

A Decade of Discovery: Methodological Innovation, Capacity Building, and Global Leadership in Hidden Population Research in Iran

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Abstract

Background: In the early 2010s, Iran lacked reliable estimates of key populations at increased risk of HIV, including people who inject drugs, female sex workers, and men who have sex with men. This information gap limited evidence-based planning, resource allocation, and monitoring of HIV prevention programs.

Methods: This paper reviews the development and achievements of Iran's population size estimation program over more than a decade. Drawing on program records, published studies, training activities, and policy contributions, we summarise the program's impact across research, education, and policy domains.

Results: Research centres structured under the Institute for Futures Studies in Health (affiliated with Kerman University of Medical Sciences) combined expertise in modelling and public health to establish a national population size estimation program. The program generated population size estimates for key populations across Iran, produced a substantial body of scientific evidence, trained researchers and public health practitioners, strengthened institutional capacity, and contributed to HIV-related policy and planning. Its standing was further reinforced through regional recognition of the HIV/STI Surveillance Research Centre as a World Health Organisation Collaborating Centre for HIV Surveillance.

Conclusion: The Iranian population size estimation program demonstrates how sustained collaboration between modelling and public health researchers can generate evidence, build national capacity, strengthen institutions, and support public health policy. The program provides a model for developing similar initiatives in other settings.

Keywords: Iran, Population Size Estimation, Network Scale-Up

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Introduction

In the early 2010s, a new chapter in population size estimation (PSE) research emerged in Iran, particularly within the context of human immunodeficiency virus (HIV). At the time, Iran was facing a growing HIV burden (1), yet little reliable information existed on the size of high-risk populations who were at high risk of HIV, such as people who inject drugs, female sex workers, and men who have sex with men. As surveillance systems matured,

the absence of PSE became apparent, hindering efforts to allocate resources, monitor trends, and evaluate the impact of interventions (2-5).

To address this gap, both methodological innovation and coordinated efforts were needed. At the time, several independent research centres were established in Kerman, a city in southeast Iran, including the HIV/STI Surveillance Research Centre (HIVHUB) and the Modelling in

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Key Messages:

↑What is "already known" in this topic:

Reliable estimates of key populations at risk of HIV are essential for planning, resource allocation, and monitoring prevention programs. Population size estimation methods have been widely applied internationally to estimate the size of populations such as people who inject drugs and female sex workers.

→What this article adds:

This article documents the development of one of Iran's largest population size estimation programs over more than a decade. It highlights how collaboration between modelling and public health researchers generated evidence, built national capacity, strengthened institutions, and informed HIV-related policy and planning.

Health Research Centre. These centres provided a place where modelling knowledge and public health surveillance came together. The strength of collaboration between these groups laid the groundwork for a sustained national program in PSE studies. Building on this foundation, additional centres were later established, and these were eventually integrated under the umbrella of the Institute for Futures Studies in Health (IFSH). The formation of IFSH brought formal structure to this multidisciplinary collaboration. The HIVHUB was subsequently designated by the World Health Organisation (WHO) as a Collaborating Centre for HIV Surveillance in the Eastern Mediterranean Region (EMR), formalising the role of Kerman as a regional hub for HIV research.

Over the following decade, the Kerman-based team developed and implemented one of the most comprehensive PSE programs in Iran. While Kerman remained the core site of these initiatives, the technical and methodological capacity developed there extended far beyond the city itself. Researchers trained in Kerman or through IFSH workshops played a central role in implementing PSE studies across other provinces, contributing to a growing national research effort. This paper aims to document achievements by briefly introducing some PSE studies in Iran, sharing key findings and achievements, and highlighting the human and institutional capacities built through this sustained program. A summary of the main features of this program and its achievements across domains of education, research, and policy is presented in Table 1.

Brief overview of PSE studies in Iran

Estimating the size of hidden populations requires methodological approaches that address the absence of sampling frames and the potential for underreporting. In Iran, legal constraints and sociocultural stigma surrounding behaviours such as drug use and sex work further complicate data collection. To generate valid population size estimates under these conditions, we implemented a range of direct and indirect methods. Each method was selected based on its suitability for specific target populations, feasibility of implementation, and potential to minimise bias due to non-disclosure.

Direct Methods

Direct methods rely on access to reliable data sources such as registries or service records related to the hidden populations (6, 7). Therefore, the reliability of direct methods depends on the availability, completeness, and

quality of registry and service data. It is important to note that by ‘direct methods’, we do not mean surveys in which individuals are asked to report their sensitive characteristics.

Direct methods, such as the truncated Poisson and multiplier method, were applied in provinces where administrative or service-based data were accessible. For instance, a truncated Poisson model applied to hospital data in western Iran revealed that nearly half of all suicide attempts went unrecorded (8). The multiplier method was used in southern Iran to estimate the number of transgender individuals registered with judicial authorities, revealing that only around half were officially documented (9).

Indirect Methods

Indirect methods estimate the size of hidden populations without requiring direct contact with individuals from those populations or access to registry data. These approaches restructure sensitive questions to minimise the need for personal disclosure, thereby mitigating social desirability bias and protecting respondent anonymity.

Four main approaches were applied across multiple settings. The cross-wise model was used among university students to estimate sensitive behaviours like amphetamine use (10). The single sample count method was employed to estimate the national incidence of abortion (11). Proxy respondent methods were used to estimate the prevalence of high-risk behaviours in students (12). The most extensively applied method was the Network Scale-Up (NSU) method. National surveys using NSU estimated the size of people who inject drugs (PWID) (13, 14), and female sex workers (FSW) (15), and the method was strengthened through several methodological improvements, including recalculating average network size (16), and adjusting for visibility (17-19). One of the key achievements of this decade-long program has been the ability to monitor trends over time. A recently accepted national NSU study comparing three survey waves over ten years revealed upward trends in the estimated prevalence of multiple types of drug use (20). These findings reinforce the need for repeated, systematic application of PSE methods.

Capacity Building and Achievements

Over the past decade, the Kerman-based program for PSE has evolved from a local initiative into a nationally and regionally recognised model for research, training, and policy impact. The program simultaneously adopted

Table 1. Main features of the population size estimation program in Iran

Education	Research	Policy
1. Trained more than 15 postgraduate students across the country	1. Published nearly 40 peer-reviewed articles	1. Informed national HIV program planning and surveillance
2. Conducted over 30 national and international workshops	2. Developed and adopted several PSE methods	2. Influenced policy change
3. Delivered guest lectures at global institutes such as UCSF	3. Contributed to one-fourth of global NSU references	3. Provided technical support and input to WHO, UNAIDS, and national stakeholders
4. Built a national and regional network of trained researchers	4. Authored the reference book on PSE	4. Positioned Iran as the leader of PSE studies in EMR

and advanced alternative size estimation methods, trained a new generation of researchers, and contributed to the strengthening of HIV surveillance systems in Iran and EMR.

Research Outputs

Nearly 40 peer-reviewed papers were published in national and international journals, covering a wide range of PSE methods and populations. One of the program's major contributions was the adaptation of the Network Scale-Up (NSU) method. A systematic review of NSU studies published in recent years showed that approximately one-fourth of all references cited originated from the Kerman research team, underscoring their international contribution (21). Furthermore, the publication of the reference textbook *Methods in Epidemiology: Population Size Estimation* (Springer, 2021) (22) consolidated these experiences and is now widely used by researchers and students globally.

Capacity Building and Training

Another feature of the program was its sustained investment in training and mentorship. Over 15 postgraduate students completed their theses on PSE and related epidemiological topics in Kerman. Many of these graduates now hold academic or technical positions across Iran and in international institutions, contributing to independent studies in other provinces and sectors.

In addition to formal academic supervision, the team conducted more than 30 national and international workshops and participated in more than 150 national or international consultancies with organisations such as WHO and UNAIDS. Moreover, our workshops hosted over 1000 national and international participants. The program's impact extended internationally through guest lectures delivered at the University of California, San Francisco (UCSF), where Kerman researchers shared methodological insights and case studies with global public health students and faculty. These engagements not only built technical capacity but also helped establish a global dialogue

around ethical and innovative methods for studying hidden populations.

National and Regional Policy Impact

The work conducted in Kerman had tangible effects on national surveillance and policy. PSE estimates generated by the team informed strategic HIV program planning, resource allocation, and behavioural surveillance. Moreover, the methodologies refined in Kerman were adopted in various provinces, and many national studies were led by researchers trained in Kerman.

For example, we led a study estimating the annual abortion rate two years after the government ceased subsidising contraceptives as part of a pronatalist policy shift. Our findings revealed a rise in abortion rates following the change, highlighting unintended consequences for women's health (23). These results contributed to a policy reassessment, and the government revised its approach. In another case, our 2013 national study estimating the size of people who use illicit drugs (13) has been cited over 130 times and played a significant role in shaping public health planning in Iran.

Iran now leads the EMR in both the number and diversity of PSE studies. Over the past 10 years, researchers in Iran have published several PSE studies, with many led or technically supported by experts trained in Kerman. A systematic review published in 2016 highlighted the lack of sufficient population size estimates for FSW, Men Who Have Sex with Men (MSM), PWID, and transgender women in low and middle-income countries (24). This scarcity of data highlights Iran's unique role as a regional leader in this field.

The program's success can be structured into a reinforcing three-pillar model, where each pillar strengthens the others. This can be visually represented in Figure 1. The reinforcing cycle of the Kerman Model shows the scientific credibility (Pillar 1) attracts students and grants for training (Pillar 2). The skilled graduates embed themselves in the health system (Pillar 3), creating a demand for more high-quality research. Policy impact (Pillar 3)

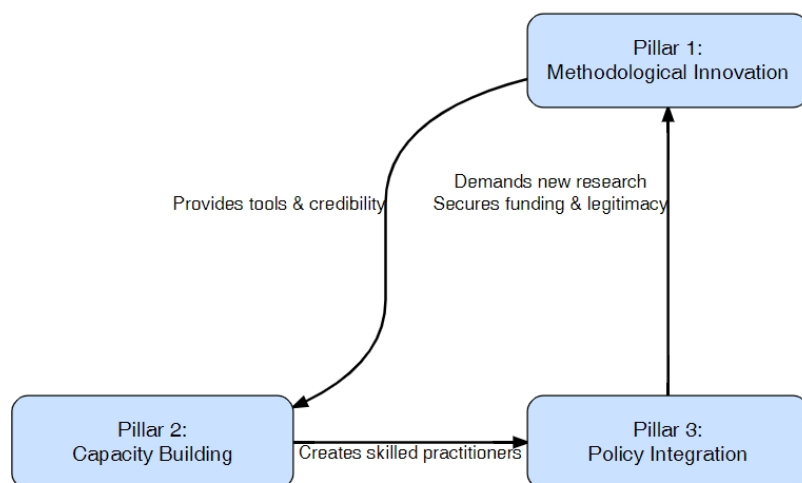


Figure 1. The Kerman Model for Evidence-Based Public Health: A Reinforcing Cycle of Research, Capacity, and Policy

then secures further government support and funding, enabling more innovation and training (Pillars 1 & 2). This creates a virtuous, self-sustaining cycle of evidence-based health advancement.

Pillar 1: Methodological Innovation & Groundbreaking Research

Activity: Adaptation of methods like NSU; high-volume, high-impact publication; textbook development.

Output: Scientific credibility, international recognition, and the foundational tools for change.

Pillar 2: Multi-Tiered Capacity Building

Activity: Academic training (theses), national/international workshops, global consultancies (WHO, UNAIDS).

Output: A sustainable network of skilled professionals embedded in the health system ("the Kerman network").

Pillar 3: Direct Policy Integration & Impact

Activity: Informing HIV resource allocation, leading national studies on sensitive topics (e.g., abortion, drug use).

Output: Tangible improvements in public health policy, government trust, and a demonstrated demand for research evidence.

Methodological contributions to population size estimation research

Beyond local implementation, the Kerman program also contributed to the methodological development of population size estimation (PSE) research. Several studies conducted by the team addressed important methodological challenges in the application of the Network Scale-Up (NSU) method. For example, one of our studies demonstrated that assuming the age-gender distribution of respondents' social networks mirrors that of the general population can bias estimates for behaviours concentrated within specific demographic groups, such as abortion among women of reproductive age (17). Another methodological investigation showed that estimates of social network size are highly sensitive to the choice of estimator, definition of calibration ratios, and exclusion criteria for unreliable reference groups, highlighting the importance of transparent calibration procedures in NSU studies (25). These contributions moved beyond the simple application of existing techniques and helped refine practical approaches for conducting NSU-based PSE studies in complex and culturally sensitive settings.

Conclusion

The Iranian experience with PSE offers a compelling example of how coordinated national efforts, when anchored in academic institutions, can generate lasting impact. The delegation of responsibility for PSE research and implementation to Kerman University of Medical Sciences led to a uniquely integrated model where scientific rigour and the support of national and international policy actors came together.

This program not only advanced methodological innovation and built national capacity but also created a structure for sustainable collaboration between research centres, public health institutions, and policy stakeholders.

The success of this approach lies in its ability to balance academic excellence with practical application and policy relevance.

We recommend that other countries adopt the Iranian integrated PSE model for public health system strengthening. By delegating primary responsibility for core research and implementation to an academic institution, this approach creates a unified system that merges scientific rigor with policy action. It serves as a replicable template for building sustainable national capacity, generating evidence-based responses, and ensuring public health efforts are both scientifically excellent and sustainably embedded within the national health architecture.

Acknowledgment

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Special thanks are owed to the national stakeholders who supported the implementation of population size estimation studies and to the international partners, including UNAIDS and WHO, who provided technical assistance, research funding, and global platforms for knowledge exchange. The collaboration between national and international actors has not only advanced the science of hidden population estimation in Iran but has also contributed to broader regional and global learning.

This collective effort stands as a testament to what can be achieved when scientific inquiry, institutional support, and shared public health goals come together in pursuit of evidence-based solutions.

Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

MRB and AHH conceptualised this study and wrote the first draft of this manuscript. All authors have read, edited, and approved the final version of the manuscript.

Ethical Considerations

All original studies described in this paper received ethical approval from the Ethics Committee of Kerman University of Medical Sciences prior to data collection and

implementation.

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N/A.

Data Availability

No new datasets were generated or analysed for this study. The paper summarises findings from previously published and conducted studies.

AI Use Statement

The manuscript was written by the authors. AI tools were used to assist with grammar, language editing, and improving readability. All content, interpretations, and conclusions were developed, reviewed, and approved by the authors.

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