Global Burden of Animal Diseases (GBADs) - Vision to implementation

Jonathan Rushton
and GBADs collaborators
jrushton@liverpool.ac.uk
Juanita Peréz
- A woman livestock keeper living on the margins
These are people who depend on livestock and aquatic animals. They are people living on the margins of society.

*https://animalhealthmetrics.org*
Poorly defined targeting of the animal health resources for poor disadvantaged livestock keepers

- Lack of data and information for the public and private sector to build business cases to address the last mile of delivery
- It is suspected that expenditure versus production loss is stark in many livestock systems
- Hundreds of millions of poor livestock owners are poorly served with veterinary services
Difficult funding environment for animal health

• Lack of data and information to build business cases
• World Bank teams struggle with analyses
• Evidence the global programmes for FMD and PPR are still not adequately funded at global or national levels

https://animalhealthmetrics.org
Little or no information on the success (or failure) of animal health policy areas

- No time series data on livestock production, productivity and trade that isolate animal health inputs and outputs
- Public strategy and policy development people are dissatisfied with current datasets available
- Recent attempts at a cost benefit analysis of rinderpest eradication failed to generate enough data to do justice to the success of this programme

https://animalhealthmetrics.org
Definitions

• **Global** – we will make estimates at a world level built on information from member states and private sector stakeholders

• **Burden** – our estimates will be based on the economic and social impacts of diseases

• **Animal** – we cover terrestrial and aquatic species that are kept for food, wool, manure, power, social capital

• **Diseases** – our estimates cover infectious, non-infectious and external causes (injury, accidents, predation)

**Global Burden of Animal Diseases - GBADs**

[https://animalhealthmetrics.org](https://animalhealthmetrics.org)
What motivates the GBADs programme?

Our livestock keepers, consumers and the environment need:

• **Investment plans** which ensure there are adequate animal health systems

• **Allocation of resources** to problems that most affect their health and wellbeing

• **Evaluation** of animal health investments to ensure they are delivering on societal outcomes
Vision

• **Vision:** For GBADs to be a world leader on livestock data and analysis for the economics of animal health built on data science and epidemiology

• **How:**
  - Tested and accepted methods of burden estimation
  - Publication of dataflow and methods
  - Publication and endorsement of global, regional and national burden estimations
  - Operational excellence in delivery of an expanded programme
  - Growing number of people and organisations using our approach

• **Value:** better investment, allocation and evaluation of animal health systems

https://animalhealthmetrics.org
GBADs – framework development and country case study implementation
A metric that is simple to describe powerful in meaning and use yet complex to calculate
GBADs - Analytical structure to provide clarity on data and analysis

Livestock Populations at Risk → Animal Health Loss Envelope → Attribution to specific causes → Impact across the economy

- Their biomass and the inputs
- Value of the animals and their outputs
- How much are we losing
- How much are we spending
- Absolute burden due to each disease
- Relative burden compared to total burden
- Who across society is affected

Rushton et al 2021

https://animalhealthmetrics.org
Framework to capture interactions between human and animal health

Animal health
- Abatement Strategies
- Animal Affected with Cause X
  - Productivity Loss
    - Mortality
    - Morbidity
      - Reproduction
      - Product loss
      - Efficiency change

AMR
- Climate Change
- Land-use Change
- Emerging Infectious Diseases
- Natural Disasters

Dire Zoonoses
- Increased Labour
- Environmental contamination

Nutrition
- Reduced Wean

Human health
- Wealth Impacts On Health
- Malnutrition Impacts On Health
- Other nutrition Impacts

Infected person with pathogen X
- Differential diagnosis

Climate related impacts on health

https://animalhealthmetrics.org

Courtesy of David Pigott, Brecht Devleesschawuer

GBADS
Global and national burden estimations
Number of animals

\[ N \]
Biomass

\[ N \times W = \text{Biomass} \]

\[ W \ - \ \text{weight per head} \]
Asset Value

\[ N \times W \times P = \text{Asset Value} \]

\( P \) — *price per unit of weight*
Economic Value (EV) - Asset plus Output Value

\[(N \times W \times P) + (O \times P) = EV\]

\(O \rightarrow total\ weight\ of\ output\)
Mortality loss

\[(N \times Mr) \times W \times P = Mortality\ loss\]

Mr — proportion of mortality loss
Morbidity loss

\[(O \times El) \times P = Morbidity\ Loss\]

\(El\) — yield gap proportion

\(P\) — price per unit of livestock product
Expenditure

\[ EV \times C = \text{Expenditure} \]

C — proportion of EV
Animal Health Loss Envelope

\[(N \times W \times P \times Mr) + (O \times P \times El) + (EV \times C) = AHLE\]

- Change in Assets
- Change in Revenue
- Change in Expenditure
Global livestock biomass (Schroebback et al, 2023)

0.6 billion tonnes of livestock and farmed aquatic species
US$1.6 trillion invested in these animals
US$ 1.7 trillion in meat, milk and eggs

https://animalhealthmetrics.org
Relative and absolute losses to disease - Animal health loss envelope

What is the best observed performance with current technology - **attainable**

Loss envelope, includes avoidable and unavoidable loss across all farms

<table>
<thead>
<tr>
<th>Loss (L) to disease</th>
<th>Expenditure (X) on control ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L_1</td>
<td>X_1</td>
</tr>
<tr>
<td>L_2</td>
<td>X_2</td>
</tr>
<tr>
<td>L_3</td>
<td>X_3</td>
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</tbody>
</table>

**Loss envelope, includes avoidable and unavoidable loss across all farms**

- **Burden 1**: Losses avoidable through better resource allocation on farm
- **Burden 2**: What is unavoidable with the technologies available

**Minimal cost optimum**

© Courtesy of Will Gilbert
Avoidable and unavoidable losses

• Total burden (AHLE) can be divided between **avoidable** and **unavoidable** losses

• Avoidable losses indicate technical and allocation issues within the system
  • Spending the wrong amount, on the wrong things
  • Unequal access across the population

• Unavoidable losses indicate lack of technical options for producers
  • The interventions needed don’t exist, or are not accessible to the population

https://animalhealthmetrics.org
Attribution

• To attribute the AHLE by a type of disease or health problem you need data on presence of the problem and its impact on mortality and morbidity

• Our public surveillance systems are established to focus on transboundary animal diseases in livestock with normally an indicator of present or absent – not a level
  • There are systems in the private sector where diseases and health problems are monitored yet these data are private

• The research and hence the literature on the impact of a disease issue is variable
Attributing AHLE to specific causes

Cause-specific models

Level I – IV

https://animalhealthmetrics.org

Courtesy of Mieghan Bruce and her team
**CAUSE**

aetiology

**Brucella melitensis**

**POPULATION**

Level: National  
Country: Ethiopia  
Species: Sheep and goats  
Production system: CLM

**OUTCOME TREE**

Asymptomatic infection

Symptomatic infection

Severities and duration

**Manifestations [ Syndromes ]**

- foetal loss
- abortion
- stillbirth

- lamb ill-thrift

- epididymitis

- hygroma [lameness]

**Change in production parameter**

- ↓ parturition rate  
- ↓ milk yield

- ↑ neonatal mortality

- ↓ parturition rate

- ↑ culling rate

**Animal Health Loss**

- ↓ output lambs

- ↓ output lambs

- ↑ output lower quality offtake

**Expenditure**

Vaccination  
Movement control

*Courtesy of Mieghan Bruce and her team*
Data collation: backyard poultry systems in low- and middle-income countries

- Backyard poultry production is the most widespread form of poultry keeping in the world, being an important component of small farmers’ livelihoods and a tool for poverty alleviation
- Systematic review for prevalence and incidence estimates of important diseases in backyard chickens
- Use imputation models based on meta-regression analysis to estimate disease prevalences in all LMICs
- Estimate disease burdens - attributing losses of each disease into the AHLE
- Bottom-up approach using co-morbidity model

https://animalhealthmetrics.org
Predicted prevalence of coccidiosis (A) and ascaridiosis (B) in low and middle-income countries

Once completed for all major diseases, burden estimates will be made based on outcome trees and measures of disease impact

Courtesy of Violetta Moñoz Gomez and Paul Torgerson
For greater granularity, predictions at sub national level.

For example: Predicted prevalence of coccidiosis (A) and ascaridiosis (B) in Eastern Africa

Courtesy of Violetta Moñoz Gomez and Paul Torgerson
Attribution of the global burden of animal diseases

• Comorbidity model to attribute animal disease burdens
• Model builds up from observed output then adds in estimated losses based on the incidence and impact of major diseases in a production system
• Developed on UK dairy system*, but rolled out to global estimates


Disease attribution

Loss per cow

Loss by disease and type of loss


https://animalhealthmetrics.org
Farm versus global burden estimations

- In general the literature is dominated by estimations of the burden of diseases that are financial estimations of the impact at farm-level.
- Economists will challenge these as the removal of these impacts will change the supply of livestock products and shift the equilibrium points across the economy.
- The scale of these changes at an economy level depends on the importance of the livestock sector relative to other parts of the economy.
- Using economy models – either partial or general equilibrium models – allows us to look at where the benefits to society occur and GDP changes.
Economy and trade implications

• Global modeling to reflect the impact and distortions diseases and their control have on the private and social good to countries and regions

• Global modeling will provide
  • Impacts on country level GDP, economic efficiency, prices, etc.
  • Impacts on domestic and international trade patterns
  • Impacts on the redistribution of wealth to consumers and firms
  • Information on how to more efficiently and equitably invest
  • Guidance on policy impacts

• Estimation
  • Partial Equilibrium Modeling (supply chain)
  • General Equilibrium Modeling (e.g., GTAP)
Results from Ethiopia
– courtesy of Professor Wudu Temesgen, ILRI and Dr Gashaw Benyene, Ministry of Agriculture, Ethiopia
Results from Ethiopian case study

• Results on
  • population, biomass and economic value
  • Animal health loss envelope
  • Attribution
  • Wider economic impact

• Presented in
  • stakeholder workshops held in Addis Ababa in November 2022, May 2023 & April 2024
  • WOAH general session in Paris May 2023 where over 70 people attended

• Reception to the work is positive
Ethiopian livestock population to biomass and value (from the GBADs webpage)

Population (head)  Biomass (kg)  Value of animals ($)

https://animalhealthmetrics.org
Animal health loss envelope (AHLE)

Small ruminants AHLE (2021)

- Ideal GM = 5.71E+09 USD
- Current GM = 1.50E+09 USD
- AHLE = 4.20E+09 USD

Components of small ruminants AHLE

- Morbidity loss: 18.0%
- Mortality loss: 0.1%
- A.H. Expenditure: 81.9%

Courtesy of Wudu Temesgen

https://animalhealthmetrics.org
Subnational Cattle AHLE by regional states (2021)

Total AHLE by regional states  AHLE per kg of biomass by regional states

https://animalhealthmetrics.org
Attribution at high level causes (Level 1), e.g., of Small Ruminants

https://animalhealthmetrics.org
Attribution at specific cause/disease level

- PPR and brucellosis impacts were estimated based on literature review and expert elicitation.
- These diseases are relatively small proportion of the estimated total loss yet cause significant farm level financial impact.
  - PPR – US$ 185.5 million
  - Brucellosis – US$ 26.3 million
Attribution of PPR impacts by production system and age group

• Through literature review and imputation of these data it is possible to attribute the PPR impacts in small ruminants to production system and age groups

• Information provided is intended to help target interventions such as vaccination and movement controls
Dashboards that provide information on economy and market shifts

Illustration of Attainable

Illustration of Attainable

https://animalhealthmetrics.org

Courtesy of Tom Marsh, Golam Shakil, Dustin Pendell
Animal health services impact consumers

- Animal health burdens affect consumers and value chain actors more than producers.
- A shift in animal health burdens will generate benefits across society and in particular urban consumers.

![Percentage of Total Change in Economic Surplus: Ideal Scenario](chart)

**Percentage of Total Change in Economic Surplus: Ideal Scenario**

**Producer Surplus + Asset Value**: 14.62%
**Processor Surplus**: 41.64%
**Consumer Surplus**: 43.71%

*Courtesy of Tom Marsh, Golam Shakil, Dustin Pendell*
GBADs summary estimates for Ethiopia

Livestock populations at risk

Standing value of animals $38.63 billion
- $31.20 billion cattle
- $5.95 billion sheep & goats
- $0.14 billion poultry
- $1.34 billion equids

Animal Health Loss Envelope

$24 billion AHLE split by:
- $17 billion cattle
- $4.2 billion sheep & goats
- $2.8 billion chicken
Or
- $5.89 billion mortality
- $17.16 billion morbidity
- $0.26 billion expenditure

Attribution by disease, health problem and accidents

$4.2 billion in sheep & goats attributed to:
- $1.89 billion infectious diseases
- $1.39 billion non-infectious diseases
- $0.92 billion external causes

Impact across the economy

Wider economy
- 3.6% GDP due to animal diseases burden from cattle & small ruminants
- Consumers are the main beneficiaries from improvements
- Trade impacts are positive to neighbouring countries

https://animalhealthmetrics.org

Courtesy of Wudu Temesgen & GBADs collaborators
GBADs work on working equids in Ethiopia

• An ongoing analysis shows the seldom recognized importance of donkeys in Ethiopia's diverse production systems

• Donkeys provide essential economic services, helping marginalized households with limited resources to significantly enhance their well-being and financial circumstances
  • Contributes up to 26% of annual income for owners

Courtesy of Girma Asteraye et al

https://animalhealthmetrics.org
Capacity building of stakeholders on the economics of animal health

• Support to develop a cadre of people in the application of economics of animal health through:
  • Two rounds of training on the economics of animal health including GBADs approach to assessing animal disease burdens
  • Coaching of core group from Ministry of Agriculture in the use of economics to animal health

https://animalhealthmetrics.org
GBADs Ethiopia case study dashboard

<table>
<thead>
<tr>
<th>User Guide &amp; References</th>
<th>AHLE</th>
<th>Attribution</th>
<th>Wider Economic Impact</th>
<th>Population</th>
<th>Data Viewer</th>
</tr>
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</table>

**Burden of Animal Disease in Ethiopia**

- **Currency**: Bir

**Selection**

- **Select Country**: Ethiopia

**View as...**

- Components
- Cumulative
- Over Time

**Year**: 2021

**Geographic Scope**

- National
- Subnational

**Subnational state**

**Select Subnational**

---

**Graphs**

- **National Values and Costs | All species, All Production Systems**

*Data and analysis courtesy of Wudu Temesgen & GBADs collaborators*
## Decision making within the Ministry of Agriculture - use of GBADs outputs now and in the future

<table>
<thead>
<tr>
<th>Decision / Question</th>
<th>Information Desired</th>
<th>Dashboard components</th>
</tr>
</thead>
</table>
| How much is the disease burden and how much should we invest or allocate to animal health system? | - the overall annual disease burden  
  - How disease impact changes over time  
  - the impact of all and specific diseases on the national and agriculture GDP      | AHLE                 |
| ⇒ Develop a national control program                                                |                                                                                     |                     |
| ⇒ Design policy and strategy                                                        |                                                                                     |                     |
| What is the optimal allocation of investments to diseases, based on their relative impact? | - the relative impact of each disease by region  
  - the relative costs and efficacy of treatment for those diseases                 | Attributed AHLE      |
| Which region should we focus on for intervention?                                   | - the impact of disease burden in each region                                       | Subnational AHLE (map) |
| For which cause do we need to design intervention and allocate more funds?          | - the burden for each cause  
  - How the impact of each cause changes over time                                    | Attributed AHLE      |

Courtesy of Gashaw Benyene et al
Impacts from the work

• Advocacy for livestock policies with the use of the economic impact estimations

• PPR project has used GBADs PPR work and has not repeated it

• Ease of access to data from the livestock facilitating analysis of policies and interventions
GBADs programme: empowering decision-making on livestock health through comprehensive data in Ethiopia

https://animalhealthmetrics.org
Results from other regions
Courtesy of:
- CSIRO/BRIN/Griffith – Indonesia,
- Anne Meyer, DSV, ISRA – Senegal
- Emma-Jane Murray and Conor MacLoon (UCD), David Graham (AHI) and Eoin Ryan (Irish Government) – Republic of Ireland
Utility of GBADs in Indonesia

• There are multiple potential end users & pathways to impact
• There is a need for accurate & timely information to support decision making
  • Interviewees perceive GBADs to be credible & relevant
  • Strong interest in all GBADs products (not just disease burden)
  • Information needs to be locally relevant
• The use of GBADs information as a tool for lobbying was consistently highlighted across different levels of decision making

Courtesy of Dom Smith, Di Mayberry, Yin Li, Harimurti et al
Indonesian biomass density 2021

Tonnes liveweight / km²

- Strong positive correlation between human & livestock biomass density
- Implications for resource use, zoonotic disease transmission

\[ y = 1.1651x + 0.5807 \]
\[ R^2 = 0.8854 \]

Courtesy of Dom Smith, Di Mayberry, Yin Li, Harimurti et al
Species differences in how livestock are valued

- Poultry are valued for their products; meat & eggs
- Cattle, small ruminants & pigs have larger population (asset) value

![Graph showing production and population values for different species of livestock](https://animalhealthmetrics.org)

*Courtesy of Dom Smith, Di Mayberry, Yin Li, Harimurti et al*
Total livestock value in 2021 (USD)
Asset + production value

 Courtesy of Dom Smith, Di Mayberry, Yin Li, Harimurti et al

https://animalhealthmetrics.org
Livestock value as a portion of GRP in 2021 (%)

Asset + production value

Courtesy of Dom Smith, Di Mayberry, Yin Li, Harimurti et al
Senegal - High-level attribution of mortality and production losses (expert-based)

• Similar methods were applied in the Senegal case study as for Ethiopia
• Lessons were learned on best practice
• This generated the overall loss (AHLE) and allowed high level attribution by cause

Courtesy of Anne Meyer, DSV, ISRA
Senegal estimated losses in mixed crop livestock systems in sheep and goats in 2022

All Cause

- Animal health expenditure: 4.7%
- Mortality losses: 22.4%
- Production losses: 72.9%

PPR

- Animal health expenditure: 4.5%
- Production losses: 14.8%
- Mortality losses: 80.7%

Courtesy of Anne Meyer, DSV, ISRA
Republic of Ireland

- Cattle case study funded by the Republic of Ireland government
- A further pig study is planned
- Cattle systems analysis is linked to government data sets with discussions on how GBADs methods can be embedded in government analytical structures

The research to estimate the biomass of Irish cattle by production type, and the associated changes over time, will be highly relevant to ongoing policy discussions about the Irish cattle herd and environmental issues. Issues such as whether policies supportive of a reduction in cattle numbers are needed in order to reduce methane emissions, and the impacts across the cattle sector of a reduction in stocking density in some dairy farms due to changes in the nitrates derogation limits in 2024, are a focus of considerable public and stakeholder interest and debate in Ireland. The results of this research will provide an evidence base to inform such discussions by robustly estimating the cattle biomass across types of farming systems in Ireland, as well as changes in biomass over time. This work will also provide an example for other countries facing similar discussions and debates relating to biomass, production and environmental issues.

Reaction from Dr Eoin Ryan, Head of Animal Welfare Division, Department of Agriculture Food and the Marine on the biomass work

Courtesy of Emma-Jane Murray, Conor Macloon UCD, David Graham, AHI, Eoin Ryan, Irish Government

https://animalhealthmetrics.org
Other general support and interest

- EU H2020 funded DECIDE project with burden estimations of endemic diseases in Europe
- EU Animal health and welfare partnership has funded a European burden of disease study
- EFSA call on the burden of zoonoses and Livestock Innovation (USAID) tender refer to GBADs methods
- Two established WOAH Collaborating Centres for Economics of Animal Health – Europe and the Americas
- Brooke fund a study in Ethiopia and would like to extend this for a further two years
- CAHEC China intend to add GBADs into their two year workplan
- NIVEDI, India are developing a proposal for two Indian states
- Australia biomass estimates will be used in environment work
- ILRI have included GBADs methods in a new project on RESTORE (restoration of livestock services in Ethiopia) – EU funded
GBADs – initial findings and the future
Key findings to date

• Methods are workable and can be rolled out
  • Ongoing investment to improve access to data and information

• Livestock populations continue to increase
  • With implications to the environment, public health and the economy

• Low levels of animal health expenditure in small scale producers compared to technologies available & production losses experienced
  • Access is a problem to millions of poor producers

• Animal health burdens have largest impacts on consumers, value chain actors and then producers
  • There are public good implications in the provision of animal health services
GBADs - Analytical structure

Livestock populations

Animal Health Loss Envelope

Attribution by disease, health problem and accidents

Farm-level Burden

- Their biomass and the inputs
  - Value of the animals and their outputs
  - How much are we losing
  - How much are we spending

- Absolute burden due to each disease
- Relative burden compared to total burden

Impact across the economy

Social & Economy Burden

- who across society is affected

Rushton et al 2021

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GBADs phase III

• Global estimations

• Country case studies
  • Guides developed leading to intervention identification and also standardized approaches (normative) procedure

• Knowledge Engine

• Capacity development in development and application of the economics of animal health
Global Estimations

- Focus on:
  - Mortality
  - Morbidity
  - Expenditure
  - Attribution by major diseases

\[(N \times W \times P \times Mr) + (O \times P \times E1) + (EV \times C) = AHLE\]

Change in Assets  
Change in Revenue  
Change in Expenditure

Reports every two years

https://animalhealthmetrics.org
Country case studies

- Rollout of country case studies based on the experiences from Ethiopia, Senegal, Indonesia, Republic of Ireland
- Customized according to in-country user-needs
- Co-produced dashboards, reports
- Links to improve global estimations

https://animalhealthmetrics.org
Strengthening the GBADs utility

- Matrix evaluation
- Survey of users and potential users
- Modifications of offerings
  - Dashboards
  - Data analytics
  - Guides
  - Courses

Diagram:

1. Measure demand
2. Assess gap and the change needed to fill it
3. Needs assessments
4. Assess quality of new products
5. Determine resource allocation for new products
GBAD's knowledge engine refinement

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<table>
<thead>
<tr>
<th>GBADs datasets</th>
<th>Exist</th>
<th>General user</th>
<th>Other specific user</th>
<th>GBADs utility</th>
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<tr>
<td>Populations at risk</td>
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https://animalhealthmetrics.org
Capacity development

• Integration of the capacity development with epidemiology and surveillance
• Focus on adding value to these data through economic and social analysis
GBADs guides with a special edition of WOAH Rev Tech Sci

• Phase II will generate five guides on estimations of:
  • Biomass
  • Economic value
  • Animal health loss envelope
  • Attribution by cause
  • Wider economic impacts

• There will also be a special edition of Rev Tech Sci that looks at policy implications
Case Study Countries

Continue to develop and support a community of practice

Key
Ongoing
Being initiated

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GBADs – the legacy of estimating burdens

Methods & Capacity

- Institutionalisation of GBADs methods
- Tools for Prioritisation and policy needs
- Educational materials
- Codes of best Practice

Information

- Impacts that can be compared between countries and food systems
- Health losses by disease and by people affected
- Distribution of livestock losses by species, systems, geographies
- Distribution of livestock by biomass, capital value

Burden of animal disease

- Production Loss
- Expenditure
- Economy & Trade

Attribution to diseases, co-morbidities, nutrition, injury

Estimations of the animal health loss envelope

Split by species and production systems

Livestock Populations

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People on the margins

- Nutrition
- Genetics
- Parasites
Building capacity
Developing teams
Acknowledgment: GBADs funders and collaborators

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