Dedications

To my husband and family,

To Kuku Dairy producers

and those who suffered From Brucellosis

I dedicate this work.

Khansaa

ACKNOWLEDGEMENTS

First, Thank God who gave me the patience, ability and strength to complete this work.

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The National Veterinary laboratory- Department of Brucella Provided the Rose Bengal antigen. Drs Rageb Mohammed Bakheit, Enaam Alsanossi and Nawaai contributed much in this respect . The Advice and Support of Prof. Osman Saad, and Dr. Fegiri were greatly appreciated.

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I owe thanks to colleagues in the private sector as well as the people of Kuku Scheme Dr Zubeeda ,Neama , Dr. Altaeib Alnour ,Osman , Hamid Samuel and Bekri.

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Most importantly, my family has all sacrificed so that I could be a student:

My mother, husband, Anfal ,Amel, Sami, Amin, Rawan Elnour and Aam . I can never repay that debt.

ABSTRACT

The objective of this research is to quantify the impact of Brucellosis on Kuku Dairy scheme. Ecozoo model with introduction of some modifications was used as analytical framework. It provides the information needed to analyze the epidemiology of the disease in both animals and humans as well as the economic analysis. Epidemiological data required were obtained from primary sources. These include two seroprevalence surveys for cattle, personal communications were also used as a source of primary data.

Two field surveys (including seroprevalence and socioeconomic surveys) were conducted during the period Jan- June 2004 . The Humans Brucellosis survey included 176 Volunteers from the population at risk. In the Bovine Brucellosis survey the sample design was based on two stages random sample design. In the first stage, holdings (the primary statistical units) were identified. Then the individual Animals (the Secondary Statistical units) were selected. The size of the primary Statistical units was calculated as 30.1 with α =0.05 and desired accuracy of (10) . The number of animals examined was 574.

The laboratory diagnosis relied mainly on serological tests namely Rose –Bengal Test (RBT) as screening test and Competitive Enzyme linked Immuno- Sorbent Assay (cELISA) as confirmatory test. Tube agglutination test (TAT) was used as a routine test.

According to the confirmatory test : the herd prevalence rate is 90%, individual animal prevalence rate 24.9% and average within herd prevalence rate 24.5% (Sd 15.7 CI 4.088 at 95%). Based on c-Elisa human prevalence rate is 11.3% considering the seropositivity and 2.8% considering active brucella infection. Based on prevalence rates estimates on human parameters was found to be 18 active infected person in the baseline year and the infected cattle are 1508 head. These parameters were introduced into Ecozoo model. Data for DALYs calculation were obtained from primary sources as well as secondary sources.

Based on the epidemiological and economic data the total cost of the disease in both dairy and health sectors was found to be 67126953.8 SD out of which 66910503.8 SD was the cost of the dairy sector and 216450SD was the cost of health sector. Accordingly, the dairy sector Shouldered 99.76 % of the cost, while the health sector Shouldered 0.33% of Brucellosis cost in the base line year.

The burden of the disease was measured in DALYs. In the baseline year 18 persons were infected with Brucellosis . If we considered Brucellosis associated with level 0.1-disability weight, every infected person will loose 0.392659 year of his healthy life as a result of the infection. The total infected people will loose 7.067862 years of their healthy life. If the disease associated with level 0.2 disability weight, every infected person will loose 0.785318 years and the whole infected people will loose 14.13572 years of their healthy life.

Evolution of the disease over 11 years was investigated in two scenarios. In scenario 1 the total animal population was left to grow at the normal rates. In this case the number of seropositive animals will increase with growth rate of 103.2% followed by the increase in number of actively infected humans with growth rate of 27.8%.

The total cost of the disease in both dairy and health sectors were found to be 1022123020SD (745547286 SD in PV) equivalent to 4088492.08 US$over the 11 years.

The total loss of healthy years over the 11 years will account to 59.7 years (0.1 DW). And 119.4 years (0.2 DW).

In Scenario 11 the total number of animals was held constant. In this case the number of seropositive animals will increase during the 11 years with growth rate of 258.1% Followed by the increase in number of actively infected humans with growth rate of 133%. The total cost of the disease in both dairy and health sectors was found to be 1414827570 SD (101505075 in PV) equivalent to 5655170.142US$ over the 11 years.

The total loss of healthy years over the 11 years will account to 89.1 years (0.1 DW). And 178.3 years (0.2 DW).

Most of the producers (80%) are well informed about the disease and its zoonotic nature, (53%) are well acquainted with the economic importance of the disease. All of them Support the idea of disease control.

The study confirm the endimicity of the scheme with both human and bovine Brucellosis.and prove the economic loss due to disease both financial and its burden on human heath.

The study recommends intervention to control the disease. Adoption of Whole herd Vaccination policy was recommended. Simulation of different intervention strategies to analyze the cost and benefits will help policy makers in setting up their priorities

الخلاصـــة

استهدفت الدراسة تقدير الخسائر الناتجة عن تفشى مرض البروسيلوزس بمشروع ألبان كوكو.

استخدمت الدراسة نموذج ال Ecozoo مع إجراء بعض التعديلات كأداة للتحليل.تم الحصول على البيانات المطلوبة من مصادرها الأولية والثانوية. للحصول على البيانات الأولية تم إجراء مسحين حقليين لجمع بيانات عن بر وسيلا الإنسان وأخر عن بر وسيلا الأبقار.أيضا تم استخدام أسلوب المقابلة الشخصية مع المنتجين و الخبراء لجمع البيانات الأولية.

تم إجراء مسح بر وسيلا الإنسان فى الفترة ما بين يناير إلى يونيو 2004 حيث جمعت عينات للدم من 176 متبرع بالإضافة الى البيانات المطلوبة.

اعتمد التشخيص المعملي على اختبارات المصل بالتحديد اختبار الروز بنغال ككاشف مسحي واختبار c-ELISA كاختبار تأكيدي. أخضعت العينات أيضا لاختبار TAT اختبار روتيني يجرى بالسودان.

لتقدير عبء المرض على الإنسان تم استخدام مؤشر غير نقدي (زمني) يعرف بسنوات التعطيل المعدلة .

بالنسبة لبر وسيلا الأبقار تم اختيار العينة على مرحلتين ،فى المرحلة الأولى تم اختيار الحيازات (القطعان) عشوائيا. فى المرحلة الثانية تم اختيار الوحدات الإحصائية(الحيوانات). استهدفت الدراسة كل الأبقار البالغة. بلغ عدد الحيازات المختارة 30 حيازة بينما بلغ عدد الأبقار 574 . حيث تم اخذ العينات وفحصها بواسطة اختبار الروز بنغال و c-ELISA .

فيما يتعلق بانتشار المرض توصلت الدراسة الى النتائج التالية:

بلغ معدل انتشار المرض فى الانسان11.3 .% بناء على ايجابية اختبار المصل و2.8% بناء على الإصابة الحقيقية.

بالنسبة للأبقار بلغ معدل انتشار المرض فى القطعان 90%، معدل الانتشار بين الأبقار 24.9% ومتوسط معدل الانتشار داخل القطيع 24.5%.

بناء على هذة المعدلات بلغ تقدير عدد الأشخاص المصابين فى سنة الأساس 18 شخصا وعدد الأبقار المصابة 1508. بلغ تقدير الخسائر الناجمة عن المرض ب67126953.8 دينار (سبعة وستون مليونا ومائه ستة وعشرون ألفا وتسعمائة ثلاث خمسون دينار). منها 66910503.8 دينار(ستة وستون مليونا ستمائة وعشرة ألفا وخمسمائة وثلاث دينار) خسائر قطاع الألبان.بينما بلغت الخسائر فى قطاع الصحة 216450 (مائتان وأربعة عشر ألفا وأربعمائة وخمسون دينار). عليه فان قطاع الألبان يتحمل 99.76 % من تكلفة المرض بينما يتحمل قطاع الصحة0.33% من التكلفة .

فيما يتعلق بالعبء الصحى على الإنسان، توصلت الدراسة الى أن الفرد المصاب يفقد 0.392659 من سنوات عمره المعافاة اذا ارتبط المرض بوزن التعطيل0.1، و 0.785318 سنه إذا ارتبط المرض بالوزن 0.2 ، وعليه يبلغ عدد سنوات العمر المعافاة النى يفقدها المصابون فى الحالة الأولى 7.067862 سنه و 14.13572 سنه فى الحالة الثانية.

بحثت الدراسة تطور المرض خلال 11 سنه من خلال سيناريوهين ، فى السيناريو الاول ترك العدد الكلى للحيوانات ينمو وفق المعدلات الجارية. فى هذه الحالة فان عدد الحيوانات المصابة سوف ينمو بمعدل 103.2% و ينمو عدد الأفراد المصابين بمعدل 27.8% وتكون تكلفة المرض الكلية فى خلال إحدى عشر سنة (2004-2014) 1022123020 دينار 745547286دينار بالقيمة الحالية. ما يعادل 4088492.08 دولار .

بلغ عدد سنوات العمر المعافاة المفقودة إحدى عشر سنة 59.7 سنه بوزن 0.1 و119.4سنه بوزن 0.2 .

أجرى السيناريو الثانى بافتراض ثبات العدد الكلى للحيوانات. فى هذة الحالة فان عدد الحيوانات المصابة سوف يزيد بمعدل1 258% في خلال إحدى عشر سنة بينما يزيد عدد الأفراد

المصـابين أصـابه فعليـه133% . تبلـغ التكلفـة الكليـة للمـرض1414827570 **دينـار** SD101505075 دينار بالقيمة الحالي. ما يعادل 5655170.142 دولار .

يقدر الفقد الكلى لسنوات العمر المعافاة ب 89.1 سنه بوزن 0.1و 178.3بالوزن 0.2 . توصلت الدراسة الى أن معظم المنتجين(80 %) لديهم العلم الكافي بالمرض وطبيعته المعدية للإنسان.وأن (53 %) منهم يدركون أهميته الاقتصادية.أكدت الدراسة استيطان المرض بالمشروع وأثبتت الخسائر الناجمة عنه. كما أوضحت تطور المرض والخسائر الناتجة عن ذلك عند عدم السيطرة عليه فى خلال إحدى عشر سنه .أوصت الدراسة بالتدخل للسيطرة على المرض فى الحيوان وذلك بإتباع سياسة التطعيم الكلى للقطيع ثم تطعيم العجول سنويا والحيوانات البالغة كل سنتين لمده عشر سنوات ثم إتباع سياسة الفحص وذبح الحيوانات الموجبة .وذلك بعد مضاهاة الاستراتيجية المختارة بمعدلات مختلفة لكفاءة المصل لتحديد نسبه التكاليف والمنافع مما يساعد متخذي القرار فى اختيار البديل المناسب .

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ACAPP	Arab Company for Agriculture production and processing
ASA	Applied science and analysis
BBAT	Buffered Brucella antigen tests
BEP	Brucellosis Eradication Program
BTB	Bovine tuberculosis
Cc	Conjugate control
c-ELISA.	Competitive Enzyme Linked Immuno- sorbent Assay.
CDC	The Centers for Disease Control and Prevention
CNS	Central Nervous System
CF	Complement fixation
DALYs.	Disability-adjusted life years
Defra	Department for Environmental, Food and Rural Affairs
DW	Disability weight
DBMD	Division of Bacterial and Mycotic Diseases
FAO	Food and Agriculture Organization
GATT	General agreement on Trade and Tariff
GU	Genitourinary

H2O2	Hydrogen peroxide
HR P	Horse- radish peroxidase
IELISA	Indirect Enzyme Linked Immuno- sorbent Assay
ICFTU	International Complement Fixation Unit
IM	Intra muscular
IMI	intramammary infusion
IV	Intravenous
KCDFs	Kuku cooperative dairy farms
LA-OTC	long-acting oxytetracycline
LDCs	Less developing countries
LDPS	livestock development planning system
M.D	Medical Doctor
MAb	Monoclonal. Antibody
MMWR	Mortality and Morbidity Weakly Report
MRT	Milk Ring Test
OD	Optical density
OIE	Office International des Epizooties
OIEISS	OIE International Standard System
PBS	Phosphate buffer saline
PCR	polymerase chain reaction
PI	percentage inhibition
PO	Per Oss
PP	per cent positivity
RBSA	Rose-Bengal slide agglutination

RBT	Rose –Bengal Test
SAT	Serum agglutination test
S-LPS	Smooth Lipopoly Saccaride
ST	streptomycin
STA	Standard tube agglutination
TAT	Tube Agglutination Test
TMP-SMZ	trimethoprim/sulfamethoxazole
WHO	World Health Organization
WTO	World Trade Organization

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as the economic analysis. Epidemiological data required were obtained from primary sources. These include two seroprevalence surveys for cattle, personal communications were also used as a source of primary data.

Two field surveys (including seroprevalence and socioeconomic surveys) were conducted during the period Jan- June 2004 . The Humans Brucellosis survey included 176 Volunteers from the population at risk. In the Bovine Brucellosis survey the sample design was based on two stages random sample design. In the first stage, holdings (the primary statistical units) were identified. Then the individual Animals (the Secondary Statistical units) were selected. The size of the primary Statistical units was calculated as 30.1 with α =0.05 and desired accuracy of (10). The number of animals examined was 574.

The laboratory diagnosis relied mainly on serological tests namely Rose –Bengal Test (RBT) as screening test and Competitive Enzyme linked Immuno- Sorbent Assay (c-ELISA) as confirmatory test. Tube agglutination test (TAT) was used as a routine test.

According to the confirmatory test : the herd prevalence rate is 90%, individual animal prevalence rate 24.9% and average within herd prevalence rate 24.5% (Sd 15.7 CI 4.088 at 95%). Based on c-Elisa human prevalence rate is 11.3% considering the seropositivity and 2.8% considering active brucella infection. Based on prevalence rates estimates on human parameters was found to be 18 active infected person in the baseline year and the infected cattle are 1508 head. These parameters were introduced into Ecozoo model. Data for DALYs calculation were obtained from primary sources as well as secondary sources.

Based on the epidemiological and economic data the total cost of the disease in both dairy and health sectors was found to be 65833570 SD out of which 65617120 SD was the cost of the dairy sector and 216450SD was the cost of health sector. Accordingly, the dairy sector Shouldered 99.97 % of the cost, while the health sector Shouldered 0.03% of Brucellosis cost in the base line year.

The burden of the disease was measured in DALYs. In the baseline year 18 persons were infected with Brucellosis . If we considered Brucellosis associated with level 0.1-disability weight, every infected person will loose 0.392659 year of his healthy life as a result of the infection. The total infected people will loose 7.067862 years of their healthy life. If the disease associated with level 0.2 disability weight, every infected person will loose 0.785318 years and the whole infected people will loose 14.13572 years of their healthy life.

Evolution of the disease was investigated in two scenarios. In scenario 1 the total animal population was left to grow at the normal rates. In this case the number of seropositive animals will increase with growth rate of 1.574 followed by the increase in number of actively infected humans with growth rate of 1.875.

The total cost of the disease in both dairy and health sectors were found to be 936445610SD (**665340905.8** SD in PV) over the 10 years, out of which 934974941SD (664219621.8SD in PV) was the cost of the dairy sector and 1610142 SD (1121284 SD in PV) was the cost of health sector.

The total loss of healthy years over the 10 years will account to 52.61631 years (0.1 DW). And 105.2326 years (0.2 DW).

In Scenario 11 the total number of animals was held constant. In this case the number of seropositive animals will increase during the 10 years with growth rate of 2.27. Followed by the increase in number of actively infected humans with growth rate of 3.667. The total cost of the disease in both dairy and health sectors was found to be **1321723709** SD (912709172SD in PV) over the 10 years, out of which 1319199296 SD (911003344SDPV) was the cost of the dairy sector and 2524413 SD (1705828 SD in PV) was the cost of health sector.

The total loss of healthy years over the 10 years will account to 82.06573 years (0.1 DW). And 164.1315 years (0.2 DW).

Most of the producers (80%) are well informed about the disease and its zoonotic nature, (53%) are well acquainted with the economic importance of the disease. All of them Support the idea of disease control.

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فيما يتعلق بانتشار المرض توصلت الدراسة الى النتائج التالية:

بلغ معدل انتشار المرض فى الانسان11.3 .% بناء على ايجابية اختبار المصل و2.8% بناء على الإصابة الحقيقية.

بالنسبة للأبقار بلغ معدل انتشار المرض فى القطعان 90%، معدل الانتشار بين الأبقار 24.9% ومتوسط معدل الانتشار داخل القطيع 24.5%.

بناء على هذة المعدلات بلغ تقدير عدد الأشخاص المصابين فى سنة الأساس 18 شخصا وعدد الأبقار المصابة 1508. بلغ تقدير الخسائر الناجمة عن المرض ب67126953.8 دينار (سبعة وستون مليونا ومائه ستة وعشرون ألفا وتسعمائة ثلاث خمسون دينار). منها 66910503.8 دينار(ستة وستون مليونا ستمائة وعشرة ألفا وخمسمائة وثلاث دينار) خسائر قطاع الألبان.بينما بلغت الخسائر فى قطاع الصحة 216450 (مائتان وأربعة عشر ألفا وأربعمائة

وخمسون دينار). عليه فان قطاع الألبان يتحمل 99.76 % من تكلفة المرض بينما يتحمل قطاع الصحة0.33% من التكلفة .

فيما يتعلق بالعبء الصحى على الإنسان، توصلت الدراسة الى أن الفرد المصاب يفقد 0.392659 من سنوات عمره المعافاة اذا ارتبط المرض بوزن التعطيل0.1، و 0.785318 سنه إذا ارتبط المرض بالوزن 0.2 ، وعليه يبلغ عدد سنوات العمر المعافاة النى يفقدها المصابون فى الحالة الأولى 7.067862 سنه و 14.13572 سنه فى الحالة الثانية.

بحثت الدراسة تطور المرض خلال 11 سنه من خلال سيناريوهين ، فى السيناريو الاول ترك العدد الكلى للحيوانات ينمو وفق المعدلات الجارية. فى هذه الحالة فان عدد الحيوانات المصابة سوف ينمو بمعدل 103.2% و ينمو عدد الأفراد المصابين بمعدل 27.8% وتكون تكلفة المرض الكلية فى خلال إحدى عشر سنة (2004-2014) 1022123020 دينار 745547286دينار بالقيمة الحالية. ما يعادل 4088492.08 دولار .

بلغ عدد سنوات العمر المعافاة المفقودة إحدى عشر سنة 59.7 سنه بوزن 0.1 و119.4سنه بوزن 0.2 .

أجرى السيناريو الثانى بافتراض ثبات العدد الكلى للحيوانات. فى هزة الحالة فان عدد الحيوانات المصابة سوف يزيد بمعدل1 258% في خلال إحدى عشر سنة بينما يزيد عدد الأفراد المصابين أصابه فعليه133% . تبلغ التكلفة الكلية للمرض1414827570 **دينار** SD101505075 دينار بالقيمة الحالي. ما يعادل 5655170.142 دولار .

يقدر الفقد الكلى لسنوات العمر المعافاة ب 89.1 سنه بوزن 0.1و 178.3بالوزن 0.2 . توصلت الدراسة الى أن معظم المنتجين(80 %) لديهم العلم الكافي بالمرض وطبيعته المعدية للإنسان.وأن (53 %) منهم يدركون أهميته الاقتصادية.أكدت الدراسة استيطان المرض بالمشروع وأثبتت الخسائر الناجمة عنه. كما أوضحت تطور المرض والخسائر الناتجة عن ذلك عند عدم السيطرة عليه فى خلال إحدى عشر سنه .أوصت الدراسة بالتدخل للسيطرة على المرض فى الحيوان وذلك بإتباع سياسة التطعيم الكلى للقطيع ثم تطعيم العجول سنويا والحيوانات البالغة كل سنتين لمده عشر سنوات ثم إتباع سياسة الفحص وذبح الحيوانات الموجبة .وذلك بعد مضاهاة الاستراتيجية المختارة

بمعدلات مختلفة لكفاءة المصل لتحديد نسبه التكاليف والمنافع مما يساعد متخذي القرار فى اختيار البديل المناسب .

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$$1/n = 1/nX + 1/N \quad (1)$$

$$Z_{\cdot} \mathbf{st(p) = Z \{ (P.q/n) (N-n)/N \}^{½}} \quad \mathbf{(2)}$$

$$\alpha_{c(effective)} = \alpha_{c(baseline)} (1- (\eta)) (Y/ X+Y) \quad (3)$$

$$I\ ncidence_{\ cattle} = \gamma_c \beta_c XY \quad (4)$$

$$dx/dt = \alpha_c (X+Y)(1-(\eta (Y/(X+Y)))) - \mu_c X - \gamma_c \beta_c XY \quad (5)$$

$$dY/dt = \gamma_c \beta_c XY - \mu_c X \quad (6)$$

$$dA/dt = \nu_h (A+B+C) + \lambda C - (\gamma_c \beta_{ch} AY) - \mu_h A \quad (7)$$

$$dB/dt = (P\gamma_c \beta_{ch} AY) - \kappa B - \mu_h B \quad (8)$$

$$dC/dt = (1-P)\gamma_c \beta_{ch} AY + \kappa B - \lambda C - \mu_h C \quad (9)$$

$$\mathbf{YLD = DW \{ \frac{KCe^{ra}}{(r+\beta)^2} \{e^{-(r+\beta)(L+a)} \{-(r+\beta)(L-a)-1\} - e^{-(r+\beta)a}\{-(r+\beta)a-1\}\} + \frac{1-K}{r}(1-e^{-rL})\}} \quad (10)$$

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LIST OF ABBREVIATIONS

ACAPP	Arab Company for Agriculture production and processing
ASA	Applied science and analysis
BBAT	Buffered Brucella antigene tests
BEP	Brucellosis Eradication Program
BTB	Bovine tubercullosis
Cc	Conjugate control
CELISA.	Competitive Enzyme Linked Immuno- sorbent Assay.
CDC	The Centers for Disease Control and Prevention
CNS	Central Nervous Sytem
CF	Complement fixation

DALYs.	Disability-adjusted life years
Defra	Department for Environmental, Food and Rural Affairs
DW	Diability weight
FAO	Food and Agriculture Organization
GATT	General agreement on Trade and Tariff
GU	Genitourinary
H2O2	Hydrogen peroxide
HR P	Horse- radish peroxidase
IELISA	Indirect Enzyme Linked Immuno- sorbent Assay
ICFTU	International Complement Fixation Unit
IM	Intra muscular
IMI	intramammary infusion
IV	Intravenous
KCDFs	Kuku cooperative dairy farms
LA-OTC	long-acting oxytetracycline
LDCs	Less developing counteries
LDPS	livestock development planning system
M.D	Medical Doctor
MAb	Monoclonal. Antibody
MMWR	Mortality and Morbidity Weakly Report
MRT	Milk Ring Test
OD	Optical density

OIE	Office International des Epizooties
PBS	Phosphate buffer saline
PCR	polymerase chain reaction
PI	percentage inhibition
PO	Per Oss
PP	per cent positivity
RBSA	Rose-Bengal slide agglutination
RBT	Rose –Bengal Test
SAT	Serum agglutination test
S-LPS	Smooth Lipopoly Saccaride
ST	streptomycin
STA	Standard tube agglutination
TAT	Tube Agglutination Test
TMP-SMZ	trimethoprim/sulfamethoxazole
WHO	World Health Organization
WTO	World Trade Organization

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