Meeting global health challenges through operational research and management science

Geoff Royston[a]

Abstract This paper considers how operational research and management science can improve the design of health systems and the delivery of health care, particularly in low-resource settings. It identifies some gaps in the way operational research is typically used in global health and proposes steps to bridge them. It then outlines some analytical tools of operational research and management science and illustrates how their use can inform some typical design and delivery challenges in global health. The paper concludes by considering factors that will increase and improve the contribution of operational research and management science to global health.

Abstracts in عربي, 中文, Français, Русский and Español at the end of each article.

Introduction

The historic international health conference at Alma-Ata in 1978 first identified the need for research on "operation, control and evaluation problems" in primary health care.[1] Since then, successive reports from the World Health Organization (WHO) have expressed the need for improvements in organization and delivery and have called for research, both on particular interventions and on entire health systems.[2] Penetrating the "fog of delivery" clearly presents a major global health research challenge.

Operational research (also known as operations research) and management science have made major contributions in improving organization and delivery in many fields of human activity. Operational research originated in the military arena with the design of an integrated information and control system for the British air force in World War II, work which was estimated to have doubled the efficacy of its fighter command. Since then its use has spread, often providing big returns on investment. Two recent examples are: the world's largest logistics company redesigned its overnight delivery network which was estimated to yield savings of more than 270 million United States dollars (US$) and a global automobile manufacturer streamlined its prototype vehicle testing, saving US$ 250 million annually. These examples and more are available at: http://www.scienceofbetter.org.

However, operational research and management science are underused in the health field, certainly in global health. For example, the Global Fund to Fight AIDS, TB and Malaria allows 5–10% of each grant for monitoring, evaluation and operations research. However, recent estimates are that projects only budget an average of 3% for operational research and actually spend considerably less.[3]

Missing links

Despite the low priority that global health has given operational research, some valuable work has been and is being done. Some examples include: a 32-country programme on primary-care operations research established in 1981 by the US Agency for International Development;[4] a sustained operational research effort over several decades underpinning the development of a global strategy on tuberculosis control;[5] and an established body of operational research around HIV/AIDS.[6]

In global health, operational research has an extremely broad interpretation. The term is used for almost any type of improvement-oriented investigation into a programme's operations. Where management science generally uses systems modelling and related analytical techniques, operational research in global health does not use these tools sufficiently. Almost two decades ago a review of this field noted this gap and stated that many operational research studies in global health "do not carry the full flavour of operational research".[7] With some exceptions, such as for HIV/AIDS where there has been a good deal of operational research modelling work,[8,9] that gap clearly remains, particularly for neglected tropical diseases.[10] For example, guides on operational research published by WHO and the Global Fund to Fight AIDS, TB and Malaria focus mainly on the use of interviews, questionnaires and observations, with less emphasis on experimentation and no coverage of modelling or other analytical methods.[11] Stronger links between the practical and analytical approaches would bridge this gap.

Strengthening the use of management science in global health would also improve communication between operational research workers in global health and development. A recent review of operational research in developing countries provides useful detail.[12]

Analytical tools

Management scientists use a range of analytical tools, from quantitative prediction and optimization techniques to qualitative problem structuring and solution search approaches (Fig. 1).[13] The tools listed on the top left side of the figure are predominantly qualitative and are typically used with groups of people in participative sessions while those on the bottom right are predominantly quantitative and are typically used by individual analysts in desk-based work. For example, behavioural simulation involves groups of stakeholders acting out a system change or problem situation to gain insights – in a risk-free environment – into likely consequences of their actions. Discrete event and agent simulation seeks to gain such insights rapidly by using computer modelling to represent key system components

[a] Consultant, Burton Leonard, Harrogate, HG3 3SJ, England.
Correspondence to Geoff Royston (e-mail: geoff.royston@gmail.com).
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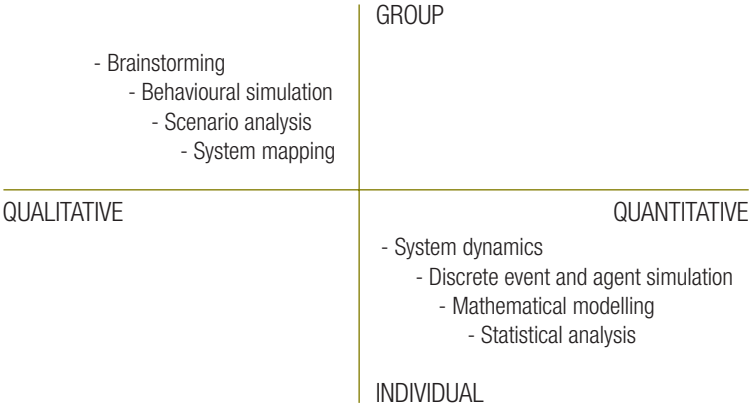
Fig. 1. **Analytical tools of operational research and management science**



(agents), their interactions and resulting changes (discrete events).

Qualitative approaches are most likely to be of use at the early stages of analysis, or when time and/or data are in short supply or when the problems are ill-defined. Several problem-focused qualitative analytical tools, such as root cause analysis or influence diagramming (which could be termed "system mapping" approaches), combine analytical rigour with simplicity and transparency. They are particularly useful where it may be difficult or inappropriate to use more quantitative methods.

Some of the more quantitative or computational approaches can be useful, even with limited data, as their key outputs are often determined more by the structure and logic of a situation than precise values of parameters. One such approach is "system dynamics" modelling, a more aggregate modelling approach than discrete event or agent simulation and one that pays particular attention to feedback effects. A noteworthy example of this is the system dynamics epidemiological model used in the global campaign to eradicate polio. The model incorporated a feedback loop that represented how observed impacts of interventions would influence subsequent interventions. This informed a debate on the best approach by showing that eradication was a more effective and less costly long-term strategy than control as the latter approach would not prevent regular major flare-ups of the disease.[14]

These tools are not mutually exclusive. For example, workers on pandemic influenza have used tools including: brainstorming-based SWOT (strengths, weaknesses, opportunities and threats) analysis,[15] behavioural simulation exercises, [16] scenario analysis,[17] system dynamics modelling[18] and various combinations of simulation and mathematical modelling.[19]

Nor should modelling be divorced from experiment; they can make a powerful combination with the strengths of one compensating for the limitations of the other. For example, given some basic experimental data, modelling can rapidly explore the effect of varying testing intervals in screening programmes rather than waiting years for field tests on each option.

Note that the word "system" appears twice at the very centre of Fig. 1. While some aspects of health-care delivery are essentially logistical, and so amenable to the use of traditional analytic methods, many health issues are complex and require systemic analysis,[20] as is being increasingly recognized. For instance in a recent WHO report,[21] which stated "systems thinking has a huge and untapped potential, first in deciphering the complexity of an entire health system, and then in applying this understanding to design and evaluate interventions". Systems thinking has several important differences from the more usual "linear" perspective, some of which are summarized in Table 1.

Global health challenges

We now look at some key generic challenges that arise in global health (Fig. 2) and consider how operational research and management science can contribute to each.

Identifying problems

Operational research methods are useful for the systematic identification of problems and the search for potential solutions. Structured approaches to identifying options, such as the strategic choice approach[23] or systematic creativity approaches such as the Russian-invented methodology TRIZ (translated as "theory of inventive problem solving"),[24] have great potential for use in low-resource settings.[25] New approaches are important for global health because strategies and programmes must be designed to deal with both current and future challenges – from the global spread of disease to the impact of climate change. This can sometimes take us beyond traditional forecasting methodologies to the use of scenario analysis and other futures thinking methods. There has been a fair amount of such work in the health field and its methods have been adopted in high-profile initiatives such as by the

Table 1. **Differences between traditional thinking and systems thinking skills**

Traditional skill	Systems thinking skill
Static thinking: focusing on particular events	**Dynamic thinking:** framing a problem in terms of a pattern of behaviour over time
System-as-effect thinking: viewing behaviour generated by a system as driven by external forces	**System-as-cause thinking:** placing responsibility for a behaviour on internal actors who manage the policies and "plumbing" of the system
Tree-by-tree thinking: believing that knowing something well means focusing on the details	**Forest thinking**: believing that knowledge requires understanding the context of relationships
Factors thinking: listing factors that influence or are correlated with some result	**Operational thinking**: concentrating on causality and understanding how a behaviour is generated
Straight-line thinking: viewing causality as running in one direction, with each cause independent from other causes	**Closed-loop thinking**: viewing causality as an ongoing process, not a one-time event, with effects influencing causes and causes affecting one another

Source: Richmond.[22]

Government Office for Science in the United Kingdom of Great Britain and Northern Ireland. However, little appears to have been done on global health with the exception of scenario analyses on pandemic influenza[17] and on AIDS in Africa up to the year 2025.[26]

With an expected increase in extreme events linked to climate change, disaster planning and humanitarian logistics are becoming even more important.[27] Decision support tools specifically designed for wide-scale emergency situations should play an increasing role.[28] Developing experience in this sort of logistics analysis will have application in global health both in and beyond emergency situations.

Choosing interventions

Choosing appropriate interventions is clearly a crucial step. Effectiveness, safety, cost and equity should all be considered and researchers will be familiar with standard text-book methods for assessing these. But, in reality, assessments are rarely straightforward. It is often more effective and efficient to combine interventions, or to treat more than one disease at a time. For example, the integration of treatments for different diseases into cost-saving combined "packages". Finding the best combinations and delivery methods is a major research exercise in its own right. Modelling different intervention strategies before roll-out is now ubiquitous in many industries but is less common in health care.[29] Combining this approach with the necessary field and pilot studies should speed up and focus efforts. Modelling work has been done on ways to reduce maternal mortality[30] and in cervical cancer screening in low-resource settings.[31]

Introducing new interventions

Innovation is a key issue in global health. For instance telemedicine is increasingly being used in high-income countries, and beginning to be applied in middle- and low-income countries, enabled by the rapid global spread of mobile phone networks. However, many such applications in developing countries are not evaluated so there is a clear role for operational research to assess them and to improve their design and delivery.[32]

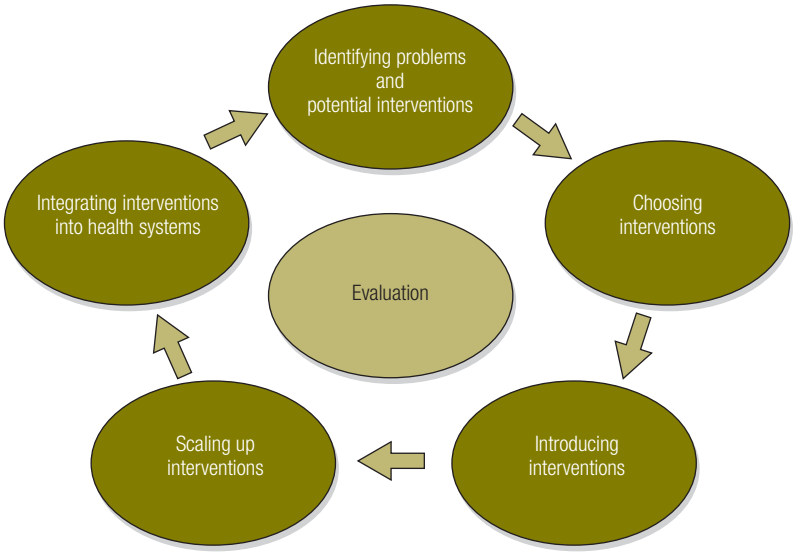
Mobile phones also allow much easier collection and collation of data for operational and related research. For example, an analysis of mobile phone data in Zanzibar (in the United Republic of Tanzania) showed movement patterns to regions with high levels of malaria. Combining this information with mathematical models of disease transmission suggested ways to improve malaria control.[33]

The contribution that operational research and management science can make to design and delivery is not restricted to high technology. Oral rehydration therapy is a "low-tech–low-cost–high-impact" innovation in which operational research was used to explore ways it could be administered at low cost using readily available ingredients by lay people, with an escalation pathway to treatment by health-care professionals when necessary.[34]

Scaling-up

Small-scale projects generally need considerable modifications to work on a larger scale. For example, we need to understand better what happens when whole countries are treated with drugs or vaccines. Such upscaling includes a need to forecast future demand, to decide the location and size of facilities and to set staffing levels. Classic operational research techniques such as simulation modelling can be used in locating services, managing the pharmaceutical supply chain and developing the health care workforce. One paper[35] presents models for efficient and equitable location of community health facilities in rural areas while another[36] describes the development of a simulation model of task allocation to reduce pressures on physicians at HIV clinics in Rwanda.

Fig. 2. **Global health challenges for operational research and management science**



Integrating into health systems

Successes in global health programmes often result from synergistic interactions between individual, community and national actors rather than from any single "magic bullet". We need a greater focus on how interventions should be used in a complex behavioural environment, to better capture the dynamics of social networks and to understand how complex systems can adapt positively to change. This is a task where operational research and management science tools can be useful, as demonstrated by systems analysis of programmes for cervical cancer prevention[37] or agent simulation modelling of spread of HIV in villages.[38]

Health systems are of course embedded in wider systems. Modelling can be a powerful tool in considering the sustainability of health interventions in the context of the wider environment[39] and in designing systems that affect health, such as waste management.[40]

Evaluation

One of the greatest challenges for global health is the measurement and evaluation of performance of projects and programmes (Fig. 2). Recent evaluation has shown that the results of the United Nations Children's Fund (UNICEF) accelerated child survival and develop-

Box 1. **Success factors for operational research in global health**

People:

- build bridges between service personnel (particularly managers) and the academic experts in a community, service personnel have the major say in determining research priorities;
- have a good mix of resources from universities, research institutes, nongovernmental organizations, government and private sector, linked to local implementers and researchers;
- use knowledge and expertise of the public and patients by involving them in prioritizing, designing and conducting research;
- encourage data collectors by showing use of their data;
- emphasize transfer of analytical skills to local researchers.

Methods:

- use systems analysis to identify the most important problems;
- use systematic search for a variety of possible solutions;
- tailor methods to level (local, national, international);
- clarify which management science tools can be used routinely in health and which need to have management scientists adapting methods to each different context;
- simplify archetypal decision models so that they do not require highly trained people to use them;
- avoid solutions requiring intensive local information and communication technology;
- use more participative tools (e.g. system mapping, root cause analysis) to facilitate public and patient involvement;
- reduce emphasis on "one-shot" studies with more provision for on-going research.

Communications:

- develop communications and public relations skills for translation of research findings into guidelines and influencing decision-makers;
- give more attention to possibilities for generalizing findings to more than one country;
- submit work for publication in peer-review literature.

ment programme fell far short of original claims,[41] a study that prompted an accompanying editorial in the *Lancet* that stated: "Evaluation must now become the top priority in global health".

Standard control trial approaches to evaluation are sometimes feasible and appropriate but often a more flexible systems-oriented approach is required, together with modelling (for example, for assessing screening programmes[42] or to help assess the effectiveness of preventive interventions).[43] Decision tree modelling can give rapid insights into the operational effectiveness and cost-effectiveness of procedures[44] and programmes[45] and a variety of operational research and management science tools have assisted evaluative work on broader global health issues.[46]

Ingredients for success

A first requirement for success is the availability of appropriate research and analysis skills and resources, which is clearly a challenge particularly in developing countries. This can be ameliorated by training people within the health service who can lead and champion operational research, such as the programme launched by the International Union Against Tuberculosis and Lung Disease.[47] Further steps might include extending the scope of the international consortium to strengthen health research capacity in Africa to include a full range of operational research and management science activities.

A second requirement is the effective deployment of capacity in operational research and management science. While there is an important role for people with these skills in developed countries to contribute to global health endeavours, more work is needed at the local level. Two recent articles[48,49] discussed factors for and barriers against successful operational research in low-income countries. While they share some features of operational research in health with countries such as the United Kingdom of Great Britain and Northern Ireland,[50] some features are specific to low-income settings. Success factors that are particularly important in such settings include involving appropriate people, using accessible methods and ensuring effective communication of results (Box 1).

Attention to these factors should help reduce implementation problems. Developing stronger links with those active in practical quality improvement work in health care, such as the Institute for Health care Improvement,[51] could also assist.

Conclusion

Achieving major improvements in global health will require some fundamental changes,[52] including advances in research and analysis of organization and delivery of health care. Operational research and management science approaches can inform a range of important design and delivery issues, but need to pay more attention to success factors and to draw on a broader range of analytical methods, with more interchange with wider operational research work. With greater capability in this field, operational research and management science can play a significant role in global health. ■

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ملخص

التصدي للتحديات العالمية من خلال البحث الميداني وعلم الإدارة

تظهر هذه الورقة العلمية كيف يمكن للبحث الميداني وعلم الإدارة أن يحسّن تصميم النظم الصحية وإيتاء الرعاية الصحية، ولاسيما في المناطق المحدودة الموارد. كما تحدد هذه الورقة العلمية بعض الثغرات في الطريقة المعتادة لاستخدام البحث الميداني في الصحة العالمية، وتقترح خطوات لرأب هذه الثغرات. ثم تستكشف بعض أدوات تحليل البحث الميداني وعلم الإدارة، وتوضح كيف يمكن لاستخدامهما أن يطلعنا ببعض التحديات أمام التصميم النموذجي وإيتاء خدمات الصحة العالمية. وتستنتج الورقة العلمية العوامل التي من شأنها أن تزيد وتحسن مساهمة البحث الميداني وعلم الإدارة في الصحة العالمية.

摘要

通过运筹学和管理学迎接全球健康挑战

本文利用运筹学和管理学方法分析如何改善卫生系统设计以及卫生保健服务提供,特别是低资源国家的情况。本文明确了运筹学通常用于全球健康研究方面的一些空白,并提出了弥补空白的措施。文章还概述了一些运筹学和管理学分析工具,并阐释了这些工具的运用如何告知全球卫生系统中一些典型的设计和卫生保健服务提供方面的挑战。文章最后考虑了增加并改进运筹学和管理学对全球健康贡献的因素。

Résumé

Relever les défis de la santé mondiale par la recherche opérationnelle et à la science de gestion

Ce document examine comment la recherche opérationnelle et la science de gestion peuvent améliorer la conception des systèmes de santé et la prestation de soins de santé, en particulier dans les milieux à faibles ressources. Il identifie certaines lacunes dans la façon dont la recherche opérationnelle est généralement utilisée dans la santé mondiale et propose des mesures pour y remédier. Il décrit ensuite certains outils d'analyse de la recherche opérationnelle et de la science de gestion et montre comment leur utilisation peut influencer certains défis typiques en termes de conception et de prestation dans la santé mondiale. L'article conclut en étudiant les facteurs qui accroîtront et amélioreront la contribution de la recherche opérationnelle et de la science de gestion à la santé mondiale.

Резюме

Решение глобальных проблем в области охраны здоровья путем применения методов исследования операций и науки управления

В данной статье показано, как исследование операций и наука управления могут улучшить структуру систем здравоохранения и обеспечить предоставление медико-санитарных услуг, особенно там, где ресурсы невелики. Статья указывает на некоторые упущения в том, как обычно используются методы исследования операций в вопросах охраны здоровья на глобальном уровне, и предлагает меры по их преодолению. Далее в статье кратко представлены некоторые аналитические инструменты исследования операций и науки управления, и показано, как их использование может обеспечить информацию по некоторым типичным проблемам, касающимся структуры и решения задач охраны здоровья на глобальном уровне. Статья завершается рассмотрением факторов, которые позволят увеличить и улучшить вклад исследования операций и науки управления в охрану здоровья на глобальном уровне.

Resumen

Cumplimiento de los retos sanitarios globales a través de la investigación operativa y las ciencias administrativas

Este artículo valora la medida en la que la investigación operativa y las ciencias administrativas podrían mejorar el diseño de los sistemas sanitarios y el suministro de atención sanitaria, especialmente en entornos de escasos recursos. También identifica algunas lagunas en la manera en la que se suele utilizar la investigación operativa en la sanidad global y propone los pasos que deben darse para cubrir dichas carencias. Además, se perfilan algunas herramientas analíticas de investigación operativa y ciencias administrativas y se muestra cómo su uso puede servir de apoyo en algunos diseños típicos y en retos de suministro de la sanidad global. El artículo concluye considerando los factores que incrementarán y mejorarán la contribución de la investigación operativa y las ciencias administrativas a la sanidad global.

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