismantlement. The list goes on and on! In fact, 692 organizations (business, government, academic, etc.) are recognized and honored as supporting or benefiting from finalist projects (some counted more than once).

Finally, the O.R. impact reported here is just the "tip of the iceberg" because the Edelman competition only captures those O.R. professionals choosing to compete! Just think, the count of Edelman finalist authors (1,249 with some counted twice) represents about 10% of the current INFORMS membership[3]. Undoubtedly, there is a vast number of O.R. projects with significant impact that did not compete due to confidentiality, lack of internal support to compete (e.g., no one thought of it, too busy, no management support, inadequate documentation), or the team was simply unaware of the competition.

The impact is immense... O.R. professionals should be proud of their profession – you can say "billions and billions" when asked about the value of O.R.

[1] For CDC: 6000 lives/year ≈ 314M U.S. population *5% epidemic penetration *10% die under current practices *(1-80% fatality reduction under improved practices) *1 epidemic per 200 years. Value of quality year of life in the United States is $2M/average life ≈ $50K/year (a standard value) *78 years life expectancy *50% average life lived. Total expected annual impact is $12B = 6000 x $2M. See "Advancing Public Health and Medical Preparedness with Operations Research," *Interfaces*, 2013, Vol. 43, No. 1, pp. 79–98 (note Figure 6). Numbers are reasonable values offered by the author.

[2] "Bayesian Networks for Combat Equipment Diagnostics," *Interfaces*, 2017, Vol. 47, No. 1, pp. 85–105.

[3] It is interesting how the average number of authors per paper has grown from 1.8 over first 10 award years (1974–1982) to 8.1 over the last 10 award years (2008–2017). Linear regression gives 0.16 annual growth in average authors per paper with $R^2 = 0.79$.