

Validating Biosecurity Principles for Indigenous Chicken Scale

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Abstract Indigenous chicken are populous in most developing countries, supporting the livelihoods of many rural folks yet are produced under very low or no biosecurity principles, leading to low productivity. Consumers on the contrary, exhibit high preferences for indigenous chicken. The research question was: what are the consumer attitudes on biosecurity principles for indigenous chicken? The aim of the study was to validate a psychometric scale to measure consumer attitudes on biosecurity principles for indigenous chicken. The sub-aims were to reduce scale so it clearly measures the constructs and to test one hypothesis: H0: There are no significant consumer attitudes on biosecurity principles for indigenous chicken in Kisumu City, Kenya. Starting from a 74-item with 4:1 subject to item ratio biosecurity principles for indigenous chicken scale constructed using Fishbein's Multiattribute model, the hypothesis was tested on pilot data gathered from 300 students of a large university in Kisumu County, Kenya using maximum likelihood factor analysis. Reliabilities for each biosecurity principle ranged from $\alpha = .817$ to $\alpha = .817$ respectively. Initial KMO were low ranging between .519 to .595 but improved significantly after refining the scale. Only one factor was extracted from each principle based on theory. Each extracted factor explained variances ranging from 25.099% to 34.307% respectively, though <50 percent. A total of 37 items loaded on these four factors with respect to the four biosecurity principles. The factor matrices for each extracted factor were significant at $p = .000$ and $p < .05$ respectively. Thus the null hypothesis was rejected. The results can further be confirmed in subsequent studies.

Keywords Maximum Likelihood, Exploratory Factor Analysis, Principal Component Analysis, Fishbein Multi-Attribute Model, Biosecurity Principles, Perceived Benefits, Perceived Concerns

1. Introduction

Indigenous chicken are populous in most developing

countries and supports the livelihoods of many rural folks (Sonaiya and Swan, 2004). They are produced under very low or no biosecurity principles (Nyaga, 2007a) which is a major challenge for the sub-sector (Okeno, Kahi and Peters, 2010). Hence, their productivity is very low (Omiti, 2011). Consumers on the contrary, exhibit high preferences for indigenous chicken. They are willing to pay a premium price for it (Bett et al., 2011). This high preference, given very low levels of indigenous chicken biosecurity, is paradoxical (Aila, 2012). Little research on consumer attitudes on biosecurity principles for indigenous chicken is available. The research question was: what are the consumer attitudes on biosecurity principles for indigenous chicken? The aim of the study was to validate a psychometric scale to measure consumer attitudes on biosecurity principles for indigenous chicken. The sub-aims were to reduce scale so it clearly measures the constructs and to test one hypothesis: H0: There are no significant consumer attitudes on biosecurity principles for indigenous chicken in Kisumu City, Kenya.

Fishbein Multi-Attribute Model (Fishbein and Ajzen, 1975) can aid in constructing consumer attitudes. It is well recognized as an established framework for explaining attitude, intention and choice. It has widespread acceptance for use in consumer research and for its values in explicating attitudes (Agarwal and Malhotra, 2005; Kim, 2009). In measuring attitudes, one should locate the subject on bipolar affective or evaluative dimension on a given object (Fishbein and Ajzen, 1975).

Biosecurity is a relatively new word in common vocabulary and is not found in many dictionaries and thesauri. Its broad meaning is the literal safety of living things, or the freedom from concern of sickness or disease (Amass and Clark, 1999). It is security from transmission of infectious diseases, parasites and pests to a poultry production unit (Permin and Detmer, 2007); and the implementation of policies and procedures that prevent the introduction and spread of disease (Nyanga, 2007a).

Four biosecurity principles: management of the flock; control of incoming animals; control of in- and out- going material; and control of other animals have been proposed (Permin and Detmer, 2007). These four have been adapted to

indigenous chicken production (Nyaga, 2007b). Consumer attitudes for indigenous chicken have been proposed (Aila et al., 2012) but have not been validated so far.

Exploratory factor analysis can be used to validate new scales (Costello and Osborne, 2005). The most commonly used exploratory factor analysis technique is Principal Component Analysis (PCA) (Chukwuone et al. 2006; Akinnagbe, 2010; Hair et al., 2010). PCA has however been criticized for not being a factor analysis technique at all despite its common usage (Fabrigar et al, 1999). Maximum likelihood, principal factors, and iterative principal factors have been proposed as better alternatives to PCA in factor extraction (Costello and Osborne, 2005). Maximum Likelihood Factor Analysis has particularly been proposed to be a superior exploratory factor analysis technique as it allows for the computation of a wide range of indexes of the goodness of fit of the model (Fabrigar et al., 1999). These fit measures are intended to assess the degree to which a given model provides an approximation of observed correlations and covariances.

2. Methodology

Starting from a 74 item biosecurity principles for indigenous chicken scale (Aila et al., 2012) constructed using Fishbein’s Multiattribute Model (Fishbein and Ajzen, 1975), a descriptive study to validate the scale was designed. The respondents were asked to express their beliefs and levels of agreement measured on a Likert scale, with scores typically anchored at the extremes 1 and 7 where 1=Strong disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree or disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree (Vagias, 2006; Caracciolo *et al.*, 2011). The reconstructed instrument was administered on 300 students of a large university campus in Kisumu County,

Kenya (Brooker, 1975; Nunnaly, 1978; De Vallis, 1991; Lee et al., 1997; Sow and Grongnet, 2010). Bahia and Nantel (2000) used 300 students to validate their scale. Respondents were selected using systematic sampling technique (Saunders et al., 2003). The data were analyzed using descriptive statistics to exhibit their exploratory capacity. Factors were extracted using maximum likelihood (ML) exploratory factor analysis (Costello and Osborne, 2005). Theoretically, the set of items under each biosecurity principle represented one factor. Thus, the number of factors to be retained was determined a priori. Given the choice of ML, the oblique rotation was performed.

3. Results and Discussion

The response was impressive at 100% with females being 23% ($n = 300$) of respondents. The ages of the respondents were below 20 years-22%, 21-30 years 74% and the rest 4% ($n = 300$) respectively. The sample size was adequate for using factor analysis (Nunnaly, 1978; DeVallis, 1991; Bahia and Nantel, 2000; Labar, 2008; Kulscasr, 2010). The subject to item ratio was 4:1 within the range of acceptability (Castello and Osborne, 2005). Majority of exploratory factor analysis studies in their survey (62.9%, $N = 303$) had researchers perform analyses with subject to item ratios of 10:1 or less, which is a prevalent rule of the thumb (Castello and Osborne, 2005).

The questionnaire had a reliability of $\alpha = .914$ for all 114 items. The biosecurity principles for indigenous chicken scale had a reliability of $\alpha = .911$ for its 74 items. Each biosecurity principle had an acceptable reliability (management of the flock, $\alpha = .817$; control of other animals, $\alpha = .635$; control of in-coming and out-going materials, $\alpha = .820$ and control of other animals, $\alpha = .536$) respectively as shown in Table 1 below.

Table 1. Reliability Statistics

	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Management of the Flock	.817	.819	31
Control of Incoming Animals	.635	.638	9
Control of In-coming and Out-going Materials	.820	.823	29
Control of Other Animals	.536	.539	5
Biosecurity principles for indigenous chicken scale	.911	.913	74
Questionnaire	.914		114

Source: Pilot data, 2012.

The item means was $\mu = 4.654$ ($SD = .784$) signifying somewhat agreement with the items. The scale mean was $\mu = 344.36$ ($SD = 58.049$) for the 74 items. Table 2 and 3 below presents these results.

Table 2. Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.654	3.772	5.479	1.707	1.452	.161	74
Inter-Item Correlations	.124	-.422	.730	1.152	-1.731	.023	74

Source: Pilot data, 2012

Table 3. Scale Statistics

Mean	Variance	Std. Deviation	N of Items
344.36	3369.650	58.049	74

Source: Pilot data, 2012.

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy $KMO = .247$ and Bartlett's test of sphericity $\chi^2 = 25479.569$ $df = 2701$ ($p = .000$) were performed to test the factorability of the scale. Found that the scale as a whole had low factorability. Thus, we opted to perform similar tests for each biosecurity principle. Each biosecurity principle was found to be factorable as shown in Table 4 below. For each biosecurity principle, KMO was $>.5$ which is interpreted as miserable (George and Mallery, 2009). The Bartlett's test of sphericity for each principle was significant at $p = .000$ signifying construct validity (Roberts-Lombard, 2013) as shown in Table 4 below.

Table 4. KMO and Bartlett's Test at the Beginning

		Scale	Management of the Flock	Control of Incoming Animals	Control of In-coming and Out-going Materials	Control of Other Animals
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.247	.595	.592	.583	.519
Bartlett's Test of Sphericity	Approx. Chi-Square	25479.569	4615.901	579.568	3814.877	174.844
	Df	2701	496	36	406	10
	Sig.	.000	.000	.000	.000	.000

Source: Pilot data, 2012

After several iterations, the following results were produced using ML extraction method and oblique rotation. The 74 item instrument was refined to produce a more parsimonious 37 item scale. Management of the flock extracted one factor represented by 13 items explaining 29.374% of total variance. Control of incoming animals extracted one factor represented by 6 items explaining 28.458% of total variance. Control of incoming and outgoing materials extracted one factor represented by 14 items. This explained 25.099% of total variance. Lastly, control of other animals extracted one factor represented by 4 items explaining 34.307% of total variance. The KMO of the refined scale for respective biosecurity principles showed marked improvements. Both management of the flock and control of incoming and outgoing materials had KMO improving from $>.5$ to $>.7$ respectively. Control of incoming animals showed KMO improve from $>.5$ to $>.6$ while control of other animals remained at $KMO >.5$ (see Table 5 below).

Table 5. KMO and Bartlett's Test after Factor Extractions

		Management of the Flock	Control of Incoming Animals	Control of In-coming and Out-going Materials	Control of Other Animals
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.773	.641	.735	.573
Bartlett's Test of Sphericity	Approx. Chi-Square	1564.242	354.197	1312.041	135.127
	Df	91	15	406	6
	Sig.	.000	.000	.000	.000

Source: Pilot data, 2012

We examined the scree plots for each biosecurity principle to ascertain whether the number of factors retained as tandem with theory was replicated by the data. Both Fig. 1 and 3 below show that one factor was rightly extracted, even though the

variance explained was below 50 percent. Fig. 2 and 4 below show that more than one factor should have been extracted.

Scree Plot

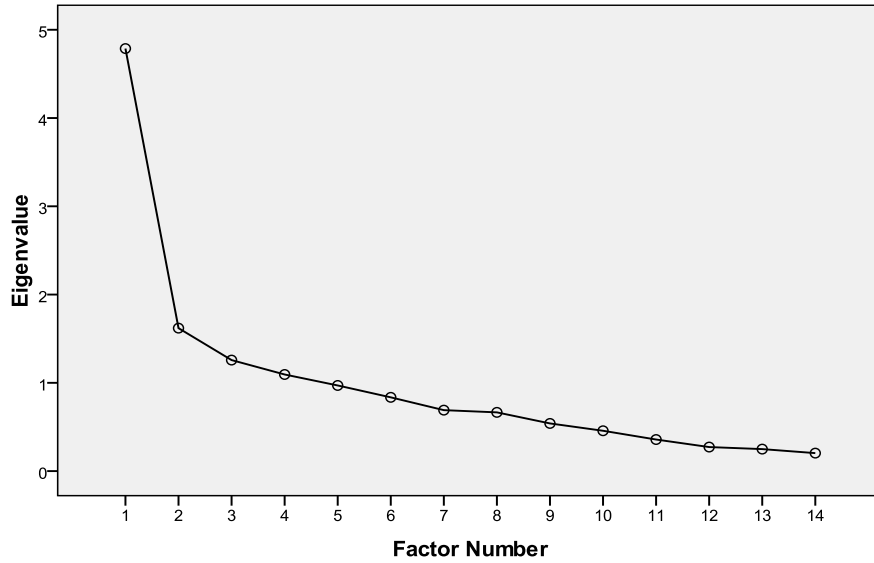


Figure 1. Management of the Flock (Variance explained=29.374%)

Scree Plot

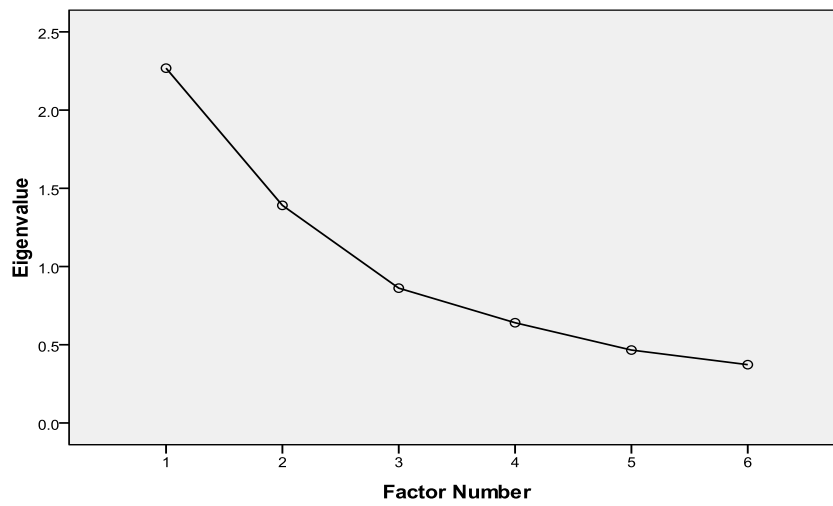


Figure 2. Control of Incoming Animals (Variance explained=28.458%)

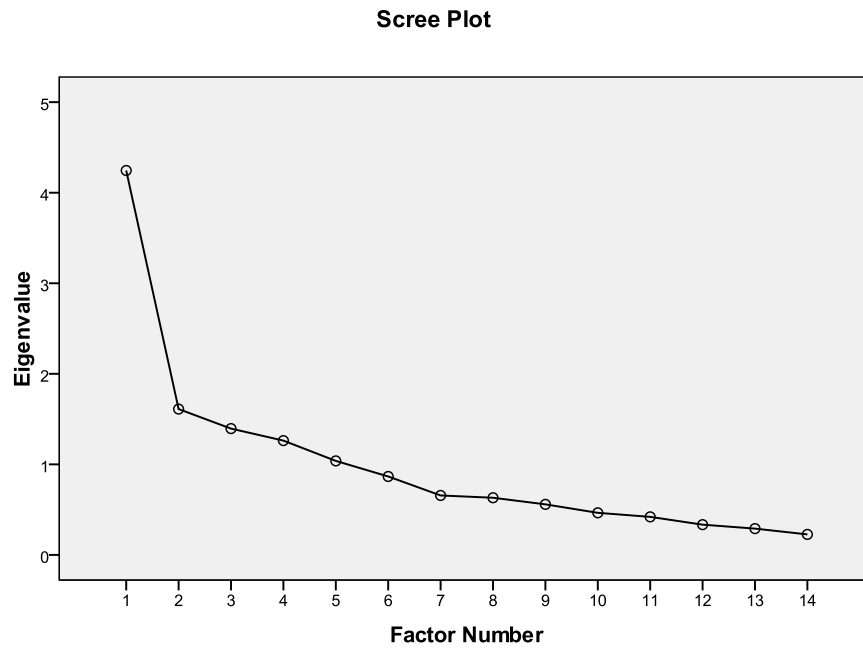


Figure 3. Control of incoming and outgoing materials (Variance explained=25.099%)

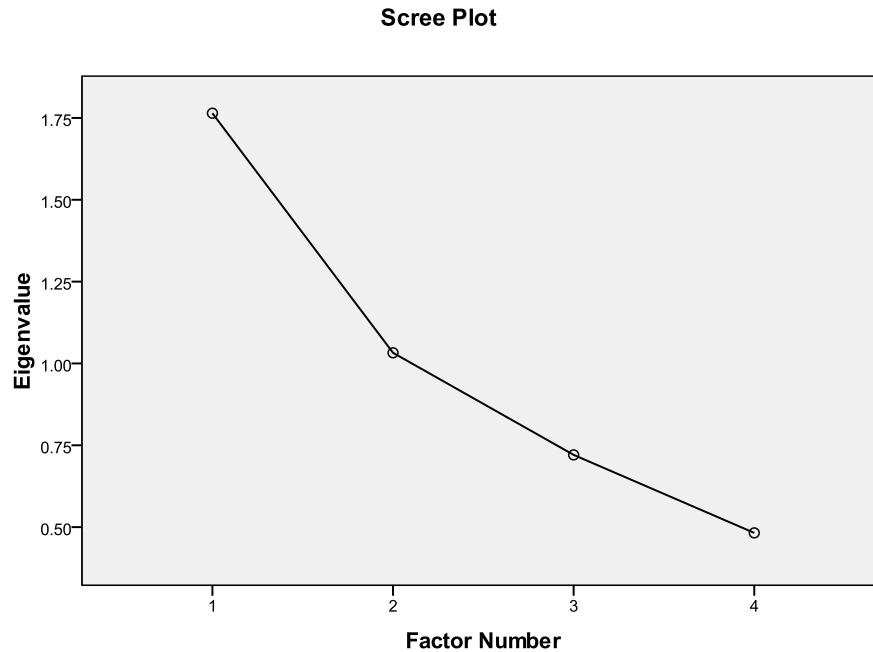


Figure 4. Control of other animals (34.307%)

Appendix 1-4 below presents the factor matrices for each of the four biosecurity principles. In Appendix 1, the 13 item factor matrix of management of the flock is presented. All items have factor loadings $>.30$ and the scale is significant at $\chi^2 = 624.868$ $df = 77$ ($p = .000$) (Table 6 below). Factor loadings ranged from .311 to .740 respectively. “Observing

regular personal hygiene such as washing of hands, and use of clean or dedicated clothes and shoes is a beneficial practice,” (.740) loaded highly on the factor. It was construed as a perceived benefit of this biosecurity principle (Nyaga, 2007b). “*Isolating flocks from situations that expose them to diseases is preventive in nature*” even though

a perceived benefit had the lowest factor loading. Both “Most farmers raise flocks using home-grown skills” (.353); “Attendants wear domestic cloths while on duty without protective head gears and footwear” (.366) and “Non-vaccinated flocks tend die of diseases such as Newcastle Disease (NCD)” (.588), the only biosecurity concerns extracted loaded lowly to moderately on the factor.

Appendix 2 presents the factor matrix of six control of incoming animals principle. Four items had factor loadings >.30 while the remaining two less than it. “Use of appropriate disinfectants in the hatchery and in the brooding house minimizes disease occurrence” (.742) and “Separately brooding indigenous chicks (chicks alone or chicks together with mother hen) for at least three weeks of their life ensures their adaptability to their new environment” (.812) had strong loadings on the factor. These two biosecurity protocols if observed are beneficial as they ensure survivability of new flocks (Okeno, Kahi and Peters, 2010). “Day old chicks are not exposed to dirty environments” (.225) and “Clean beddings are provided for brooding hens” (.226) loaded lowly on this factor. These items were negatively scored. In theory, day old chicks are exposed to dirty environments; moreover, no clean beddings are given to brooding hens among indigenous chickens (Nyaga, 2007b). Inclusion of these two items in the final scale was justified on the basis of the overall fit of the factor model. Deleting either or both of these factors would have yielded an insignificant goodness of fit. With their inclusion, the factor was significant at $x^2 = 96.947$ $df = 9$ ($p = .000$) (Table 6 below).

Appendix 3 presents the factor matrix of 14-item control of incoming and outgoing materials. Only two items loaded highly on the factor. These are “The small proportion that does not get inspected may need to be identified and be brought into the inspection loop” (.631) reflecting a biosecurity concern and “Identifying clean and dirty processes in the farm, sales and slaughtering processes so as to avoid contaminating clean areas is logical” (.610) reflecting a biosecurity benefit. A total of 11 items loaded moderately on the factor: >.400 six and >.5 five respectively. One item loaded lowly on the factor at >.3, that is “The traders themselves act as sources of infectious agents” (.319) which represented a biosecurity concern. All these 14 items were significant at $x^2 = 630.834$ $df = 77$ ($p = .000$) (Table 6 below).

Appendix 4 presents the 4-item factor matrix for control of other animals principle. One item “As birds scavenge they interact with several disease carrying agents” (.983) loaded so highly on the factor as it was a major biosecurity concern (Nyaga, 2007b; Onim, 2002; Kagira and Kayari, 2010; Bird Life International, 2013). The rest loaded very lowly to moderate. In fact, one item, “While on transit, the birds are either exposed to the atmosphere or are in contact with humans” (.281) had a loading <.300 and should have been deleted. Deleting this item would have improved the factor loadings (see Fig. 4 above) but rendered the factor

insignificant. Retaining it yielded a significant goodness of fit $x^2 = 9.842$ $df = 2$ ($p = .007$) (See Table 6 below). The x^2 was significant at $p < .05$ confirming that all four items significantly tapped on the factor.

Table 6. Goodness-of-fit tests

Biosecurity principle	Goodness-of-fit Test		
	Chi-Square	Df	Sig.
Management of the flock	624.868	77	.000
Control of incoming animals	96.947	9	.000
Control of incoming and outgoing materials	630.834	77	.000
Control of other animals	9.842	2	.007

Source: Pilot data, 2012

From the analysis presented above, the goodness-of-fit test (see Table 6 above) was used to test the hypothesis:

H_0 : There are no significant consumer attitudes on biosecurity principles for indigenous chicken in Kisumu City, Kenya.

Each of the biosecurity principles had significant factor matrices for each factor representing a biosecurity principle. Thus the null hypothesis was rejected and the alternate accepted.

4. Conclusion

The study set to validate a psychometric scale to measure consumer attitudes on biosecurity principles for indigenous chicken. There were twin sub-aims: to reduce scale so it clearly measures the constructs and to test one hypothesis. Using pilot data, with 4:1 subject to item ratios, the 74-item scale was reduced to a more parsimonious 37-item scale using maximum likelihood exploratory factor analysis. The variance explained by each single factor representing respective biosecurity principle was rather low <50 percent. Observing the scree plots, biosecurity principles that had large number of items >20, extracted a single factor that explained the largest variance. The principles with <10 items did not significantly extract a single factor. Further deletions could have produced stronger single factors. The null hypothesis, H_0 : There are no significant consumer attitudes on biosecurity principles for indigenous chicken in Kisumu City, Kenya was rejected as the goodness-of-fit tests revealed that respective factor matrices for biosecurity principles was significant at $p = .000$ and $p < .05$ respectively. Thus, the alternative hypothesis H_1 : There are significant consumer attitudes on biosecurity principles for indigenous chicken in Kisumu City, Kenya was accepted. Further study may be needed to refine this scale and to confirm its applicability to the context at hand.

APPENDIX 1: Management of the Flock Factor Matrix^a

Management of the Flock	Factor 1
Farmers grouped in farmer associations tend to vaccinate their flocks routinely.	.581
Non-vaccinated flocks tend die of diseases such as Newcastle Disease (NCD).	.588
A disinfectant dip placed at the door of each house can prevent entry of diseases agents into the flock house.	.568
Poultry houses facilitate parasite and disease control. They promote faster growth and protect the chicken from predatory birds and animals and adverse weather conditions and theft during the night as well as during the day time.	.483
Clothes dedicated for handling chicken worn in the poultry house would reduce chances of entry disease into the flock houses.	.460
Training in good husbandry practices for all poultry farmers can improve biosecurity measures markedly.	.556
A program of educating farmers on the role and usefulness of isolation and other biosecurity measures can be developed and implemented	.565
Observing regular personal hygiene such as washing of hands, and use of clean or dedicated clothes and shoes is a beneficial practice.	.740
Clothes dedicated for handling chicken, which may not necessarily be new, should be provided for use exclusively in the flock houses.	.589
There are adequate feeding troughs and watering equipment for all birds in the poultry house.	.332
Attendants wear domestic cloths while on duty without protective head gears and footwear.	.366
Most farmers raise flocks using home-grown skills.	.353
Isolating flocks from situations that expose them to diseases is preventive in nature.	.311

Extraction Method: Maximum Likelihood.

a. 1 factors extracted. 5 iterations required.

Source: Pilot data, 2012

APPENDIX 2: Control of Incoming Animals Factor Matrix^a

Control of incoming animals	Factor 1
Day old chicks are not exposed to dirty environments	.225
Clean beddings are provided for brooding hens.	.226
Laying nests are provided for layer birds.	.329
Protocols and procedures in the hatcheries if monitored regularly can assure they supply clean day old chicks free from bacterial and viral agents that may emanate from hatcheries.	.535
Use of appropriate disinfectants in the hatchery and in the brooding house minimizes disease occurrence.	.742
Separately brooding indigenous chicks (chicks alone or chicks together with mother hen) for at least three weeks of their life ensures their adaptability to their new environment.	.812

Extraction Method: Maximum Likelihood.

a. 1 factors extracted. 5 iterations required.

Source: Pilot data, 2012

APPENDIX 3: Control of In- and Out-going Materials Factor Matrix^a

Control of In- and Out-going Materials	Factor
	1
Feeds often get contaminated at its administration by fecal matter/chicken droppings containing disease agents.	.452
Manure and slaughter wastes are disposed on the farm. These are accessible to both domestic and wild animals.	.524
Risks of disease causing agents are inherent within the trade cycle.	.482
For farm-, market- or restaurant-slaughtered birds, the concern is on where and how the waste water, feathers and offals, which may lead to spreading of disease, are disposed.	.423
The traders themselves act as sources of infectious agents.	.319
The risks at the slaughtering process are many e.g. dry defeathering scatters feathers all over the sales areas at the local markets.	.481
For wet defeathering, the disposal of waste water, the offals, the feathers and the presence of worn out cement floors, the presence of bird cages and storage of personal effects in the cages that also held chickens poses a big risk.	.523
Indigenous chicken sold in live markets, slaughtered at market-, restaurant-, home-backyard are seldom inspected.	.517
There is no formal inspection carried out for eggs except grading.	.517
Poultry feed that is free from disease agents should be kept in a clean, dry store free from rodents and insect pests.	.580
A disinfectant dip at the entrance to the flock houses keeps at bay pathogens and prevents from escaping into or out of the poultry house.	.405
Use of disinfectants to decontaminate materials and equipment that has gone to the market before it is re used at the farm is prudent.	.461
Identifying clean and dirty processes in the farm, sales and slaughtering processes so as to avoid contaminating clean areas is logical.	.610
The small proportion that does not get inspected may need to be identified and be brought into the inspection loop.	.631

Extraction Method: Maximum Likelihood.

a. 1 factors extracted. 4 iterations required.

Source: Pilot data, 2012

APPENDIX 4: Control of Other Animals Factor Matrix^a

CONTROL OF OTHER ANIMALS	Factor
	1
As birds scavenge they interact with several disease carrying agents.	.983
Wild birds' attractants (spilled feeds, open water spots, dead carcasses) are seldom removed from the poultry compound.	.379
While on transit, the birds are either exposed to the atmosphere or are in contact with humans.	.281
There is evidence of domestic birds mixing with wild birds.	.427

Extraction Method: Maximum Likelihood.

a. 1 factors extracted. 22 iterations required.

Source: Pilot data, 2012

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