# USING VALUE CHAIN AND TRADE NETWORKS IN THE EASTERN CAPE PROVINCE OF SOUTH AFRICA, AS A BASIS FOR TARGETED RURAL CHICKEN SURVEILLANCE

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## ABSTRACT

Despite the benefits of rural chickens in the Eastern Cape Province (ECP) of South Africa, this sector is still underdeveloped and poorly surveyed for poultry diseases. The lack of a sustainable poultry disease surveillance system coupled with communities and practices where the interactions between birds are high, emphasize the need for targeted surveillance of chicken diseases in the province. However, to set up such a system requires knowledge of the value chain and trade networks. Consequently, a survey, which involved a rural chicken value chain analysis that also included an assessment of trading practices to identify biosecurity hotspots and an identification of barriers to market entry for rural farmers was conducted. Secondly, a social network analysis of chicken movements in the province was carried out to identify trade hubs that could be targeted for disease surveillance based on their centrality within the network and their size and influence within their ego networks. Traders and their transport vehicles were identified as biosecurity hotspots that could be targeted for disease surveillance within the

chain. Social network analysis identified three municipalities viz. Umzimvubu, King Sabata Dalindyebo (KSD) and Enoch Mgijima as trade hubs where interaction between rural chickens occurs and resources can be focused. The movement of spent hens from commercial operations that are transported over long distances and distributed in the rural areas and townships were a major risk for spread of poultry diseases. This is the first study to formally describe chicken trade networks within the province and the surrounding region. Its findings provide a model for cost effective targeted surveillance in the ECP and similar resource poor regions of the world. The study also provides insight into the profitability of rural chickens and a possible contribution to job creation and poverty alleviation once the barriers to market entry are lifted.

**Keywords:** disease surveillance, hotspots, value chain, rural chicken, trade networks

## 1. Introduction

Livestock plays a major role in the social, cultural and economic environment in the Eastern Cape Province (ECP) of South Africa. The Eastern Cape is among the lowest commercial poultry producing provinces in South Africa with 6.5% of total production (SAPA, 2017). This production statistic, however, doesn't include the majority of rural chickens owned by many households in the province. The province has the highest number (31%) of agricultural households engaged in poultry farming (an average of 1 to 10 chickens per household) compared to other provinces in South Africa (STATS, 2016).

Rural chickens serve as the main source of protein, generate income through sales of eggs and birds; and play a significant role in sociocultural activities such as traditional ceremonies and rituals (Mtileni et al., 2009; Conan et al., 2012). Chickens are mainly managed by women and income from the chickens often pays for the education and nutrition of their children and households in general (Jensen and Dolberg, 2003).

In the Eastern Cape Province, similar to countries in Sub-Saharan Africa, infectious diseases constitute a major challenge to the growth and profitability of the rural poultry sector. A recent serological survey done in this province revealed a high prevalence of antibodies to H6N2 subtype avian influenza, avian infectious bronchitis and *Mycoplasma gallisepticum* (Anonymous, 2021). Due to limited resources, veterinary services rely on passive surveillance for the control of chicken infectious diseases in the village settings, which precludes early detection, or the prevention of disease spread.

Given their important societal value, rural chickens are moved extensively within villages and beyond via informal trade (McCarron et al., 2015). In most of the cases, this trade is facilitated by middlemen who buy chickens directly from commercial farms and resell them. Such movements are known to be accompanied by the spread of highly infectious diseases such as Newcastle disease and avian influenza (Meyer et al., 2017; Poolkhet et al., 2018; Guinat et al., 2020; Hautefeuille et al., 2020; Gierak et al., 2021).

The lack of a sustainable active poultry surveillance system coupled with communities and practices where poultry interactions are high, present an opportunity for targeted surveillance in resource-poor regions (Anonymous, 2017). This involves placing surveillance systems in areas that are considered high-interaction areas or hot spots for livestock movement such as large markets with traders from many areas. Continuous assessment of the poultry disease situation in these foci could serve to monitor the disease status for the region. Timing this targeted surveillance with occasions associated with increased poultry movement, such as a holidays and cultural celebrations, would further increase the effectiveness of early disease detection (Anonymous, 2017).

The knowledge of a rural poultry sector which includes its value chain can lead to a deeper understanding of the local trade and its practices, which can in turn assist in identifying

high-risk pathways that could be targeted for surveillance within the chain (Anonymous, 2018). Combining this information provides a basis for social network analysis (SNA) that could be used to plot the movement of poultry (Anonymous, 2018). In recent years, social network analysis has been increasingly used in veterinary epidemiology as a tool for disease management and risk-based surveillance (Dube et al., 2009; Frossling et al., 2012). Positional analysis of nodes within a network enables the selection of nodes for which the probability of an outbreak is the highest, and consequently where the surveillance should be focused. These potential super-spreader areas can thus be used for targeted surveillance (Rasamoelina-Andriamanivo et al., 2014).

However, despite the economic importance of chickens in the ECP, there are no published studies on rural chicken trade networks. The first objective of the study was therefore to identify biosecurity hotspots and chicken trade hubs that could be targeted for disease surveillance within rural ECP by combining value chain analysis and SNA. The second objective was to use the value chain analysis to identify the barriers to market entry for rural chicken farmers in the province.

## 2. Materials and Methods

### 2.1 Study design

#### 2.1.1 General overview

An interview-based questionnaire survey targeting rural chicken farmers and other stakeholders involved in the rural chicken value chain (Table 1) in the ECP was conducted in two steps; from February to June 2019, an initial survey targeting chicken farmers was conducted, which was followed by a second survey from November 2020 to July 2021, based on information provided by chicken farmers in the first survey. The second survey targeted traders and processors identified by the farmers.

**Table 1**: Primary data sources for the survey conducted from February 2019 to July 2021 in the Eastern Cape Province

| Main actors | Number of participants, and size of flock owned (range), as applicable | Gender | Towns/Municipality |
|---|---|---|---|
| Producers | 210 farmers* | 65 males<br>145 females | 29 municipalities** |
| Traders | 28 | 18 males<br>10 females | Mthatha, Queenstown, Mount Ayliff, King William's Town, East London, Komga, Lady Frere, Gqeberha, Sterkspruit, Aliwal North, Mount Frere and Matatiele |
| Wholesalers | 2 | 2 males | East London and Queenstown |
| Butcheries | 8 | 8 males | Nelson Mandela, Emalahleni and Enoch Mgijima |
| Restaurants | 38 | 38 females | Engcobo, Queenstown, Mthatha, Matatiele, Aliwal North, Sterkspruit, Mount Frere, Aberdeen, Grahamstown, Alexandria, Gqeberha and Kariega |
| Meat inspector | 2 | 2 females | Enoch Mgijima |

*****Average range of chickens kept by farmers: chicks: 1-500; pullets: 1-500; cockerels: 1-30; hens 1-550

******ECP municipalities except Raymond Mhlaba, Great Kie, Kouga and Kou-Kamma

Questionnaires that targeted each respective type of stakeholder were developed and administered by the research team. The questionnaires were based on those used in Eastern Zambia (Anonymous, 2018). Validation of the questionnaires was done through consultation with state veterinarians and animal health officials working in the areas being surveyed. The authors further validated the questionnaires by including questions that were common to all questionnaires and comparing them during the final analysis of data.

### 2.1.2 Study area

The study area was the whole of the ECP. The province has a population of 6,676,590 people (STATS, 2021), with a density of 39 people /km.$^2$ The main spoken language is Xhosa and the province is economically the poorest province in South Africa and has the highest unemployment rate in the country (Musemwa et al., 2013; Manyani et al., 2021). . It therefore relies heavily on subsistence agriculture to support its economy. The informal poultry sector in the ECP is estimated to have 3,841,174 birds (STATS, 2016), most of which are found in the 6024 villages scattered throughout the province (Census, 2011).

ECP is divided into two metropolitan municipalities, viz. Buffalo City and Nelson Mandela Bay and six district municipalities. The district municipalities are in turn divided into thirty-one local municipalities. All thirty-one local municipalities and two metropolitan municipalities were included in the study.

### 2.1.3 Sampling procedure

A two-stage sampling strategy was used to calculate the required number of villages and households to be used in the study (Equation 1) (Thrusfield, 2005).

$$g=1.96^2\{nV_c+p_{exp}(1-p_{exp})\}/nd^2 \quad (1)$$

where $g$ is the number of clusters (number of municipalities) to be sampled, $n$ is the predicted average number of villages per municipality estimated at 100, $p_{exp}$ is the expected prevalence or proportion of farmers that are involved in trade of poultry, which was estimated at 0.7 (Bongile Mlahlwa, Animal health technician, Chris Hani, personal communication, 2021), $d$ is the desired precision at 0.1, and $V_c$ is the between-cluster (municipality) variance estimated at 0.02 for the first stage. A low between-cluster variance of 0.02 was assumed because the population structure in most rural communities is generally similar (Anonymous, 2018).

Equation (1) was used again to calculate a sample size of three villages per selected municipality where $n$ (the predicted average number of households per village), $V_c$ (the between-village variance), $p_{exp}$ (the prevalence of poultry movement among households) and $d$ were 100, 0.02, 0.7 and 0.1, respectively. Consequently, a total number of 99 villages covering the entire province was calculated. Since the study design included a pig survey (data to be published elsewhere), a list of farmers with at least four chickens and four pigs was generated with the help of the extension officers and a sample of five households per selected village was randomly selected giving a total number of 15 households (or 15 farmers) per local municipality. The total number of households was therefore 495, which was rounded to 500 households and divided into 250 chicken farmers and 250 pig farmers.

An interview-based questionnaire of households with chickens was administered by the research team with the assistance of veterinary and extension services from the Department of Rural Development and Agrarian Reform, Eastern Cape Province.

For SNA and value chain purposes, an attempt to identify all chicken traders, middlemen, and processors (e.g., restaurants) was made through follow up from chicken farmers' interviews and the existing number of chicken traders at the major towns in the province.

Additional information was obtained from wholesalers, butcheries, restaurants and meat inspectors (Table 1).

### 2.2. Study procedures and data analysis

#### 2.2.1 Interviews

An information sheet and consent form were provided to respondents prior to the commencement of interviews, and the participants were required to sign a consent form acknowledging that they had read and understood the documents.

The questionnaire comprised different sections, namely general information, such as farm structure and flock size, types/sources of inputs (feed, water, day-old chicks used on the farm), data on the movement of live chickens and chicken products, trading practices, existing regulations of chicken trade, and finally animal health management and waste disposal.

#### 2.2.2 Data management and analysis

The questionnaires were recreated and stored in Epi Info®. All the data obtained from the interviews were then entered and stored in Epi Info as database files. During analysis, the tables required for analysis were exported to Excel, where they were merged, sorted and edited, after which they were exported to the appropriate software package for analysis. To maintain confidentiality, all the data were treated anonymously.

##### 2.2.2.1 Value chain analysis

For the purpose of this study, descriptive data analysis was used to characterize the value chain of rural chickens in the ECP. The data collected was analysed to identify the main actors and to characterize the key structure or elements of the value chain. Quantitative and qualitative data collected from key informants were also analysed to assess the costs and

calculate the net profit margin in the value chain. A descriptive analytical narrative was used to present the findings from the study in order to have a comprehensive picture of the key issues concerning the value chain of rural chickens in the province.

#### 2.2.2.2 Identification of biosecurity hotspots within the value chain

Biosecurity hotspots in the value chain were identified by assessing the practices of the chicken trade in the ECP using information provided by rural chicken farmers and traders in the questionnaire survey. This research used similar methodologies from other studies (Kerkhove et al., 2009; McCarron et al., 2015; Anonymous, 2016, 2018) to identify the biosecurity hotspots within the value chain.

#### 2.2.2.3 Mapping of the chicken value chain in the Eastern Cape Province

The mapping part of the study involved the creation of profiles (i.e., diagram representing people, flows of animals and products etc.) for the key components of the rural chicken system. For each profile, relevant data from the interviews were analysed and combined to create a detailed profile map**.** The main actors in the chains were identified and linked graphically by arrows to represent flows of people, animals and products. Other data regarding interactions present within the chains was kept for the narrative explanation.

#### 2.2.2.4 Identification of barriers to market entry for rural farmers using the value chain analysis

Data from the questionnaire interviews were combined and analysed to determine the barriers to market entry for rural chicken farmers. The identified barriers were grouped into different categories as described in the Pro-Poor Livestock Policy Initiative manual (Anonymous, 2009).

## 2.3 Social Network Analysis

### 2.3.1 Conversion of cross-sectional data to social network data

Data on the movement of live chickens and related products obtained through farmers and traders (combined) interviews were exported from Epi Info to Excel for merging and editing. Each unique destination of chicken and its matching origin were entered under two columns (origin and destination) in the spreadsheet. These data were formatted as nodelists (a format which is used only for binary data with no tie strengths) in the software program Ucinet® (Borgatti et al., 2002). The municipalities were assigned as nodes whereas the movement of chickens and downstream products between these nodes was assigned as ties (Hanneman and Riddle, 2005; Borgatti et al., 2018). These ties had no direction (undirected network). .

### 2.3.2 Network visualization

The live poultry and product network was visualized as one network using Net Draw®, a software program embedded within Ucinet® (Borgatti et al., 2002; Hanneman and Riddle, 2005). The sociograms created were then edited and saved as jpeg files.

### 2.3.3 Centrality

Betweenness centrality of each node in the whole network (defined as a measure of how often a given node falls along the shortest path between two other nodes) was calculated using the Freeman betweenness centrality method in Ucinet® (Borgatti et al., 2018). High betweenness nodes were identified as central nodes (chicken trade hubs) based on their potential for controlling flows through the network.

### 2.3.4 Ego network analysis

A personal-network research design was used, where an ego network is first obtained by sampling a population to obtain a set of respondents (egos) and then a list of people (alters) the egos are connected to is collected for each ego, along with the nature of the ties connecting them to the ego, characteristics of the alters, and the respondent's perceptions of the ties among the alters. Data obtained for this ego network design are therefore ego-alter ties (Borgatti et al., 2018). An ego network analysis was therefore conducted by assessing the density measures of each ego in its neighbourhood. In this study, "ego" was an individual "focal" node (municipality). It consists of the ego, the node/s that the ego is connected to (referred to as ego's alters), and the ties between ego's alters (Borgatti et al., 2018). As mentioned above, the type of ego neighbourhood was undirected. Density measures assessed, included size, number of directed ties, brokerage and betweenness of each ego. Egos with the largest networks, normalized brokerage and betweenness were identified as being powerful and central. The following are brief descriptions of these measures as outlined by Hanneman & Riddle (2005) and Borgatti et al., (2018) (Table 2).

**Table 2:** Descriptions of the social network measures used in the study according to Hanneman & Riddle (2005) and Borgatti et al., (2018).

| Network parameter | Definition |
|---|---|
| The size of the ego network | Number of nodes that included one-step out neighbours of the ego, plus the ego itself. |
| The number of directed ties | Number of connections among all nodes in the ego network. |
| The number of ordered pairs | Number of possible directed ties in each ego network. |
| The density | Number of ties divided by the number of pairs, representing the percentage of all possible ties in each ego network. |
| Brokerage | Function associated with having structural holes (a structural hole is the lack of a tie between two alters within an ego network). |
| Normalized brokerage | Brokerage divided by the number of pairs: It assesses the extent to which the ego's role was that of the broker. |
| Betweenness | It is when the ego is between two other actors if it lies on the shortest directed path from one to the other. |
| The ego betweenness | Indexes the percentage of all geodesic paths from neighbour to neighbour that passes through the ego. |
| Normalized betweenness | Compares the actual betweenness of the ego to the maximum possible betweenness in the neighbourhood of the size and connectivity of egos. |
| The network centralization index | It is calculated as the sum of differences between the centrality of the most central node and the centrality of every other node, divided by the maximum possible |

### 2.3.5 Identification of chicken trade hubs

Nodes (municipalities) that were most centrally located in the whole network analysis (using Freeman betweenness centrality) and identified as influential egos according to the size, normalized brokerage and normalized betweenness in the ego networks analysis were identified as important chicken trade hubs that could be targeted for disease surveillance.

## 3. Results

### 3.1 General information

The number of farmers, traders, processors and other key-informants interviewed is provided in Table 1. Among 210 farmers interviewed, females were more represented (69 %) than males (31 %).

### 3.2 Description of chicken farmers (producers)

Indigenous breeds were generally scavenging for food around the yard or village during the day and kept in poultry houses at night, with occasional or no supplementation. Other breeds (layers and broilers) were kept in a confined area and fed on commercial feed. This feed was produced by specialized companies in South Africa. The majority of farmers acquired one day old chicks through breeding of the indigenous chickens or from commercial hatcheries (layers and broilers). Occasionally commercial hatcheries used traders to supply these chicks. Extension services occasionally supported the households with small poultry projects by contracting a service provider to supply these chicks. The study found another category of traders within the community who owned incubators to produce one day old chicks.

A total of 210 farmers were interviewed. Among these, 68 farmers (32.4%) were not frequently selling their chickens or chicken products. Farmers involved in selling of their

chickens and chicken products on a regular basis (every month) were 32 (15.2%) whereas the majority of farmers were not selling at all (52.4%) (Table 3).

**Table 3**: Monthly and annual frequency of chicken products produced and trade undertaken in the ECP (February to June 2019).

| Municipality | No. of farmers | Frequency | | Not selling | Live chicken (n) | Products | |
|---|---|---|---|---|---|---|---|
| | | Monthly | Yearly | | | Carcass (kg) | Eggs (n) |
| Amahlathi | 6 | 1 | 5 | 0 | 292 | 126 | 0 |
| Bizana | 8 | 1 | 2 | 5 | 672 | 0 | 0 |
| Blue Crane | 3 | 0 | 0 | 3 | 0 | 0 | 0 |
| Buffalo City | 4 | 2 | 1 | 1 | 201 | 0 | 360 |
| Dr Beyers | 1 | 1 | 0 | 0 | 700 | 0 | 0 |
| Elundini | 10 | 1 | 1 | 8 | 574 | 0 | 0 |
| Emalahleni | 13 | 1 | 4 | 8 | 125 | 16 | 108000 |
| E. Mgijima | 10 | 0 | 3 | 7 | 183 | 0 | 0 |
| Ingquza Hill | 8 | 0 | 0 | 8 | 0 | 0 | 0 |
| Intsika Yethu | 12 | 2 | 4 | 6 | 196 | 12 | 2935 |
| I. Yethemba | 4 | 1 | 1 | 2 | 82 | 0 | 750 |
| KSD | 8 | 0 | 4 | 4 | 363 | 0 | 0 |
| Makana | 4 | 4 | 0 | 0 | 1140 | 448 | 192 |
| Matatiele | 8 | 0 | 4 | 4 | 93 | 77 | 0 |
| Mbashe | 6 | 1 | 1 | 4 | 294 | 0 | 0 |
| Mhlontlo | 9 | 1 | 4 | 4 | 506 | 0 | 0 |
| Mnquma | 8 | 1 | 3 | 4 | 115 | 148 | 80 |
| Ndlambe | 2 | 2 | 0 | 0 | 365 | 0 | 0 |
| NMB | 1 | 1 | 0 | 0 | 0 | 196 | 0 |
| Ngcobo | 8 | 0 | 2 | 6 | 7 | 0 | 0 |
| Ngqushwa | 4 | 1 | 1 | 2 | 4212 | 45 | 13500 |
| Nyandeni | 9 | 1 | 6 | 2 | 288 | 0 | 54 |
| PSJ | 7 | 0 | 0 | 7 | 0 | 0 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sakhisizwe | 20 | 3 | 5 | 12 | 724 | 0 | 24 |
| Senqu | 11 | 0 | 7 | 4 | 197 | 27 | 90 |
| S. Rivers | 1 | 1 | 0 | 0 | 230 | 20 | 0 |
| Tabankunlu | 11 | 2 | 4 | 5 | 591 | 0 | 0 |
| Umzimvubu | 10 | 4 | 4 | 2 | 1339 | 80 | 2520 |
| W. Sisulu | 4 | 0 | 2 | 2 | 3 | 0 | 30 |
| Total | 210 | 32 | 68 | 110 | 13492 | 1195 | 128535 |
| Percentages | 100 | 15.2 | 32.4 | 52.4 | | | |

### 3.3 Actors in the value chain and identification of biosecurity hotspots.

The following actors in the chain were identified: producers (farmers), traders, processors (restaurants) and consumers (Fig. 1). For most of the farmers (78%), chicken farming was contributing a small percentage (an average of 30%) of their total monthly income once they had deducted the cost of production. Only 2% of farmers confirmed that their activity contributed above 50% to the total monthly income. By calculating the net profit margin, the following categories in the value chain were found to add value to the selling activity of chickens and chicken products: farmers (producers) who sell eggs from commercial layer breeds (Table 4), those selling live spent hens, processors (restaurants) (Table 5) and traders who sell day old chicks hatched from individual incubators (Table 6).. Traders with trucks were buying live spent hens from the farm gate or depots at the average cost of R35 and were selling them to other small traders and restaurants at the average cost of R90. These small traders were in turn selling their chickens directly to the consumers or restaurants at the average cost of R120. The majority of farmers confirmed they sold more chickens and their products in winter (from May to July) and during the festive season (from November to January). However, for traders, there was no specific period with increased sales (year-around sales). Traders along with their vehicles used to transport

chickens were therefore identified as biosecurity hotspots that could be targeted for disease surveillance.

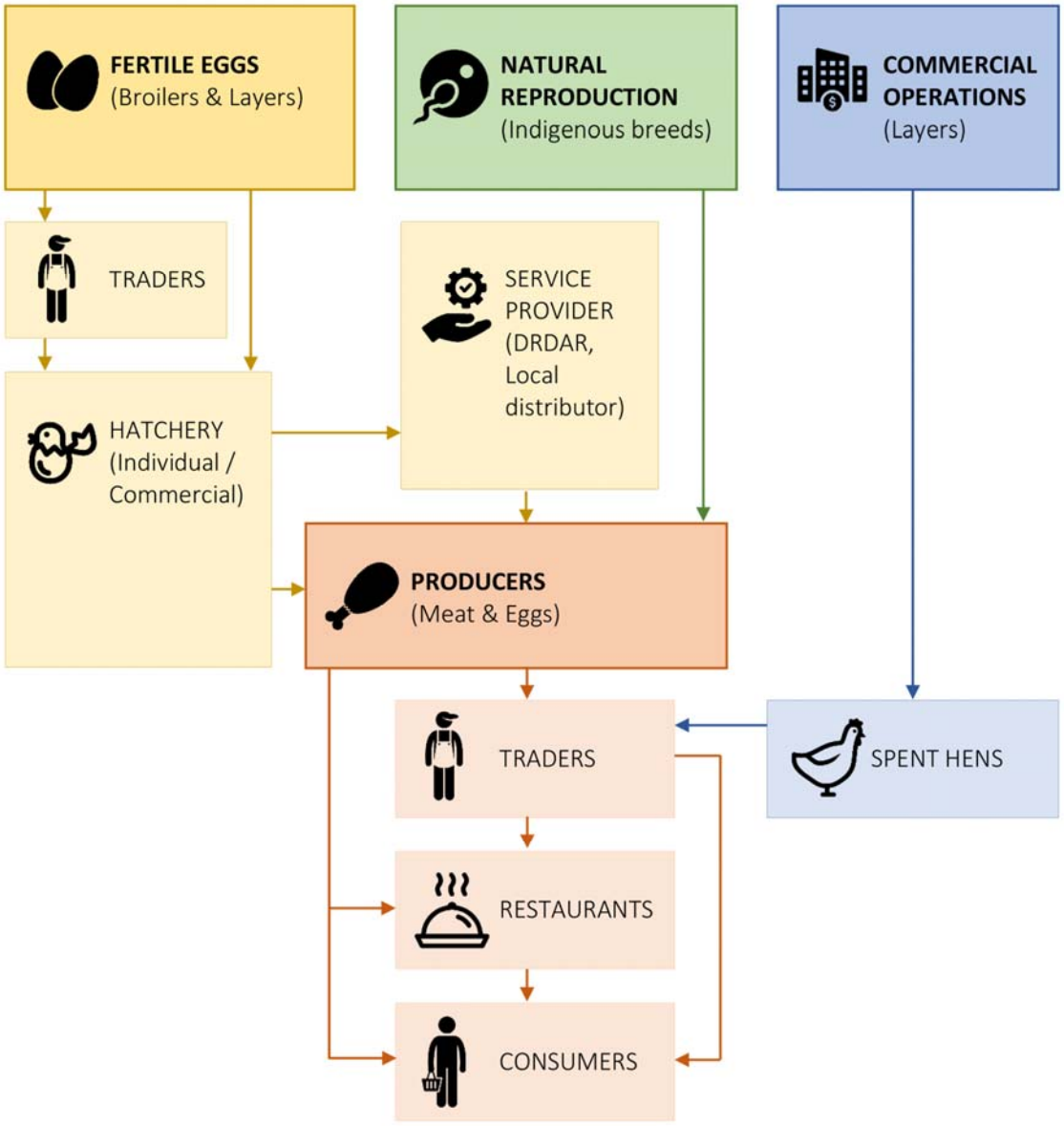


**Fig. 1:** Mapping of rural chicken value chain in the Eastern Cape Province, 2021.

**Table 4**: Net profit margin for twelve ECP egg producers from November 2020 to July 2021

| No. of point of lay hens | Total cost[1] | Total cost of feed per year[2] | Total cost of remedies | Av. annual egg production[3] | Total income per year[4] | Annual net profit | Net profit margin |
|---|---|---|---|---|---|---|---|
| 300 | R25500 | R127750 | R1000 | 109500 | R219000 | R64750 | **29.57%** |

[1] The average cost of one layer was calculated at R85 each

[2] The average cost of feed was calculated at R350 per bag. The average feed intake per day was one bag (50kg)

[3] It was assumed that one layer was giving a minimum of one egg per day

[4] The average selling price of one egg was calculated at R2

1 South African Rand= 0.067 US Dollars

**Table 5:** Net profit margin for different restaurants (processors) in the EC major towns, on a weekly basis from November 2020 to July 2021

| Number of restaurants | Number of chickens used per week | Cost of live chicken | Total cost of live chicken | Cost per plate | Number of plates sold per week | Total income | Weekly profit | Net profit margin |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 | R100 | R600 | R40 | 60 | R2400 | R1106.5 | 46.1% |
| 2 | 15 | R115 | R1725 | R30 | 120 | R3600 | R1181.5 | 32.8% |
| 3 | 24 | R150 | R3600 | R53 | 180 | R9540 | R5246.5 | 54.9% |
| 4 | 12 | R120 | R1440 | R40 | 108 | R4320 | R2186.5 | 50.6% |
| 5 | 6 | R120 | R720 | R35 | 48 | R1680 | R266.5 | 15.9% |
| 6 | 20 | R80 | R1600 | R40 | 60 | R2400 | R106.5 | 4.4% |

Estimated average processing cost per restaurant per week, based on the price of ingredients used for cooking: R693.5

1 South African Rand= 0.067 US Dollars

**Table 6:** Net profit margin per incubation period for three ECP traders with individual incubators from November 2020 to July 2021

| Description | Quantity | Cost | (n) chicks per incubation period* | Selling price | Income | Net profit | Net profit margin** |
|---|---|---|---|---|---|---|---|
| Fertile eggs (layer) | 3 boxes with 360 eggs each (1080 eggs) | R1800 per box (R5400) | 972 | R21 per hen | R20412 | | |
| Fertile eggs (broilers) | 6 boxes with 360 eggs each (2160 eggs) | R3.78 per egg R9389.52 (15% VAT included) | 1944 | R10 per boiler | R19440 | | |
| Petrol (transport) | - | R1400 | - | | | | |
| Main power | - | R3000 | - | | | | |
| Dividing boxes | 100 | R2700 | - | | | | |
| Medication | - | R260 | - | | | | |
| Electricity | - | R4000 for the whole incubation period | | | | | |
| Petrol for incubator | - | R500 | | | | | |
| Total | | R26649.52 | | | R39852 | R13202.48 | **33.13%** |

*The average mortality rate of 10% was considered for both broilers and layers

**Net profit margin: $\frac{Net\ profit}{Total\ revenue} \times 100$

1 South African Rand= 0.067 US Dollars

### 3.4 Identification of barriers to market entry for rural farmers

The following categories were identified as the main barriers to market entry for rural farmers after analysis of the questionnaire data: production barriers, product barriers, social barriers, trading barriers and policy as a barrier (Table 7).

**Table 7**: Classification of barriers to market entry for ECP rural chicken farmers according to the survey done from February to June 2019

| Category | Example of specific barriers |
|---|---|
| 1. Production barriers | Access to means of production<br>Knowledge of how to produce<br>Knowledge of when to supply<br>Knowledge of cost of production<br>Risk in production cycle<br>Quality of product available for sale |
| 2. Product barriers | Perishability of product (chicken meat) |
| 3. Social barriers | Nature of personal relationships (between markets and producers) |
| 4.Trading barriers | Culturally production system not aligned to the market system |
| 5. Policy as a barrier: advantages given to large scale commercial producers (through policy) | Subsidised loans,<br>Import from high chicken meat producing countries, |

### 3.5 SNA of live chicken movement and products in the province

A total of 83.8% (176 from 210 farmers interviewed) reported details of destinations and origins of chickens and chicken products in the previous year, while 75% of traders (21 out of 28 traders interviewed) provided these details.

### 3.5.1 Network visualization

A total of 35 nodes were identified in the network for chickens and chicken products (Fig. 2). The nodes representing Eastern Cape municipalities tallied 27 whereas 8 nodes fell outside the province. These included municipalities from the Free State, KwaZulu-Natal, and Gauteng Provinces and one node represented the Republic of Lesotho. All of these nodes were identified by respondents as either destinations or origins of their chicken or chicken products.

### 3.5.2 Centrality measure

Betweenness centrality results demonstrated that Umzimvubu lay along every shortest path between every pair of other nodes; therefore, it was more central and powerful with a normalized betweenness value of 20.48, followed by KSD with a normalized betweenness value of 15.47 and Enoch Mgijima (normalized betweenness value of 13.43). The overall network centralization index was 18.03%.

### 3.5.3 Ego network analysis

The results of the ego network analysis are shown in Table 8. The larger ego networks had the highest normalized brokerage and ego betweenness. A higher normalized brokerage implies that a high number of altars depends on the ego for a connection, while higher normalized ego betweenness indicates how central the egos are in their network. Thus, normalized brokerage and normalized ego betweenness indicate how powerful and central a municipality is within its neighbourhood.

### 3.5.4 Identification of chicken trade hubs

Based on centrality within the network, size, high brokerage and betweenness within their ego networks (Table 8), Umzimvubu, KSD and Enoch Mgijima were identified as

important chicken trade hubs of Eastern Cape Province. These hubs could be targeted for disease surveillance.

**Table 8**: Ego network density measures of annual chicken movements and products within ten Eastern Cape municipalities according to data provided by farmers and traders during the survey conducted from February 2019 to July 2021

| Ego (Municipality) | Size | Ties (directed) | Pairs | Density | N. brokerage | N. betweenness |
|---|---|---|---|---|---|---|
| Umzimvubu | 11 | 6 | 110 | 5.45 | 0.95 | 40.45 |
| KSD | 10 | 6 | 90 | 6.67 | 0.93 | 27.78 |
| Buffalo City | 9 | 0 | 72 | 0 | 1 | 0 |
| E. Mgijima | 8 | 5 | 56 | 8.93 | 0.91 | 43.75 |
| NMB | 8 | 4 | 56 | 7.14 | 0.93 | 9.82 |
| Senqu | 7 | 4 | 42 | 9.52 | 0.90 | 27.38 |
| Matatiele | 5 | 5 | 20 | 25 | 0.75 | 25 |
| Tabankulu | 4 | 3 | 12 | 25 | 0.75 | 20.83 |
| Elundini | 3 | 2 | 6 | 33.33 | 0.67 | 16.67 |
| Emalahleni | 3 | 1 | 6 | 16.67 | 0.83 | 50 |

## 4. Discussion

The findings from this study revealed that the majority of rural chicken farmers kept a small number of chickens (1-500) of mixed types (indigenous, layers and broilers chickens), which was consistent with the previous published data on the agricultural households engaged in poultry farming in South Africa (STATS, 2016). The production of meat and eggs were found to be very low (Table 3) for the majority of farmers, leading to low and irregular sales. The analysis of the value chain identified the main actors, namely producers (farmers), traders and processors (restaurants). These actors did not necessarily belong to the same community. Some actors like traders connected different communities through

the sales of chickens and related products. The absence of retailers and wholesalers in the chain could be explained by many factors described as barriers to market entry (Table 7). The main barrier was production which involved basic knowledge from farmers (Table 7). The lack of knowledge among the majority of farmers was found to be linked to their low level of education (Nyoni and Masika, 2012; Idowu et al., 2018; Anonymous, 2021). Furthermore, as one of the poorest provinces in the country, the ECP has many people relying on social grant and pension money for survival. This makes it difficult for local producers who have to sell their chickens or chicken products on credit. The majority of farmers preferred selling live chickens but the study found a small proportion of farmers who preferred slaughtering and selling chicken meat. The existence of an informal (live sales) value chain in the rural sector of ECP was also consistent with the findings from another study in the country (Louw et al., 2017) and this could be regarded as a public health issue since there is no meat inspection done and zoonotic diseases like salmonellosis could be transmitted. The local abattoirs in the province don't slaughter rural chickens as these birds don't meet their requirements. The majority of farmers were trading within their communities only and sell directly to consumers which reduces the risk of diseases spreading. This finding is similar to that reported in Pacific Islands (Anonymous, 2017).

The dominance of the domestic market by large import volumes of broiler meat from northern hemisphere countries and Brazil is another factor that cannot be ignored, therefore policy is a barrier. South Africa's performance is comparable to these countries in terms of technical efficiency, but local producers incur losses once input costs are considered. One of the key drivers of higher production costs in South Africa, compared to Brazil and the USA, is that South Africa imports approximately 90% of its soybean meal requirements (Davids, 2013). Involving the youth and providing enough training in poultry farming to increase production could be regarded as one of the recommendations to create jobs and

alleviate the poverty. The policy makers also have a role to play in providing local producers access to loans, abattoirs and markets.

The movement of live chickens in the province was dominated by spent layers. Although these birds originate from commercial farms, they were included in the study since they most frequently ended up in the rural sector once their production cycle had come to an end. This survey confirmed the findings of previous studies (Anonymous, 2017) that the traders moved larger flocks using trucks and travelled over long distances (i.e., from KwaZulu-Natal to ECP) to supply birds to informal markets, including townships and rural areas, and the average cost of a spent hen layer was R35. The study could not identify middlemen who usually play an important role in disease transmission in other countries (Van Kerkhove et al., 2009; McCarron et al., 2015; Sealy et al., 2019). Middlemen might have been missed due to possible bias in sampling and selection of respondents (Anonymous, 2018). Unlike in Zambia where winter and festive season were the targeted periods with increased sales (Anonymous, 2018) , there was no specific season that could be targeted for disease surveillance in the current study, since the main trade was dominated by spent hens which are sold year-around.

The centrality of each municipality (node) involved in the study was assessed using the Freeman betweenness centrality method defined as a measure of how often a given node falls along the shortest path between two other nodes. Thus, if disease surveillance was placed at Umzimvubu, KSD and Enoch Mgijima (high betweenness nodes), the probability for early detection of any outbreak and its control would be high since these two municipalities have the potential for controlling flows through the network (Fig. 2).

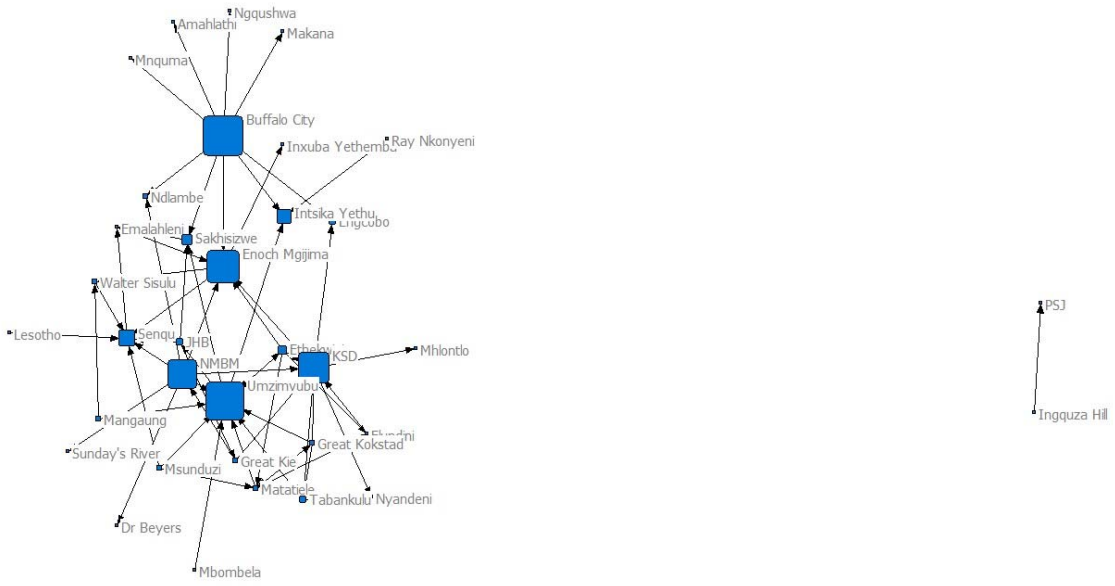


**Fig. 2:** Network visualization for live chicken movement and chicken products in the Eastern Cape Province according to the data provided by rural chicken farmers and traders during the survey conducted from February 2019 to July 2021 (Source: Ucinet®)

The ego networks analysis further revealed that municipalities with large networks and high brokerage are centrally located within their ego networks as targets for disease surveillance. The assumption made for measuring the brokerage within an ego network is that unconnected alters are more likely to offer ego more benefits and influence its effective size (Burt, 1995). Theoretically, if a disease outbreak occurred within the neighbourhood, the probability of detecting it within that neighbourhood before it spreads further is higher because most municipalities within the neighbourhood are not connected to each other but directly to a municipality in focus. Similarly, any disease outbreak inside the focal node would trigger a rapid response since the connected nodes to that focal node would be aware of it in advance. The municipalities with large networks and high brokerage (Umzimvubu KSD and Enoch Mgijima) were found in the densely populated areas, similar to Kenya and Zambia (McCarron et al., 2015; Anonymous, 2018). Buffalo City could have taken the third

place after KSD, but this was affected by the lack of directed ties (Table 8). The results identified a movement of chickens and related products from the Republic of Lesotho into other nodes closer to the identified trade hubs (Umzimvubu and Enoch Mgijima), implying that active surveillance around Senqu, Nelson Mandela Bay, Walter Sisulu and Emalahleni would be also important to prevent any disease spread from the Republic of Lesotho (Fig. 2).

The study also demonstrated the potential growth of local producers through expanding local egg producers, traders owning their own incubators and access to processors (restaurants). Although some parameters like fixed costs were not considered in this study, the data showed that the rural chicken sector is likely to be profitable, hence sustaining livelihood and food security as demonstrated by Jensen and Dolberg (2003).

The spent hens were the only chicken meat found in the surveyed restaurants because consumers considered them to be tastier. This is in agreement with another study done in South Africa (Anonymous, 2017). Although a few producers, traders and processors knew about the requirement for a health permit for selling chickens and chicken products, no one could present such a permit during the interview. Making traders aware of the importance of having permits would have a positive impact on chicken disease surveillance and follow up during outbreaks. Promoting the rural layer chicken farmers would benefit both farmers and processors based on the calculated net profit margin and this is supported by the fact that in South Africa, a layer hen still has a value at the end of its production life (SAPA, 2012).

## 5. Conclusion

This is the first study describing chicken movement networks in the Eastern Cape Province and surrounding regions. The findings provide insights into coordinating a targeted

surveillance in the province that could be extended to other provinces and resource poor countries, if deemed to be feasible. Targeted surveillance is a relatively cost-effective option for disease surveillance since it focuses primarily on hotspot areas where a high risk of disease transmission exists thus requiring less manpower and resources. The study also provides useful information on the value chain that could be used by policy makers and other stakeholders such as veterinary services. Finally, it provides a better understanding of some of the barriers to market entry for rural farmers that could be addressed by the provincial authorities in order to sustain and expand rural poultry farming in the ECP. Implementation of these measures could provide job creation and poverty alleviation.

## Conflict of interest

The authors have no conflict of interest to declare.

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