

New Zealand Society of Animal Production online archive

This paper is from the New Zealand Society for Animal Production online archive. NZSAP holds a regular annual conference in June or July each year for the presentation of technical and applied topics in animal production. NZSAP plays an important role as a forum fostering research in all areas of animal production including production systems, nutrition, meat science, animal welfare, wool science, animal breeding and genetics.

An invitation is extended to all those involved in the field of animal production to apply for membership of the New Zealand Society of Animal Production at our website www.nzsap.org.nz

[View All Proceedings](#)

[Next Conference](#)

[Join NZSAP](#)

The New Zealand Society of Animal Production in publishing the conference proceedings is engaged in disseminating information, not rendering professional advice or services. The views expressed herein do not necessarily represent the views of the New Zealand Society of Animal Production and the New Zealand Society of Animal Production expressly disclaims any form of liability with respect to anything done or omitted to be done in reliance upon the contents of these proceedings.

This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](http://creativecommons.org/licenses/by-nc-nd/4.0/).



You are free to:

Share— copy and redistribute the material in any medium or format

Under the following terms:

Attribution — You must give [appropriate credit](#), provide a link to the license, and [indicate if changes were made](#). You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

NonCommercial — You may not use the material for [commercial purposes](#).

NoDerivatives — If you [remix, transform, or build upon](#) the material, you may not distribute the modified material.

<http://creativecommons.org.nz/licences/licences-explained/>

Forage intake and feed conversion efficiency in high-producing dairy herds in New Zealand: a case study

P.V. SALLES¹, P.N.P. MATTHEWS², C.W. HOLMES², J. HODGSON¹ AND N.M. SHADBOLT³

¹Institute of Natural Resources, Massey University, Private Bag 11222, Palmerston North

ABSTRACT

In 1998 a three-year dairy farm monitoring programme was established on twelve dairy farms in the southern North Island of New Zealand where production policy had changed from a focus on high production per hectare through high stocking rates to a strategy based on high production per hectare through enhanced production per cow. Results of the third year for nine of these farms revealed a range of apparent feed intake (50,669 - 70,135 MJ ME/cow/year), milksolids production (372 - 432 kg MS/cow/year) and feed conversion efficiency (6.0 - 7.4 g MS/MJ ME intake). There was a significant positive correlation ($R^2 = 0.57$, $P < 0.05$) between annual apparent ME intake per cow and annual milksolids production per cow, with a regression coefficient equivalent to 2.5 g MS produced per MJ ME intake, but a significant negative correlation ($R^2 = 0.80$, $P < 0.01$) between ME intake and feed conversion efficiency. The apparent ME intakes measured were 21% and 8% higher than theoretical requirements for the farms with higher and lower (compared to each other) milksolids yield values, respectively. This suggests that the high-performance farms may have wasted more feed. Implications for management of feed resources to optimise efficiency in high-production systems are discussed.

Keywords: dairy systems; pasture utilisation; animal performance; feed conversion efficiency.

INTRODUCTION

Low milk-production costs in New Zealand grazing systems are based on growing and utilising large amounts of grazed pasture. The success of New Zealand dairy production in past years has been based on the increased amount of pasture harvested as a consequence of better pasture utilisation resulting from high stocking rates (Matthews, 1995), combined with genetic improvement, which increased milk production and feed conversion efficiency per animal (Holmes & Matthews, 2001). In traditional dairy systems, little attempt has been made to overcome seasonal feed deficits, and pasture limitations have resulted in low animal performance (Matthews, 1994). High pasture allowances are required in order to achieve high animal intakes necessary for high production per cow. However, greater herbage allowance is likely to increase herbage wastage, leading to a conflict between pasture utilisation and forage intake (Hodgson, 1990; Matthews, 1995).

A dairy farm monitoring programme funded by AGMARDT (Agricultural Marketing and Research Development Trust) was established in 1998 on twelve dairy farms in the southern North Island of New Zealand, where the farmers had gradually changed their production policy from a focus on high production per hectare through high stocking rate to a strategy based on high production per hectare through improved performance per cow. This was achieved through reduced stocking rates, and strategic use of forage-based supplements while still maintaining efficient pasture production and utilisation.

The project involved a detailed three-year data collection that included daily measurements of the quantity and composition of pasture and supplements consumed, as well as animal performance. In this paper, the results of the third year (2000/2001) of the project on nine of these farms are analysed, and implications for management of grazing and supplementary feed resources

to optimise the efficiency of feed use in high-production systems are discussed.

MATERIALS AND METHODS

Pre- and post- grazing herbage mass (kg DM/ha) were estimated daily by the farmers, using visual assessment (Hodgson *et al.*, 1999; L'Huillier & Thomson, 1988). Once a month, pre- and post-grazing herbage mass for 15-20 paddocks selected randomly for each farm were measured using the Ashgrove Rising Plate Meter (RPM) (Hodgson *et al.*, 1999) and standardised monthly calibration equations (Hainsworth, 1999). Regression analyses were used to derive monthly equations between RPM readings and visual sward assessment for each farm, in order to adjust individual estimations from visual assessment. Apparent herbage intake (kg DM/cow/day) on each farm was estimated as the difference between adjusted pre- and post-grazing herbage mass (kg DM/ha) divided by grazing intensity (cows/ha/day) (Matthews *et al.*, 1999). Grazing intensity was defined as the number of animals grazing divided by the area grazed per 24 hours (Matthews *et al.*, 1999). In the text, apparent ME intake is abbreviated as intake or measured intake.

The main supplements consumed by lactating animals were pasture silage (summer to winter), turnips (summer) and maize silage (autumn and winter). Grazing off was the main supplement for dry animals in winter. The quantities of all supplementary feeds were recorded by the farmers every time they were offered to the cows. The fresh weight was determined utilising feeding wagons fitted with load cells, bucket on front-end loaders or the weight of bales/bags of supplements. Samples of supplementary feed were collected for dry matter determination if it was not provided by the farmers. Wastage of 5% was assumed for all types of supplements fed on feed pads. For turnips and supplements fed on the paddocks 10% wastage was assumed. These assumptions

²Institute of Veterinary, Animal and Biomedical Sciences

³Institute of Food, Nutrition and Human Health

were based on farmers assessment. Herbage samples from each farm were collected at grazing height every ten days from August 2000 to January 2001 and once a month from February 2001 to May 2001. A representative sample of each type of supplement used was collected at the same times. Herbage and supplement samples were analysed for metabolisable energy (ME) content using Near-Infrared Reflectance Spectroscopy (Corson *et al* 1999). Total intake consisted of pasture plus supplements and included both the dry and lactating periods.

A random sample of cows representing approximately 25% of each herd was weighed and condition scored in late September, late November, mid March and late May/early June. The quantity of milksolids supplied to the factory was divided by the peak number of cows on farm and by the farm's effective area (hectares) to calculate annual milksolids production per cow and per hectare, respectively. Lactation days per cow was calculated as the sum of daily numbers of cows milked throughout the lactation period divided by peak number of cows on farm. Feed conversion efficiency (g MS/MJ ME intake) was calculated as the ratio of annual milksolids production per herd (kg/herd/year) to annual metabolisable energy intake per herd (MJ ME/herd/year). The theoretical ME requirements for maintenance, pregnancy, milk production and live weight change were calculated for the period of one year (Holmes *et al.*, 2000; Salles, 2002). The theoretical feed conversion efficiency was calculated by dividing the measured milksolids production per cow by the theoretical metabolisable energy intake per cow. Data were analysed by fitting simple linear and quadratic regressions, at herd level.

RESULTS

Case-study farms description and comparison with industry data

The case-study farms' herds consisted of Holstein-Friesian and Jersey crossbred animals which were spring calving cows. The average live weight and condition score among farms for the whole season was 484 kg (451 – 512 kg) and 4.4 (4.1 – 4.5), respectively. The average lactation days per cow among case-study farms was 258 (278 – 235). The average stocking rate for all case-study farms was similar to the top 25% farms in Manawatu but 16% and 10% lower than the top 10% farms in Waikato and Taranaki, respectively (Table 1). The average annual milksolids production per hectare for the case-study farms was, however, 28% higher than the top 25% Manawatu farms, but similar to values from the top 10% Waikato and Taranaki farms, as a result of higher milksolids production per animal on the case-study farms (27%, 21% and 14% higher than the Manawatu, Waikato and Taranaki farms, respectively).

Feed intake and feed conversion efficiency

In order to facilitate the discussion about factors influencing feed conversion efficiency, the farms were divided into two groups: group one (feed conversion efficiency lower than the average of all farms) and group two (feed conversion efficiencies higher than the average of all farms) (Table 2). There was a noticeable difference in feed conversion efficiency between the two groups, which was probably associated with differences in ME intake per cow.

TABLE 1: Effective area (ha), herd size, stocking rate (cows/ha) and annual milksolids (MS) production per cow (kg/cow/year) and per hectare (kg/ha/year), for nine case-study farms, the top 25% farms* in Manawatu and top 10% farms* in Waikato and Taranaki (Dexcel, 2002, personal communication) in 2000/2001 season.

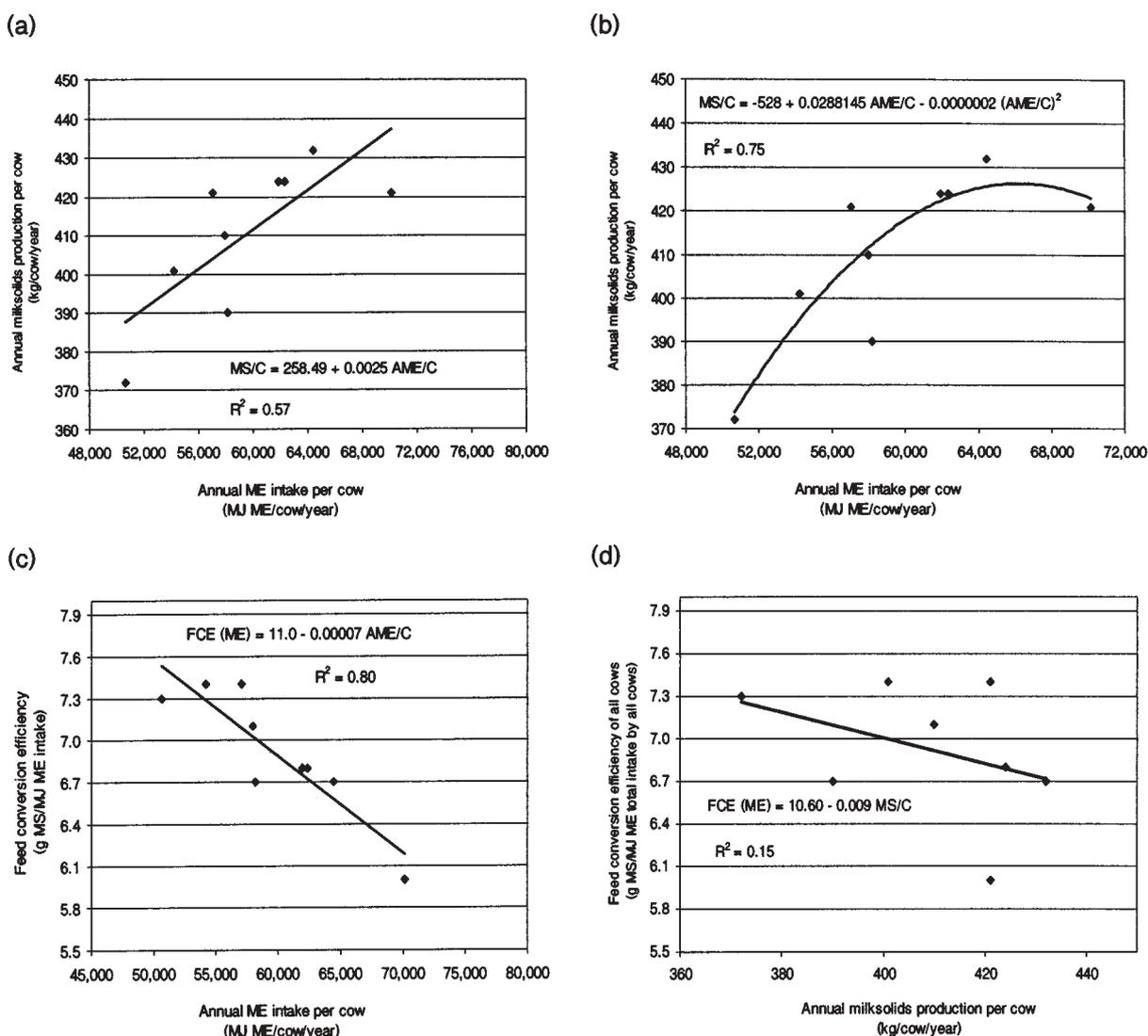
	Manawatu Case-study farms			Manawatu	Waikato	Taranaki
	Mean	Max	Min	Top 25%	Dexcel, 2002 Top 10%	Top 10%
Effective area	108	213	52	144	68	77
Herd size	287	570	148	381	216	231
Stocking rate	2.7	3.0	2.4	2.6	3.2	3.0
MS per ha	1,100	1,264	921	859	1,074	1,088
MS per cow	411	432	372	324	340	361

* Based on top 25% and 10% for payout adjusted economic farm surplus per hectare.

TABLE 2: Measured and theoretical feed conversion efficiency (FCE; g MS/MJ ME) and annual metabolisable energy intake per animal (MJ ME/cow/year), percentage of supplementary feed used from annual ME intake (%), annual milksolids production per cow (kg/cow/year) and per hectare (kg/ha/year) and stocking rate (SR, cows/ha), for farms of group one and group two.

Farm	FCE		ME intake		Supplement	Milksolids		SR
	Measured	Theoretical	Measured	Theoretical		per cow	per ha	
Group one								
6	6.0	8.2	70,135	51,197	26	421	1,002	2.4
2	6.7	7.9	58,166	48,936	23	390	921	2.4
3	6.7	8.1	64,424	53,137	25	432	1,155	2.7
1	6.8	7.7	62,367	54,725	27	424	1,135	2.7
5	6.8	7.9	61,924	53,094	21	424	1,206	2.8
Mean	6.6	7.9	63,403	52,218	24	418	1,084	2.6
Group two								
4	7.1	7.9	57,961	51,668	26	410	1,070	2.6
9	7.3	7.5	50,669	49,139	23	372	1,082	2.9
7	7.4	7.8	54,209	51,189	24	401	1,064	2.7
8	7.4	8.2	57,049	50,799	24	421	1,264	3.0
Mean	7.3	7.8	54,972	50,699	24	401	1,120	2.8
Overall mean	6.9	7.9	59,656	51,543	24	410	1,100	2.7

FIGURE 1: Regressions amongst the variables annual milksolids production per cow (MS/C) and annual ME intake per cow (AME/C) (a, b), feed conversion efficiency (FCE(ME)) and annual ME intake per cow (c), feed conversion efficiency and milksolids production per cow (d).



Factors associated with milk production and feed conversion efficiency

There was, as expected, a significant positive correlation across herds ($R^2 = 0.57$, $P < 0.05$) between ME intake per cow and annual milksolids production per cow (Figure 1a). The correlation was even higher for the quadratic regression (Figure 1b) between the same variables ($R^2 = 0.75$, $P < 0.05$). However, there was a significant negative correlation ($R^2 = 0.80$, $P < 0.01$) between ME intake per animal and feed conversion efficiency (Figure 1c). An unexpected negative correlation was also found between milksolids production per cow and feed conversion efficiency (Figure 1d), but it was not statistically significant ($R^2 = 0.15$, $P > 0.05$).

DISCUSSION

There were numerous uncontrolled sources of variation in this relatively small group of farms, and the sample size is small to draw general conclusions for dairy farms throughout New Zealand. However, analyses of commercial case-study farms reflect the trade-off between accuracy and reality (Yin, 1994).

Apparent pasture intake per cow was estimated as the

difference between adjusted estimates of pre- and post-grazing herbage mass (kg DM/ha) divided by grazing intensity (cows/ha/day), the simplest method to estimate intake at farm level. However, the difference between pre- and post-grazing herbage mass may not represent the amount of grass actually eaten by the animals, due to other causes of pasture disappearance (e.g., treading). Also, this method does not take into account daily pasture growth, which could lead to pasture intake underestimation. However, this was the only feasible technique for a project of this scale, with nine commercial dairy farms involving 974 effective hectares and 2,586 cows.

An additional source of error was associated with the method used to measure pre- and post-grazing herbage mass, in which eye assessment was adjusted to values of plate meter readings based on national standardised monthly calibration equations (Hainsworth, 1999).

Differences in ME intake between farms resulted in different milksolids production and feed conversion efficiencies (Table 2), however there was no difference in the proportion of supplementary feed used between farms of group one and group two. Measured annual

total metabolisable energy (ME) intake per animal was higher than theoretical annual ME requirements per animal by 21% and 8% for the farms in groups one and two, respectively (Table 2). It is possible that the on-farm techniques overestimated pasture intake, or wastage of feed offered could have occurred this suggests the need for a careful assessment of techniques used to monitor pasture and supplement intakes in case-study farms.

The farms from group two had the highest values of feed conversion efficiency and also the lowest ME intakes per animal (Table 2), which confirms the significant negative correlation between ME intakes and feed conversion efficiencies (Figure 1), but these farms also had lower annual milk solids production per cow than those in group one, which was probably related to lower lactation days per cow in group two (mean 247 days) than those in group one (mean 270 days). Farms of group one had the greatest difference between measured and theoretical ME intakes, possibly because measured ME intake was overestimated to a greater extent due to more wastage of feed offered, which could explain the differences in feed conversion efficiency between the two groups. The mean value of measured feed conversion efficiency from group one was 16% lower than the mean theoretical value for the same group, whereas the mean value of measured feed conversion efficiency was only 6% lower than the theoretical value for group two (Table 2). However, both groups had higher feed conversion efficiency than the mean values (5.7 to 6.3 g MS/MJ ME intake) of all treatments published by Penno (2001). Since feed waste was not measured, it was not possible to take this analysis further.

A significant negative correlation ($R^2 = 0.80$, $p < 0.01$) between annual ME intake per animal and feed conversion efficiency was observed (Figure 1c). Annual milk solids production per cow and feed conversion efficiency were also negatively correlated, contrary to expectations (Figure 1d), but this correlation was not statistically significant ($R^2 = 0.15$, $p > 0.05$). The quadratic regression (Figure 1b) describes a diminishing return curve, as shown by Broster & Thomas (1981), reflecting increased partitioning of ME intake into live weight instead of milk solids production. According to Broster & Thomas (1981), up to an intake of 100 MJ ME above maintenance, milk production is maintained at the expense of body tissue mobilisation and most of the energy ingested is used for this purpose; but higher intake results in live weight gain and less energy partitioned towards milk. However, the mean condition score throughout the year was similar for group one (4.4) and two (4.3), which is contradictory to the concept above. This could be explained by the fact that a random sample of cows representing only 25% of each herd was condition scored four times in the whole season and therefore, it is not possible to be conclusive about the condition score values. The decline in annual milk solids production per cow at high levels of annual ME intake (Figure 1b) is not realistic in biological terms. An asymptotic function would probably fit better the biological trend, but the sample size was too small to justify more complex analysis.

Despite the small sample size and the fact that the

measurements were taken across farms, there was a significant positive correlation ($R^2 = 0.57$, $p < 0.05$) between annual ME intake per cow and annual milk solids production per cow (Figure 1a). Caird & Holmes (1986) also demonstrated that total intake of grazing dairy cows was positively correlated to milk yield. The regression coefficient (which is a marginal response to extra feed, but limited by the fact that it was measured across farms) was equivalent to 2.5 g MS produced per MJ ME intake (Figure 1a), which was considerably smaller than 15 g MS/MJME theoretically possible if all the additional ME provided by feed were used directly for milk synthesis (Holmes *et al.*, 1987). It was also lower than the marginal responses reported by Penno (2001) (7.3 to 7.8 g MS/MJ ME intake) and gross efficiency in this study (Table 2). This value of 2.5 g MS produced per MJ ME intake can be interpreted to show a low response to the extra feed offered on the farms which achieved the higher yields per cow. Moreover, supplementary feed was used in the case-study farms to maintain the system's targets of average pasture cover and body condition score and may, therefore, not have shown an immediate effect on milk solids production.

The comparison with the industry data showed that the case-study farms can be classified as highly productive dairy systems in New Zealand. However, the system of achieving higher production per hectare through higher animal performance represents a new management strategy for these farmers, and there is still a need to improve management skills in order to improve efficiency of the whole system. The information analysed in this project shows that there is scope for further improvement in feed use efficiency, especially for the farms achieving the highest levels of animal performance, and this is likely to involve tighter control of feed inputs and feed wastage. A detailed financial analysis of the case-study farms was published by Salles (2002).

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of the Agricultural Marketing and Research Development Trust (AGMARDT), Massey University and New Zealand Official Development Assistance (NZODA), which provided the funding for this work. We are extremely grateful to all the farmers who supplied data and forage samples for this study. Special thanks to Fulton Hughes and Melissa Ercolin for their help in the project.

REFERENCES

- Broster, W. H.; Thomas, C. 1981: The influence of level and pattern of concentrate input on milk output. *In: Haresign, W. ed. Recent developments in ruminant nutrition*. London, Butterworth, pp 49-69
- Caird, L.; Holmes, W. 1986: The prediction of voluntary intake of grazing cows. *Journal of agricultural science* 107: 43-54.
- Corson, D.C.; Waghorn, G.C.; Ulyatt, N.M.J.; Lee, J. 1999 NZRS: Forage analysis and livestock feeding. *Proceedings of the New Zealand grassland association*, 61: 127-132.
- Hainsworth, R. 1999: Pasture assessment - talking the same language. *Farm advisor* 1: 18-19.
- Hodgson, J. 1990: Grazing management. Science into practice. Harlow: Longman Group UK Ltd.
- Hodgson, J.; Matthews, P. N. P.; Matthew, C.; Lucas, R. J. 1999: Pasture

- measurement. In: White, J.; Hodgson, J. ed. New Zealand Pasture and Crop Science. Auckland, Oxford University Press. pp 59-65
- Holmes, C. W.; Matthews, P. 2001: Feeding of conserved forage - implications to grassland management and production. *Proceedings of the XIX International Grassland Congress*, Sao Pedro, Brazil, pp. 671-677.
- Holmes, C. W.; Thomas, D.; Stantiall, J. 2000: The cow's feed requirements. *Proceedings of the conference on feeding dairy cows in pasture-based systems*, Palmerston North.
- Holmes, C. W.; Wilson, G. F.; Mackenzie, D. D. S.; Flux, D. S.; Brookes, I. M.; Davey, A. W. F. 1987: Milk production from pasture. Wellington, Butterworths of New Zealand Ltd.
- L'Huillier, P. J.; Thomson, N. A. 1988: Estimation of herbage mass in ryegrass/white clover dairy pastures. *Proceedings of the New Zealand Grassland Association* 49: 117-122
- Matthews, P. N. P. 1994: Grazing management strategies for dairy production. *Dairyfarming Annual* 46: 143-151
- Matthews, P. N. P. 1995: Grazing management principles and targets: a case study. *Dairyfarming Annual* 47: 171-174
- Matthews, P. N. P.; Harrington, K. C.; Hampton, J. G. 1999: Management of grazing systems. In: White J.; Hodgson, J. ed. New Zealand pasture and crop science. Auckland, Oxford University Press. pp 153-174
- Penno, J. W. 2001: The response by grazing dairy cows to supplementary feeds. PhD Thesis, Massey University, Palmerston North, New Zealand.
- Salles, P. V.; Shadbolt, N.M.; Matthews, P.N.P.; Hodgson, J.; Holmes, C.W. 2002: Physical and financial evaluation of a group of high producing dairy farms in New Zealand. MAppSc Thesis, Massey University, Palmerston North, New Zealand.
- Salles, P. V. 2002: Cost of production on New Zealand dairy farms; the impact of feed conversion efficiency and milk price. In: *2002 Australian Agribusiness Forum*. Available: <http://www.agrifood.info/Congress/2002/program.htm>.
- Yin, R. K. 1994: Case study research: design and methods. Thousand Oaks, Sage Publications Inc.