The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK

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Development and testing of a novel instrument to measure health-related quality of life (HRQL) of farmed pigs and promote welfare enhancement (Part 1)

ML Wiseman-Orr†, EM Scott*† and AM Nolan‡

† School of Mathematics and Statistics, 15 University Gardens, University of Glasgow G12 8QW, UK
‡ College of Medical, Veterinary and Life Sciences, University of Glasgow G12 8QQ, UK
* Contact for correspondence and requests for reprints: Marian.Scott@glasgow.ac.uk

Abstract

Health-related quality of life (HRQL) was defined for farmed animals and identified as an appropriate focus of integrative welfare measurement for farmed pigs that embraces measurement of positive welfare. The instrument for HRQL measurement was developed specifically for use by farmers and stockpersons, the prime carers of pigs, to increase ownership of welfare improvement amongst those groups. Using a psychometric approach to instrument development, relevant observations were determined by consultation with experienced farmers and stockpersons. These observations included causal variables (cause changes in HRQL) and indicator variables (manifest changes in HRQL). The variables selected as items in the structured questionnaire instrument were those most commonly applied by farmers and stockpersons and also were assigned similar quality-of-life impact by a range of experts including pig veterinary specialists and welfare scientists. The prototype instrument comprises a questionnaire with 98 causal variable items (covering five domains of welfare according with the Five Freedoms) and 30 indicator variable items. It was pre-tested with farmers and stockpersons on commercial farm units and was found to have content (face) validity and high utility. This tool is a novel measure of HRQL in farmed pigs that encompasses the measurement of positive welfare and promotes a move from welfare assurance to welfare enhancement. Further validation of the instrument is described in a companion paper in this issue.

Keywords: *animal welfare, farmed pigs, health-related quality of life, measurement, positive welfare, psychometric*

Introduction

Increasingly, there is a focus on animal-based measures for welfare assessment, moving away from traditional resource- and management-based measures. All animal-based welfare measures, to-date, have been developed for use by visiting farm assessors: there have been limited attempts to develop welfare assessment tools for use by farmers or stockpersons despite their central role in maintaining and improving farm animal welfare on a daily basis. Moving from a culture of welfare assurance to welfare enhancement requires that these groups take ownership of the process of improving farm animal welfare.

Previous tools using animal-based measures have been developed primarily for Farm Assurance purposes, eg that developed by Smulders and colleagues (2006) which was based on pig behaviour, lesions and cleanliness. Good inter-rater reliability was demonstrated, and correlations shown with measurements of stress hormones. A range of animal-based outcome measures (eg lesions, lameness, soiling, behaviour) were evaluated for use in assessment of impact on finishing pigs of an existing Farm Assurance scheme (Whay *et al* 2007). Again, designed for use by visiting assessors, the assessment protocol was undertaken to maximise inter-rater reliability, however validation studies were not undertaken. The Bristol Welfare Assessment Protocol for pigs has also been designed for use by a visiting assessor and incorporates a range of animal-based parameters relating to behaviour (Goossens *et al* 2008). A range of welfare-outcome measures (eg lameness, oral behaviour) have been tested for their feasibility as part of the UK Pig Farm Assurance Schemes (Mullan *et al* 2009), while a recently published animal-based pig welfare assessment method designed for use by trained technicians was used to determine the effects on welfare of age and floor type, although no prior evidence for validation or reliability of the assessment method was provided (Courboulay *et al* 2009). The Welfare Quality® project has presented methods for the overall assessment of pig welfare by visiting assessors using animal-based measures, and, to a lesser extent, resources or animal management (Botreau *et al* 2009; Scott *et al* 2009). All Welfare Quality®

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measures possess face validity but for most of them there is no evidence for other types of validity (Kneirim & Winkler 2009). Careful testing of a novel measure is required to establish evidence for criterion or construct validity.

Measuring animal emotion was long regarded as an impossible goal, yet the importance of affect in welfare measurement has led to increasing efforts to make progress in this area. One of the simplest methods has been a rating approach in which an active role is played by an observer in gathering, integrating and making meaning from observations of behaviour to interpret the expression of emotions (Meagher 2009). Work by Wemsfelder and colleagues (Wemelsfelder *et al* 2000, 2001, 2009; Wemelsfelder & Lawrence 2001) has shown in a number of studies that naïve observers can make a qualitative interpretation of the behaviour of individual pigs (as expressions of subjective state) with good agreement, an approach termed Qualitative Behavioural Assessment (QBA).

An evaluation of the potential of QBA for on-farm welfare monitoring, including farmers and stockpersons as participants, concluded that QBA was reliable, could be accommodated into farm work routines and should be developed for practical on-farm use (Wemelsfelder & Lawrence 2001) (now developed as part of the Welfare Quality® protocols for use by trained assessors). A system of self-evaluation of cattle welfare was developed to promote compliance with Austrian animal welfare legislation, to increase knowledge, foster awareness of welfare issues and provide information to the farmer (Ofner *et al* 2007). No other welfare assessment tools have been developed for use by the farmer or stockperson and none have used these groups as key informants for instrument development purposes.

This can be contrasted with the development of instruments for observational or proxy assessment of quality of life (QOL) for non-verbal people, which are developed with end-users as key informants (Armstrong *et al* 1999; Watson *et al* 1999; Fayers & Machin 2007). In the past twenty years there has been an exponential increase in the development and evaluation of instruments to measure the QOL impact of health status and treatment in people (Garratt *et al* 2002). The focus of such measurement is usually health-related quality of life (HRQL), which has been described as a combination of health state and affective response (Theunissen *et al* 1998) and as the subjective evaluation of circumstances that include health state (Birnbacher 1999). This represents the contemporary approach to measurement of QOL, which emphasises the individuals' evaluation of their circumstances resulting in an affective outcome experienced on a continuum representing poor to excellent QOL. Since QOL or HRQL are subjectively evaluated, they must be measured at the level of the individual. Illness and injury present significant threats to the success of pig farming as an enterprise as well as to pig welfare (EFRACom 2009), therefore HRQL is of particular relevance to farmers as well as to farmed pigs.

Although in animal welfare measurement there has been significant movement towards animal-based measures, often described as 'welfare outcome measures' (eg Mullan *et al* 2009), most such measurements are concerned with health status and other circumstances (eg dirtiness, lesions, lameness and hospitalisation) rather than with the individual's affective response to these. Measurement of circumstances can provide an indirect measure of suffering (negative welfare) but not of positive welfare. For the valid measurement of QOL or HRQL it is essential to identify variables that can capture the individual's experience of its circumstances and these variables are necessary for the measurement of positive welfare. Affect is the most important consideration in animal welfare (Kirkwood 2004; Bono & De Mori 2005; Boissy *et al* 2007; Balcombe 2009; Fraser 2009), so capturing how the animal feels is essential for valid welfare measurement.

The danger of an exclusive focus on affect, however, is that habituation may mitigate poorer provision (Cummins 2005). It is therefore important to ensure that items sampling all major influences on HRQL are included in the instrument. The Five Freedoms (Brambell 1965) and also the more recently devised Welfare Quality® criteria (Botreau *et al* 2007) provide useful frameworks against which adequacy of content, in terms of causal variables for animal HRQL, can be assessed.

Measurement of HRQL in people has evolved rapidly in recent decades, using psychometric methods that are now well-established (Fayers & Machin 2007; Brod *et al* 2009). Defined steps lead to the creation of a structured questionnaire instrument with formal scoring mechanism. The validity of the instrument is established through the methods used during its construction, evidence for various kinds of validity is sought by testing the instrument, and development and testing are fully reported. In developing such instruments to measure HRQL, it is important to distinguish between variables that tell us something about an individual's circumstances (causal variables) and those that tell us something about how that individual feels (indicator variables) since these relate to HRQL in different ways and so should contribute in different ways to its measurement (Fayers & Hand 2002).

The authors had previously applied a psychometric approach to companion animal welfare measurement (Wiseman-Orr *et al* 2004, 2006) and had generalised this approach to the measurement of farm animal welfare (Scott *et al* 2003). In the current study, a psychometric approach was adopted to develop an integrative welfare measure for use by farmers and stockpersons for on-farm measurement of commercially reared growing pigs, a period of the commercial production cycle that offers significant opportunities for improving pig performance and welfare (Gentry *et al* 2008). The construct to be measured, HQRL, was defined as the individual's circumstances, including health status, and its affective response to those circumstances, with group-level measurement represented by the distribution of HRQL scores for individuals in the group (first published in Wiseman-Orr *et al* 2008).

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Table 1 Summary of steps taken during instrument item generation and selection.

	Indicator items for positive HRQL	Indicator items for negative HRQL	Causal items for positive HRQL	Causal items for negative HRQL
Items generated following qualitative analysis of key informant (n = 21) interview transcriptions	54	65	60	131
Items selected following preliminary indicator item validation/endorsement by farmers/stockpersons expert group (n = 20)	13	18		
Items selected following validation/endorsement by expert group of farmers/stockpersons (n = 14), vets (n = 5) and welfare scientists (n = 2)	10	11	19	55
Items were added to ensure content adequacy before HRQL impact assessment exercises completed by farmers/stockpersons (n = 18), vets (n = 7) and welfare scientists (n = 4)	+5	+5	+12	+20
Items selected for prototype for pre-testing	15	15	30	69
Items selected for prototype for field testing	15	15	25	73
Total items		30		98

Materials and methods

Key informant interviews

Key informant interviews (the number determined by purposive sampling to redundancy) were used to generate potential items for the instrument (Table 1). Key informants were identified as those for whose use the instrument would be designed, and who would have expert knowledge of the observations relevant to measurement of HRQL of farmed pigs. Since the instrument was intended to be used in a range of commercial environments, key informants were sought from such a range of environments, within the main pig production areas of Scotland. Ethics approval was sought from the relevant ethics committee of the University of Glasgow, UK. The interviews, audio-recorded, followed a semi-structured format, with questions designed to initiate conversation in a particular area: current approaches to routine on-farm health and welfare measurement; observations that provide information about health and welfare at group and individual level; potential uses and possible formats for an instrument to measure HRQL. Interview recordings were transcribed *verbatim*. Qualitative analysis of the transcriptions was carried out by allocating relevant extracts to a number of categories which were determined in the course of the analysis.

Generation of item pools

Pools of potential instrument items were created by identifying from among reported observations those that were potential indicator variables and those that were potential causal variables for HRQL of farmed pigs, with causal variables further differentiated into relevant domains, such as living conditions and health status, to ensure that all potentially significant impacts upon HRQL of farmed pigs were addressed. Indicator items were also identified. In cases where observations provided information about a variable that could be both causal and indicator, these were initially included in both item pools.

Item reduction

Expert groups were asked to judge the relevance and adequacy for our measurement purposes of each item in the relevant item pool by means of a series of paper-based validation exercises. Initially, only experienced pig farmers and stockpersons (20 male, 2 female), all but one of which had participated in the key informant interviews used to generate the items, were provided with the indicator item pool differentiated into two lists: List A contained words or phrases that were proposed to 'describe the behaviour, attitude or demeanour of a pig that is happy (feeling good)

to some extent about its circumstances'; List B contained words or phrases that were proposed to 'describe the behaviour, attitude or demeanour of a pig that is unhappy (feeling bad) to some extent about its circumstances'. Respondents were asked to score through any item on either list that was not considered useful to describe the behaviour, attitude and demeanour of a pig that would convey how that pig was feeling and then to add to either list any words or phrases not listed that would be useful for that purpose. Then, an expert group of 23 experienced farmers and stockpersons (20 male, 3 female), ten pig veterinary specialists (holders of the RCVS certificate in Pig Medicine) (8 male, 2 female) and three welfare scientists (1 male, 2 female), were asked in concurrent exercises to judge the relevance and adequacy of a reduced list of indicator items and the original pool of causal items which was arranged as far as possible within a Five Freedoms' framework.

Using the resulting selection of items, a further measure of expert agreement on item relevance was obtained through paper-based QOL impact assessment exercises using the same enlarged expert group and conducted concurrently for causal and indicator items. In these exercises, each item was accompanied by a 100-mm visual analogue scale, anchored with 'quality of life could not be worse' (0) and 'quality of life could not be better' (100). Respondents were requested to consider a 16–20-week old grower-finisher pig, and to mark a vertical line to indicate the QOL associated with each observation.

Instrument design

The items selected by means of the validation and impact assessment exercises were included in a prototype instrument. The design of the instrument was informed by a range of utility considerations identified during key informant interviews (see relevant section).

Pre-testing

The purpose of pre-testing was to ensure that the instrument was quick and easy-to-use and avoided introducing error into responses through problems of design. Pre-testing was conducted on eight commercial pig-farm units using farmers and stockpersons with a range of experience. During pre-testing, 13 participants applied the prototype instrument to 71 pigs and were subsequently asked to judge the content relevance and adequacy of the instrument, and its utility. Revisions were made in the light of feedback received as pre-testing progressed.

Statistical analysis

Analysis of the data generated in the impact assessment exercise was carried out using Minitab v 15. The Kruskal-Wallis (KW) test was used to test the hypothesis, for each item, that farmers/stockpersons, veterinarians and welfare scientists had the same population median QOL and so determine whether or not ratings provided by farmer/stockperson respondents could be combined with those of other groups.

Results

Key informant interviews

Key informants (20 male, 1 female) were experienced farmers and stockpersons working in the most common commercial systems. Interviews were conducted on 15 farm locations in south west, east and north east Scotland. Eight interviewees worked mainly with outdoor production systems, 11 with indoor production systems and two with organic systems. Pig accommodation included fully and partially slatted and straw-based accommodation. Systems ranged in size from a single unit with approximately 500 pigs to a multi-site company with 13,000 sows. Interviewees' length of experience with pigs ranged from two to 50 years, with a median of 20 years. Interview durations ranged from approximately 35–75 min.

In a qualitative analysis of the data, comments were allocated to the following principal categories: 1) observations indicative of poor HRQL; 2) observations indicative of good HRQL; 3) 'key' observations indicating poor HRQL; 4) assessment of group vs assessment of individuals; 5) variables that are causal for HRQL; 6) health and welfare assessment practices and problems; 7) common practice in addressing health and welfare issues; 8) culling decisions; 9) potential applications for HRQL instrument; 10) assessing change; and 11) miscellaneous comments. Comments in the last category were found to fall into the following sub-categories: relationship between welfare and commerce; pigs' perspective vs human perception; impact of group size; health variables; pecking order; stress, causes and indicators; normal variability in behaviour; individuality and intelligence of pigs; relationship between physical signs and behavioural signs of ill health; recording; regulations; similarities between signs of HRQL in pigs and other species, including man; stockmanship.

Generation of item pools

The initial pool of potential indicator items contained 119 distinctive terms and phrases: 54 indicating positive affect (eg 'playing', 'lively' and 'running around happily') and 65 indicating negative affect (eg 'listless', 'dull', 'away from the group').

An item pool for causal items was created, largely using comments included in four of the principal categories (1–4, see above) but taking into account comments included in other categories. The initial pool of potential causal items contained 191 distinctive terms and phrases: 60 reflecting circumstances (including health state) that would have a positive impact upon QOL (eg 'good skin colour', 'good body condition') and 131 reflecting circumstances (including health state) that would have a negative impact upon QOL (eg 'queuing to feed', 'shivering', 'lame'). Most items could be incorporated under Five Freedoms' headings. Sub-headings within Freedom from Pain, Injury and Disease (Skin, Breathing, Gait, Digestion, Body shape/condition, Eyes, Injury, Posture, Face, Appetite,

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Table 2 Results of preliminary indicator item validation: items endorsed by more than 80% of respondents (and by more than 90% of respondents emboldened).

Words or phrases that describe the behaviour, attitude or demeanour of a pig that's happy (feeling good) to some extent about its circumstances	Words or phrases that describe the behaviour, attitude or demeanour of a pig that's unhappy (feeling bad) to some extent about its circumstances
Lying contented and comfortable	**On its own, away from the group**
Eating well	**Not looking right**
Lively	**Not eating**
Alert	**Not drinking**
Running around happily	**Head is down**
Bright	**Eyes are dull**
Contented	**Listless**
Has bright eyes	**Dull**
Playing	**Uncomfortable**
Play fighting	**Lying on its own**
Interested in what's going on	**Back is hunched**
Curious	**Squealing**
Interacting with other pigs	Reluctant to move
Comfortable	Reluctant to get up
Drinking	Lethargic
Inquisitive	Not moving
Approaches stockperson quickly	Has abnormal posture
Lying in one of groups spread over the pen	Inactive
	Slow moving
	Not interested in its surroundings
	Hanging back
	Lying in the wrong place
	Lying or sitting awkwardly
	Ears are down
	Ears are back
	Screaming
	Nervous

Mobility/Activity, Discharges, Miscellaneous health signs) provided appropriate content coverage for a QOL instrument that has a focus on health. Two further headings — 'Observations of group' and 'Observations over time' — were required to accommodate relevant observations.

Item reduction

Indicator items

Twenty members of the expert group completed the exercise (18 male, 2 female). Twenty of the items were endorsed by at least 90% of respondents and 45 items were endorsed by at least 80% of respondents (Table 2). None of the added items were suggested by more than one respondent.

'Comfortable' and 'uncomfortable' were considered to be causal variables and so were excluded from the reduced list of indicator items for further validation. Some of the 45 items endorsed by at least 80% of respondents were considered to provide observations not already adequately encompassed in the 20 that were endorsed by 90% of respondents. For reasons of adequacy these were added to the list of selected indicator items for further validation: 'playing', 'curious', 'interacting with other pigs', 'reluctant to get up', 'slow moving', 'not interested in its surroundings', 'hanging back'. Comparison of all remaining items offered for endorsement revealed that those were largely encompassed by the items already included, with the exception of 'nosing about', 'communicating with low grunting', 'grinding its teeth' and 'nervous' (all endorsed by at least 2/3 of respondents), and so those too were added. Some of the remaining items that were not encompassed were endorsed by fewer than 2/3 of respon-

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Table 3 Items offered in second indicator item validation exercise. List 1 contains 30 items selected on the basis of frequency of endorsement by experienced farmers and stockpersons (and adequacy of content); List 2 contains appropriate indicator items endorsed by at least two-thirds of experienced farmers and stockpersons and offered as potential additional items to ensure adequacy.

Positive mental state	Negative mental state
List 1 Selected indicator items	
Lying contented and comfortable	On its own, away from the group
Eating well	Not looking right
Lively	Not eating
Alert	Not drinking
Running around happily	Head is down
Bright	Eyes are dull
Contented	Listless
Has bright eyes	Dull
Playing	Lying on its own
Curious	Back is hunched
Interacting with other pigs	Squealing
Nosing about	Reluctant to get up
Communicating with low grunting	Slow moving
	Not interested in its surroundings
	Hanging back
	Grinding teeth
	Nervous
List 2 Additional candidate indicator items	
Play fighting	Reluctant to move
Drinking	Lethargic
Inquisitive	Not moving
Lying in one of groups spread over pen	Has abnormal posture
Running around the pen when startled	Inactive
Rooting, snuffling in the ground	Lying in the wrong place
Aware of its surroundings	Lying or sitting awkwardly
Nosy	Ears are back
Friendly	Screaming
Perky	Refusing to get up
Happy in itself	Lacking energy
Happy	Looking depressed
Relaxed	Sorry for itself
Sleeping quite soundly	Looks unhappy
	Dour
	Not interacting normally with other pigs
	Has different demeanour from rest of group
	Curled up tight
	Not eating normally
	Not interesting in feed
	Tail is drooping
	Frightened

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dents (eg 'almost aggressive'). Others were considered to be unlikely to be observed in all normal assessment circumstances, eg 'not willing to be caught'.

The resulting selection of 30 items was offered for endorsement to the enlarged expert group of experienced farmers and stockpersons, pig veterinary specialists and welfare scientists, with a supplementary list from which additional items could be chosen to ensure adequacy of content. Those supplementary items consisted of items that had been endorsed by at least two-thirds of respondents in the previous exercise, excluding those that could not be considered to be indicator items for the affective component of HRQL, that could not be observed in all common commercial breeds, that could not be observed during daily routine care or when the stockperson is not in the pen, and that could not be observed in all usual types of housing and husbandry systems for grower-finisher pigs.

The 30 items selected and the supplementary item pool are shown in Table 3. Respondents were asked to participate in the selection of items that would be relevant and adequate to reflect the mental state of any farmed pig, by indicating their endorsement of the 30 items in List 1, selecting any additional items from List 2 that they felt to be necessary and, finally, by suggesting any additional terms that might be necessary to describe a pig that was indifferent to its circumstances.

Fourteen experienced farmers and stockpersons (11 male, 3 female); five pig veterinary specialists (4 male, 1 female) and two welfare scientists (1 male, 1 female) returned responses to this exercise. The 21 indicator items selected following this exercise were those endorsed by > 90% of respondents in the farmer/stockperson group. All such items were also endorsed by a majority of respondents in the veterinary specialist group (Table 4).

Causal items

The same panel of experts assessed the relevance and adequacy of the pool of causal items for the purposes of measuring HRQL of farmed pigs according to our definition of the construct, and responded in the same numbers. Respondents were asked to identify any of the items presented that they did not think reflected the range of circumstances that would affect any farmed pig's QOL, and then to add to the relevant list any animal-based descriptive terms or phrases not already offered that were thought necessary to reflect those circumstances in full.

Based on the results of the expert validation, items selected were those endorsed by > 90% of respondents in the farmer/stockperson group. All such items were also endorsed by a majority of respondents in the veterinary specialist group (Table 4). Where additional items (n = 30) were felt to be necessary to provide items associated with positive and negative welfare, these were selected from suggestions made during the validation exercise (Table 4). The total number of causal items in this collection was 106.

Eight descriptors were common to both causal and indicator item collections (denoted by asterisks; see Table 4), making a total of 119 discrete items altogether.

Expert assessment of QOL impact associated with causal and indicator items

Responses were obtained from 18 experienced farmers/stockpersons (16 male, 2 female), six pig veterinary specialists (4 male, 2 female) and four welfare scientists (1 male, 3 female).

The KW test identified that ratings for all three groups (farmers/stockpersons, pig veterinary specialists and welfare scientists) could be combined for 85 of the 106 causal items and 16 of the 21 indicator items included in the QOL impact assessment exercise. Since the sample of welfare scientists was very small, where conditions were not met for use of KW (largest IQR for any group no more than three times that of the smallest IQR) or where the KW result indicated that population medians were not the same, the analysis was repeated for farmer/stockperson and veterinarian ratings only, and results indicated that these could be combined for a further 11 causal items and three indicator items. The KW test statistic suggested that the three groups had different population medians for 11 causal items and one indicator item.

Final item selection and instrument design

An initial selection was made of items where responses of combined groups (farmers and veterinarians) was within a relatively narrow band (IQR ≤ 20 on 0–100 scale) providing evidence of good agreement between individuals on QOL impact or indication.

A number of items was selected for each of the Five Freedoms' domains, with more items for Freedom from Pain, Injury and Disease than for the other Freedoms since the tool was designed to measure health-related QOL. Items were arranged in sub-scales: one for each of the Five Freedoms, with that for Freedom from Pain, Injury and Disease broken down further to accommodate items that described particular areas of the body or particular functions. Where additional items were required to provide adequate content in relation to the Five Freedoms' framework, those with responses in an IQR ≤ 30 (on 0–100 scale) were considered. Also, items were considered for inclusion even where there was no agreement between groups, when these were considered to be essential for content adequacy (eg 'tail bitten', 'ear bitten', 'joint swollen'). Within each Freedom, an effort was made to ensure that there were items representing a range of HRQL impacts, from poor to good.

For utility reasons, a number of causal items were excluded on grounds of redundancy — 'walking about normally', 'lying on top of each other', 'slower growing', 'even growth/sizes in group', 'making more noise than usual' and 'lying in groups all over the pen'. On the basis that observations that can be made only very infrequently will decrease utility while providing limited information, 'investigates novel objects' was also omitted.

'Not drinking' was omitted from the selection of indicator items, since impact assessments from the three groups could not be combined and also because of practical difficulties of interpretation.

Table 4 Item selection following causal and indicator item validation exercises; items associated with positive welfare are in italics; items added to improve adequacy of content are in bold.

Descriptor endorsed by 90% of farmer group	No of vets endorsing n/5	No of welfare scientists endorsing n/2
CAUSAL VARIABLES		
FREEDOM FROM HUNGER & THIRST		
Settled and content		
Excessive queuing/**fighting** to drink	4	1
Excessive queuing/**fighting** to feed	3	1
Freedom from discomfort		
Looks comfortable	5	2
Sleeping with legs stretched out/lying on side		
Panting	5	2
Ears blue	4	1
Hair standing up	5	2
Shivering	5	2
Huddled with other pigs	5	1
Curled up tight, looking cold	3	2
FREEDOM FROM PAIN, INJURY AND DISEASE		
SKIN		
Good skin colour	3	1
Shine on skin	4	0
Pale colour	4	2
Skin dull	3	2
Anaemic	5	2
Hairier than penmates	5	0
BREATHING		
Quiet, relaxed, regular breathing		
Coughing	5	2
Panting	5	2
Breathing heavily	5	2
Breathing laboured	5	2
GAIT		
Gets up fast		
Walking fine		
Lame	5	2
Holding/saving a leg	5	0
Not weight bearing on leg	5	0
Slow to move		
Dog sitting		
DIGESTION		
Normal composition of faeces	4	0
Scouring	5	2
Blood in the scour	5	1
Dung smeared over back end/on tail		
Vomiting		
Very hard dung		
BODY SHAPE/CONDITION		
Good body condition	5	2
Thriving	5	0
Looking hollow/empty	5	2
Pot bellied	5	1
CAUSAL VARIABLES		
EYES		
Clear, bright eyes	5	1
Sunken/deep-set eyes	3	2
INJURY		
No injuries		
Tail bitten	5	1
Flank bitten	5	1
Ear bitten	5	1
Damaged by navel sucking	5	1
Joint swollen	5	2
Sore foot	5	1
Sore leg	5	1
Visible wounds/lesions		
Prolapsed		
Vulva bitten		
Haematoma (ear)		
Abscess		
POSTURE		
Normal posture		
Holding head to one side	5	2
APPETITE		
Eating	5	2
Drinking	4	2
Interested in food	5	1
*Eating well**	5	2
Not eating*	5	1
Off its food	5	1
Not drinking*	4	2
Dehydrated	4	0
MOBILITY/ACTIVITY		
Running about	5	2
Walking about normally	4	1
*Lively**	5	2
Not walking properly	5	2
Not getting up	5	2
Not moving	5	2
Listless*	5	1
Lethargic	5	2
DISCHARGES		
Clear nose, no mucous	5	2
Mucous from the nose	5	2
Blood discharge from wound or other		
Discharge from eyes/tear staining		
Discharge from vulva		
MISCELLANEOUS		
Looks well		
Looks ill	5	1
Shaking	5	2
Lying on side, paddling legs	5	2
Grinding teeth*	5	2

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It was considered that some additional indicator items were required to ensure adequacy of content. Five additional items were chosen for this purpose on the basis of the expert group responses to the second validation exercise for indicator items, all of which had been endorsed by more than 85% of respondents: 'head is down', 'bright', 'nervous', 'not interested in its surroundings' and 'communicating with low grunting'. A further five items were selected that were included in the 'additional items' list in the second validation exercise (where they had been endorsed by 32–59% of respondents) and were identical or similar to terms that had been shown to have a high correlation with valence of affect during a QBA study of pigs in enriched and unenriched environments (Wemelsfelder *et al* 2001): 'not interested in feed', 'frightened', 'friendly', 'inquisitive' and 'relaxed'. This added a further 10 items to the indicator items sub-scale, making a total of 30 indicator items.

Additional questions were incorporated in the prototype, intended to capture relevant information for the validation of the animal-based measures, and potentially for educational purposes. These were adapted from existing resource-based welfare measures, and were designed to address three of the four principles (good feeding, good housing and appropriate behaviours) and associated criteria identified by the Welfare Quality® project (Botreau *et al* 2007) as those around which welfare assessment should be structured. Good health, the fourth principle, was considered to be adequately captured by the instrument's core items. Some of these questions related to group-level provision and some to the circumstances of the individual. All were designed to be able to be answered with ease by the stockperson. Respondents were also requested to provide a global assessment of the pig's HRQL, and to indicate whether their assessment of that pig resulted in any action being considered or taken.

Pre-testing

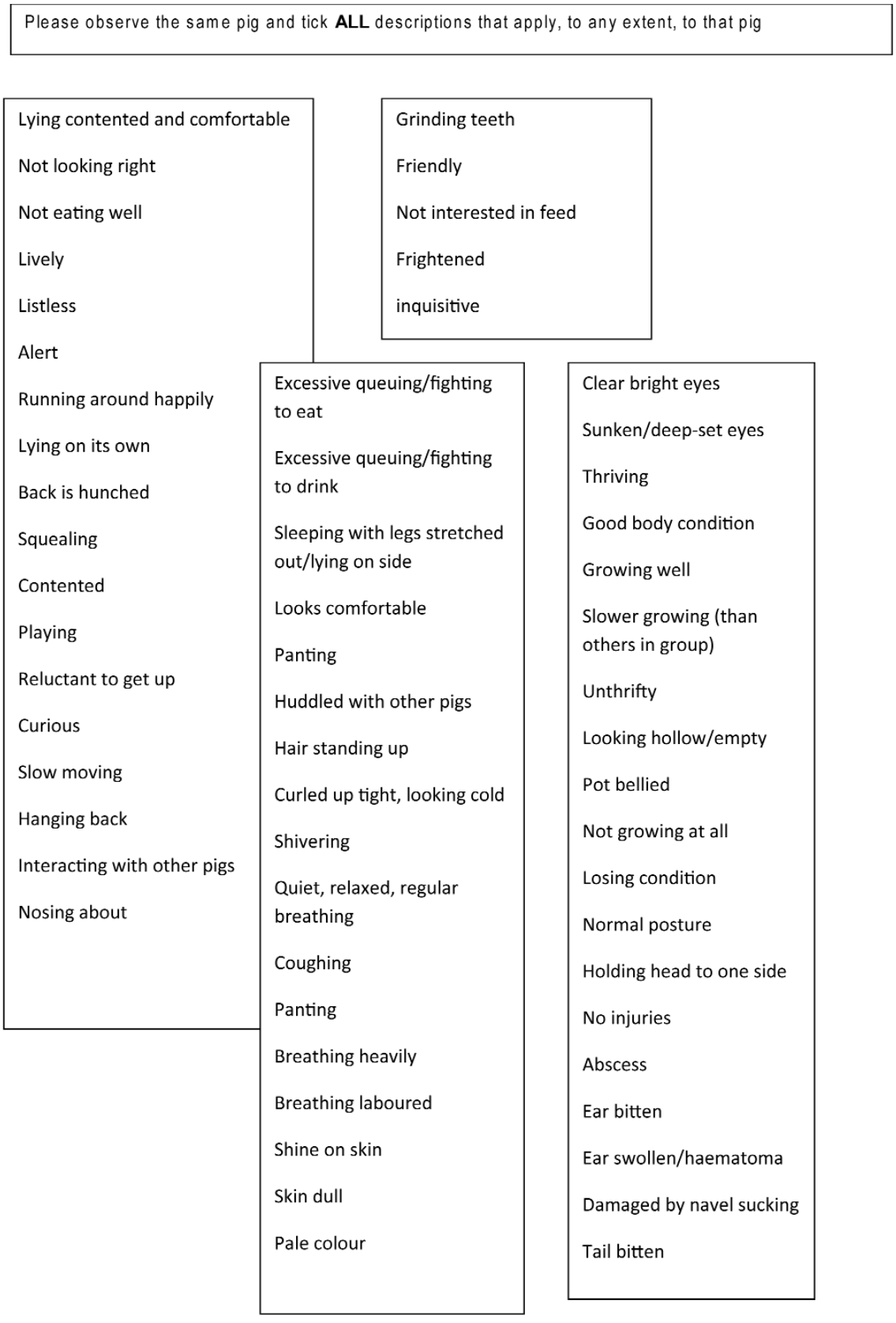
Pre-testing of the prototype was undertaken (71 instruments completed in total). Initially, two experienced stockpersons completed nine instruments in each of two phases of pre-testing. Minor refinements were made and a question was added to ascertain if the assessed pig was in a hospital pen. Following professional graphic design of the instrument, further pre-testing was carried out on one farm, to which five experienced farmers and stockpersons travelled to participate (4 male, 1 female). A total of 23 instruments were completed by this group (range per respondent 4–10). Median time to complete was 3 min (range 3–7 min). The same version of the instrument was provided by the managing director of a pig-production company to six stockpersons with a range of experience (3 months–13.5 years). Independently, they each completed five questionnaire instruments on their respective farms along with a review questionnaire.

Respondents generally found questions to be straightforward, relevant and adequate. As a result of feedback received, a number of changes were made to layout and instructions, and to some of the core items, eg 'pigs settled and content' and 'signs of scouring in pen' were moved to

Table 4 (cont)

Descriptor endorsed by 90% of farmer group	No of vets endorsing n/5	No of welfare scientists endorsing n/2
CAUSAL VARIABLES		
FREEDOM TO EXPRESS NORMAL BEHAVIOUR		
Rooting about	5	
*Interacting with other pigs**	5	
Outcast from group		
Abnormal biting/chewing/other behaviour		
Excessive fighting		
Having not enough room to move		
Grunting		
Nosey		
Mounting		
FREEDOM FROM FEAR AND DISTRESS		
Relaxed		
Unafraid of stockperson		
Investigates novel objects		
Bullied	5	2
Isolated	5	0
Squealing*	3	2
OBSERVATIONS OF GROUP		
Lying in groups all over the pen	5	2
Lying on top of each other	5	1
Making more noise than usual	4	1
Even growth in group		
OBSERVATIONS OVER TIME		
Growing well	5	2
Slower growing	5	2
Unthrifty	5	0
Not growing	4	1
Losing condition	5	2
INDICATOR VARIABLES		
Lying contented and comfortable	5	2
*Eating well**	5	2
*Lively**	5	2
Alert	5	2
Running around happily	5	2
Contented	5	2
Playing	5	2
Curious	5	2
*Interacting with other pigs**	5	2
Nosing about	5	2
Not looking right	4	2
Not eating*	4	2
Not drinking*	4	2
Listless*	5	2
Lying on its own	5	2
Back is hunched	4	2
Squealing*	4	2
Reluctant to get up	4	2
Slow moving	5	2
Hanging back	5	2
Grinding teeth*	5	2

Figure 1



Extract from instrument to show sample items.

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pen level measurement'. The finished instrument contained 98 causal variable items and 30 indicator variable items (Figure 1). A summary of the steps taken during item generation and selection is given in Table 1.

Discussion

It was considered appropriate to develop a tool for use by farmers and stockpersons, in order to promote greater ownership for welfare enhancement amongst those who routinely care for pigs and have most responsibility for their welfare. Such a tool must have high utility and face validity to ensure good uptake and use of the tool.

The most important attribute of a measurement instrument is its validity — the extent to which it measures what it is intended to measure. Content validity was established during the process of instrument development, and evidence for this was sought by means of an expert assessment of the adequacy and relevance of instrument items for the measurement of the construct of interest, in this case, HRQL of farmed pigs. In order to facilitate assessment of content adequacy, causal items were arranged within a Five Freedoms' framework, which also served to link this novel approach to well-established welfare assessment parameters.

The strength of the psychometric approach to the development of welfare assessment instruments lies in its focus from the earliest stages of development on designing an instrument with validity, reliability and utility for the intended user in the intended context and for the intended measurement purpose. A psychometric approach has been used in recent years to develop and test a number of tools to assess HRQL in companion animals (eg Wiseman *et al* 2001; Hielm-Björkman *et al* 2003; Hudson *et al* 2004; Wiseman-Orr *et al* 2004, 2006; Freeman *et al* 2005; Yazbek & Fantoni 2005; Brown *et al* 2007). In all cases, these consisted entirely of animal-based measures, containing a balance of causal variables (such as mobility and digestion) and indicator variables (such as social behaviour and playfulness), they were designed for use by an untrained respondent (owner/carer) and were subjected to testing for evidence of measurement properties before being used for clinical or research purposes. FAWC's recent report to the UK Government (FAWC 2009) has recommended that careful attention be paid to the validity, feasibility and reliability of any measure of animal welfare and that validation should be established under field as well as experimental conditions. Many existing welfare measures, including those recently developed as part of the Welfare Quality® project, have not yet been adequately tested (Knierim & Winkler 2009). There is some evidence that farm inspectors are less confident when requesting compulsory changes based on animal-based measures (Keeling 2008) so it is important that the validity and reliability of these is fully evidenced.

Criteria for the selection of causal items for this novel instrument were: face validity, comprehensive coverage, emphasis on items that are important and those that are frequently observed (Fayers & Machin 2007). Face validity, a type of content validity, reflects the extent to which an instrument's items appear, on the face of it, to be relevant to the construct of interest. Involvement of farmers and stockpersons in generation and selection of instrument items ensured face validity of the instrument. Content validity was assured by involvement of a range of experts during item selection, and by use of a Five Freedoms' framework to assess the adequacy and relevance of causal items. Feedback from participants in pre-testing provided evidence for the content validity of the instrument, but asking an independent expert group to validate as relevant and adequate the final list of items that were included in the instrument would provide further evidence for content validity. Evidence for other forms of validity, such as construct validity, must be sought during field testing of the prototype instrument: this process is described in a companion paper (Wiseman-Orr *et al* 2011).

Instruments that do not have a user focus throughout development may be difficult to use without extensive training and can be subject to user error and consequent unreliability: it has been suggested that designing an instrument for use by an untrained rater in a naturally occurring situation may be considered to be a methodological strength (Breau *et al* 2000). The pig instrument was designed with the end user in mind, pre-tested in relevant contexts, and re-designed in the light of respondent feedback, all of which contributed to the utility of the final instrument, which was judged to be high by naïve operators on-farm.

It has been reported that farmers show a high level of interest in animal-based parameters (Kneirim & Winkler 2009) and we sought to both exploit and promote this interest. A number of assessment instruments have recently been developed for on-farm welfare measurement with a focus on animal- rather than resource-based parameters because these are considered to be a more direct measure of welfare (Smulders *et al* 2006; Whay *et al* 2007; Goossens *et al* 2008; Botreau *et al* 2009; Courboulay *et al* 2009; Mullan *et al* 2009; Scott *et al* 2009). Most of these parameters concern physical condition (such as lameness, lesion and body condition scoring) which can be considered to be causal for HRQL. Some assessment protocols include parameters that can be considered to be indicator for HRQL, such as QBA in the Welfare Quality® instruments (eg Scott *et al* 2009) and behavioural outcomes such as stereotypies or positive behaviours (eg Whay *et al* 2007; Courboulay *et al* 2009), but these make a relatively small contribution to the overall assessment of which they form a part. Causal items are good at identifying individuals with poor QOL since a 'poor' score on any one causal variable may be sufficient cause for lowered QOL. However, causal variables often manifest poor measurement qualities relating to good QOL (positive welfare). Indicator variables should be effective for measuring both good and poor QOL, offering an opportunity to measure levels of positive welfare as well as suffering. The focus in existing instruments is therefore on measurement of negative rather than positive welfare. There is a need for measures of positive welfare (Boissy

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et al 2007; Yeates & Main 2008) but a focus on causal variables does not address the current and future need for positive welfare measures (FAWC 2009). Measurement of HRQL using indicator as well as causal variables permits measurement of positive welfare which the traditional focus on causal variables is unable to do. The instrument described here has a significant focus on indicator variables, with almost one-quarter of included items being of this type.

During item generation, key informants sometimes used the same terms to describe aspects of physical condition and also affective state. For example, 'lively' communicates something about the mobility of the animal as well as its attitude or demeanour. In such cases, in accordance with the importance attached in this study to all information provided by key informants, such items were initially retained in both item pools and were available for selection as both causal and indicator variables in spite of the potential problems that could result.

The hypothesis that selected instrument items have common meaning for all stockpersons is fundamental to the design and performance of the instrument. The composition of the expert group differed only slightly from stage-to-stage of the development process. Of the initial expert group of 21 farmer/stockperson interviewees, 11 participated in all and all others participated in some of the subsequent validation and impact assessment exercises. Of the seven veterinary pig specialists and four welfare scientists who participated in the expert group exercises, four veterinarians and two welfare scientists participated in all exercises. This approach is similar to a Delphi sequence, a recognised approach to arriving at a consensus opinion among a group of experts which has been used to identify appropriate measures for the welfare assessment of farm animals (Whay *et al* 2003) and laboratory mice (Leach *et al* 2008).

The QOL impact assessment exercise which also informed item selection included experts of three kinds: experienced farmers and stockpersons, pig veterinary specialists and welfare scientists. Although participant numbers were not high, the responses showed good agreement between all three groups on the QOL impact associated with 80% of causal items presented and on the QOL associated with 76% of indicator items presented. There was agreement between farmers/stockpersons and veterinarians for 91% of causal items and 90% of indicator items. There was disagreement between all three groups for only 10% of causal items (mostly relating to lameness and injuries) and one indicator item ('not drinking').

There is potential for a validated instrument of the kind developed in this study to form a complementary component of a Farm Assurance scheme, or a core part of a farm improvement scheme, offering routine welfare monitoring conducted by farmers or stockpersons and directing their attention to any problem areas. A survey of UK pig farmers reported that some two-thirds would be willing to perform welfare self assessments as part of Farm Assurance (Mullan *et al* 2008). The instrument described in this paper could facilitate benchmarking between farms, a practice that two-thirds of UK pig farmers would be willing to take part in on an anonymous basis (Mullan *et al* 2008). Most interviewees (from the commercial farming sector) considered that the instrument developed in this study would be a valuable educational tool for less-experienced stockpersons, directing attention to welfare-relevant observations during routine animal care. The importance of stockmanship for animal welfare is recognised (FAWC 2007) and the attitude of stockpersons has been identified as central to their influence (Hemsworth *et al* 2009). On-farm welfare assessments can incorporate attitude-focused training by use of an instrument such as that described here, which has a clear focus on the sentience of the animal and its capacity to experience a good or poor quality of life.

This novel instrument is at the beginning of an iterative process of testing, refinement and further testing with the aim of establishing evidence for its construct validity (see companion paper), and then of improving its measurement properties for use with particular populations, in particular contexts and for particular purposes. This fresh approach to the development of on-farm welfare measurement, which recognises the farmer and stockperson in key roles as experts in farm animal welfare and as facilitators in its improvement, is considered to be a significant advance and warrants further work.

Animal welfare implications and conclusion

A focus on HRQL for welfare measurement is appropriate for farmed pigs for which health has important commercial as well as welfare impacts. The HRQL instrument described in this paper measures positive as well as negative welfare through inclusion of indicator as well as causal variables. A focus throughout development on validity and utility has resulted in an instrument with high acceptability amongst the target user group and with good evidence for content validity. Evidence for its construct validity is available (see companion paper). With further development the instrument can be used by farmers and stockpersons to guide welfare-related decision-making on a day-to-day basis, to contribute to group-level welfare measurement at single time points and over time, and to compare the welfare impact of management practices and targeted interventions. Routine use of the instrument for educational purposes may itself have a positive impact upon animal welfare.

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