

An Ergonomic Evaluation of a Sample of Near New Domestic Kitchens in Christchurch

Paul N. Russell and Robyn N. Norton
University of Canterbury

To what extent do domestic kitchens currently built in New Zealand reflect ergonomic principles, and in particular those detailed in the relevant New Zealand Standard (NZS 4101)? Measures were taken, observations made, and housewives interviewed in 35 near new kitchens in Christchurch. Many deviations from the recommended standard and other aspects of good design were found. These included, siting which prevented the supervision from the kitchen of young children playing outdoors, layout which resulted in the working area being a traffic thoroughfare, dangerously positioned stoves, insufficient bench space between stove and sink, overly narrow benches, overly high over-bench cupboards, low levels of night-time illumination, no provision for rubbish disposal or the safe placement of electric heaters. Dwellings for which the Housing Corporation provided mortgage finance contained at least as many deviations from recommendations as other dwellings, ownership flats appeared of inferior design.

Ergonomics, or Human Factors as it is known in North America, is concerned with the design of the work place. It aims to optimize human performance, increase efficiency, reduce errors, accidents, strain, and fatigue by ensuring that the work task, tools, and environment are comfortably concordant with human psychological, anatomical, and physiological capability. It employs basic knowledge of human sensory, perceptual, and cognitive functioning derived from experimental psychology, together with anthropometric data about the physical stature of people and their strengths, and relevant medical and physiological knowledge. While it has experienced wide application in military and industrial contexts there has been little awareness until recently that the same principles and knowledge have application in the home, and in particular the kitchen, which after all, is the work place of the largest single group in our society. Studies have revealed that housewives in both Europe and the U.S. spend some 16 hours per week, that is almost half the 40 hour week of the industrial work place, preparing, cooking, and cleaning-up after meals (Grandjean, 1973; Vanek, 1974).

Many ergonomic considerations relevant to kitchen design have been incorporated into recent recommended standards for building construction. The International Organization for Standardization (1978) has outlined a number of general

The data reported were collected by Robyn N. Norton as part of an M.A. Thesis submitted to the University of Canterbury.

Requests for offprints should be addressed to Paul N. Russell, Department of Psychology, University of Canterbury, Christchurch 1, New Zealand.

provisions which it considers ought to be included in national standards. These include:

- (a) Work heights for food preparation and cleaning up areas which can be adjusted to suit the physical stature of the housewife and presumably altered at the time of occupancy changes. The present practice in New Zealand is for a nationally uniform height based on the height of the average woman to be installed in all dwellings with consequent muscular strain and discomfort and added work effort for as many as 50 percent of women who happen to be either in the tallest or shortest 25 percent of the population (Hoag & Van Dyke, 1975; Ward, 1971). Adjustable fitments are apparently available in Scandinavia (Ward, 1971).
- (b) Concerns for safety by requiring that there be uninterrupted access from the stove to the sink over a work surface (avoid burns etc), by placing cookers away from corners (so that saucepan handles do not protrude) and windows (fire risk from wind blown curtains), non-tipping drawers, shelves, and trays, special provision for the storage of poisonous substances and dangerous utensils, and sufficient space in front of work areas and doors to lessen collisions and the likelihood of falls.
- (c) Concerns for efficient work flow by providing storage of utensils and materials near their place of use, sufficient work surfaces arranged in logical sequence with respect to the work flow, heat resistant surfaces, surfaces which can be easily cleaned, and adequate heat and humidity control.

Many of these recommendations are incorporated in a New Zealand standard (NZS 4101) the stated purpose of which is to "provide manufacturers, kitchen planners, builders, joiners and kitchen users with guidelines for co-ordination of

dimensions for components of kitchen fittings such as storage units, work tops, sinks and appliances" (p.5).

To what extent are international recommendations based on ergonomic and safety considerations, and in many cases incorporated into the relevant local standard (NZS 4101), manifest in new kitchens in this country? We sought a partial answer to this question. Additionally the present study sought to:

- (a) Assess the influence of owner involvement in kitchen design by comparing those where owners were not involved with those where kitchen design was arrived at by consultation between owner and builder or owner and architect.
- (b) To compare ownership flats and houses since the former is increasing in popularity and may be the only type of housing within the financial resources of many New Zealand families.
- (c) To assess the role of the Housing Corporation in fostering good kitchen design.

Method

Measures of various physical characteristics of kitchens, observations, and interviews (a standard structured interview was used) with housewives from 35 dwellings (an additional 7 refused to participate) in the Christchurch region were completed. These were selected from seven localities designated by the Waimairi County and Christchurch City Councils as new housing areas. Four houses and one ownership flat were included from each area. Data were collected between June and October 1977. All dwellings were less than 10 years old, all but three were less than 6 years old. Full details are given in Norton (1978).

Results and Discussion

In what follows dwelling refers to the generic class including both house and ownership flat. Unless stated otherwise it is to be assumed that the trends noted apply equally to kitchens in which owners did and did not have design involvement, those financed by the Housing Corporation, and to houses and ownership flats.

Biographical Details

Demographic data. These are included to give an indication of sample characteristics. Five housewives were within the age range 20-24 years, 8 within 25-29, 11 within 30-34, 2 within 35-39, and 9 were over 39 years. In all, 15 two-person, 7 three-person, 10 four-person, and 3 five-person households were encountered. Children ranged in age from less than 1 year to 13 years, median 4 years. Whereas young married women without children worked almost none over the age of 39 without children were employed. None with preschool children worked full-time. A few with preschool and school age children were in part-time employment. Occupational status of husband (Elley & Irving, 1976) ranged from 1 to 5 with a mean of 3.3. *Mortgage finance.* Of the 35 dwellings, 28 were

mortgaged (5 freehold, 2 rented) and of these 16 were financed by the Housing Corporation and 8 by Savings Banks (almost all by the Canterbury Savings Bank).

Owner involvement. Of the 35 dwellings, 5 were not classified according to involvement (second owners, rented, altered). Of the remaining 30, owners had no involvement in the case of 18 dwellings, and at least some for 12. Almost without exception owners gaining finance from the Housing Corporation or occupying ownership flats were not involved in the design of their kitchen.

Kitchen characteristics

Location. Since the kitchen is a high use room it is generally recommended that it should receive some sun (preferably in the morning), be in close proximity to an outside entrance, adjacent to dining areas, and permit the supervision of young children playing in the living or play area or outdoors (Carpenter & King, 1974; Grandjean, 1973). Thirty-one of the surveyed kitchens were in close proximity to an outside entrance, and all dining areas were either in or adjacent to the kitchen. However, almost half the kitchens faced a sunless south, although this evoked only two complaints in interview. It was possible to supervise the outdoor play activities of children from only half of the kitchens.

Kitchen area. The minimum permissible kitchen area in New Zealand is 4 m² (NZS 1900 Model Building By-Law). All surveyed were at least of this area. The minimum areas recommended by Grandjean (1973) and based on kitchen use patterns in several European countries for four-person families are 12 m² and 8 m² respectively for kitchens with and without a dining alcove. By these standards only half were of adequate area (only 1 of 7 ownership flats) although few complaints regarding area were elicited during interview but several commented that kitchens were too small to house a freezer. Perhaps kitchen use patterns in New Zealand are different from those in Europe or housewives here have become accustomed to and expect a small kitchen.

Internal layout. Ideally, kitchen layout should be organized around four work centres; a preparation centre for mixing and storage, a cooking centre, a serving centre, and the sink centre (Carpenter & King, 1974; Grandjean, 1973; NZS 4101). Studies of kitchen work flow indicate that a left to right sequence of sink, main working surface, stove, and storage area is most convenient for right handed persons. It reduces walking and transportation (Grandjean, 1973). In particular the sink and stove should be located so that hot objects do not have to be transported across open floor space for access to the sink and heat resistant bench surfaces. In only two of the kitchens surveyed were the sink and stove opposite each other.

Adequacy of kitchen layout, work surface area and general space is frequently assessed by measuring the perimeter and side of the triangle joining the sink, stove, and fridge. This is known as the *work triangle*. Distances recommended by the Standards Association (NZS 4101) are: between stove and sink 1.2-1.8 m, sink and fridge 1.2-2.1 m, stove and fridge 1.2-2.7 m, giving a perimeter of 3.6-6.6 m (Grandjean, 1973, suggests a maximum of 7-8 m). The work triangle perimeters of 23 of the 30 kitchens for which measures were recorded (this measure was included after 5 dwellings had been surveyed) were within the range recommended in the Standard. However, individual distances deviated more noticeably. Only half the fridge to sink, and sink to stove distances were within the suggested ranges, the fridge to sink distances being equally divided between those which were too great and those which were too small while sink to stove distances were too small in 13 of the 15 cases which were outside the Standard. The sink to stove distance is particularly important for an overly small separation implies insufficient bench space on which to place items removed from the oven or cooking elements, a problem also noted in a survey of kitchens in Auckland (Reynolds & Bonny, 1976). Fridge to stove distances more closely conformed to the range recommended in the Standard with all but 1 of the 11 which were outside the recommended range being too small.

The Standards Association (NZS 4101) recommends that kitchen layout and the positioning of doors should result in a work area uninterrupted by general household traffic. This was true of only 14 of the 35 kitchens, although only 7 housewives indicated in the interview that traffic flow was a problem for them. In 13 of the 35 kitchens it was not possible to pass through a traffic way leading out of the kitchen if the oven door was open or if someone was standing at the stove. This was true of 6 of the 7 ownership flats, and of half of the dwellings designed without owner involvement.

Work centres. Bench width is determined by the extent of arm reach, the undesirability of a protruding fridge or stove, and the need for adequate surface area. The Standards Association suggests widths in the range 500-600 mm for sink and preparation centres, extended up to 750 mm where the bench is used for appliance storage. Sink bench widths ranged from 462 to 600 mm with only 14 of the 35 within the recommended range. Fourteen of the 22 dwellings with a separate preparation area had bench widths within the suggested range but 5 of the 8 outside the range were in dwellings financed by the Housing Corporation and 6 of the 8 were designed without owner involvement. Bench widths of 12 of the 16 kitchens with separate serving areas were within the recommended range. These results suggest that sink bench units presently

available in New Zealand may frequently be slightly narrower than recommended by the Standards Association. While the widths of other benches were more likely to conform to local standards, almost all were narrower than the minimum width of 600 mm suggested by Grandjean (1973).

The Standards Association (NZS 4101) gives separate recommended ranges for the lengths of the sink bench, food and preparation area, and areas abutting the stove. However, because a single area was frequently used for more than one function, the total bench length available was measured and compared with a length range derived by summing lengths recommended in the Standard. Two-thirds of the benches exceeded the 3.2 m derived minimum although only 2 of the 7 ownership flats contained at least this length of bench. Only 8 of the 35 women interviewed mentioned lack of bench space as a problem, contrary to Reynolds and Bonny (1976) who report insufficient bench space to be a common complaint in Auckland. A complete assessment of work surface provisions would require that bench space be considered in relation to the placement of stove, sink, and storage areas, a task which was beyond the scope of the present research.

Bench height poses an ergonomic dilemma. Research suggests that optimal height depends upon the height of the user and the task performed (Hoag & Van Dyke, 1975; Ward, 1971). While it may be possible to adjust bench height to suit the stature of the predominant user in the household, step variations in the heights of adjacent benches create their own difficulties. The Standards Association (NZS 4101) recommends some variation in work surface heights. This was not found in any kitchen surveyed. Thirty-four of the 35 had benches within the 850-900 mm height range suggested in the Standard for food preparation surfaces. In 30, bench height was set at 900 mm that regarded as the best compromise height for a uniform non adjustable surface by Grandjean (1973). Virtually no sink benches were set at the 950 to 1000 mm height suggested by the Standards Association (NZS 4101). Benches were level with the stove top in 33 of the 35 dwellings.

Cupboards and storage. While it is difficult to assess storage needs, certain guidelines are available (Carpenter & King, 1974; Grandjean, 1973; NZS 4101).

Most authorities recommend that the position of shelves within cupboards be adjustable to suit the stature and storage needs of the user (e.g. Grandjean, 1973; NZS 4101). No adjustable shelves were found in any kitchen surveyed, and half the housewives commented during the interview that cupboards were not related to their height.

Over-bench cupboards need to be placed so that

work surface operations are not obstructed by the cupboards yet so arranged that objects stored therein remain readily accessible. The Standards Association (NZS 4101) recommends that cupboards be 300-450 mm above the bench. Relevant measures were made in 28 kitchens. The bench to cupboard clearances ranged from 300 to 800 mm, with two thirds exceeding the range recommended. It is to be noted that Grandjean (1973) recommends a wider clearance of 400-500 mm which may be necessary with the wider bench widths also recommended by him. Even so, nearly half the cupboards were more than 500 mm above the bench. The implication is that much useful storage space in many New Zealand kitchens may be lost because over-bench cupboards are placed at a greater height than is necessary.

Over-bench cupboards are likely to obstruct bench use if they are too wide, and thus protrude too far over the bench. Therefore, their width needs to be in relation to bench width and also to take cognizance of the fact that we have limited reach into higher cupboards. The Standards Association suggests widths of 300-500 mm. The shelves in 20 of the 28 kitchens measured were within this range, a few were overly deep. The Standard makes no recommendation regarding the length of over-bench cupboards required. Only six housewives indicated that they required additional storage space, contrary to the findings of an Auckland survey (Reynolds & Bonny, 1976).

The Standards Association (NZS 4101) recommends that at least 1.8 m of below bench cupboards be provided and that shelf widths be in the range 500-600 mm. Twenty-nine of the 30 dwellings for which measures were taken had at least 1.8 m of below bench cupboards (the exception was an ownership flat), but in only 4 dwellings were all shelves of the recommended widths, a consequence of overly narrow benches as already noted.

Lighting. Night time illuminance readings were recorded using a Toshiba Photocell Illuminometer at the preparation, sink, and stove work centres. The recommended level for these areas is 200-300 lux (NZS 4101). Readings ranged from less than 10 to over 1000 lux. Only 9 had illuminance levels greater than the minimum of 200 lux at the preparation centre, 5 at the stove, and 7 at the sink. Like the recently surveyed Auckland kitchens (Reynolds & Bonny, 1976) the majority, two thirds in the present study, were illuminated by a single central luminaire which no doubt resulted in housewives working in their own shadow. It is generally regarded that such a source is suitable for background lighting only and that ideally work centres should be provided with separate light sources (Grandjean, 1973). Despite the overall poor levels of illumination, three quarters of the sample regarded their night-time illumination levels as satisfactory.

Sundry provisions. Two-thirds of the kitchens had provision for some form of heating, the remainder relying on heat filtering from adjacent living areas. Of those with heating, 12 used electric heaters, but little provision was made for their safe placement. They were typically placed beside a table, bench, stove, or beneath a window. Likewise, less than a third provided a place near the stove for the storage of pot holders and oven clothes. Space for kitchen tidies and rubbish disposal was also limited. Twelve used kitchen tidies which were generally free standing in front of a bench or cupboard or even the refrigerator, 4 used paper bags attached to the inside of a cupboard door, the remaining 19 had no provision in the kitchen for disposal of refuse taking it outdoors or to the laundry to the awaiting council bag. Over three-quarters of the kitchens had at least two power outlets in addition to the two on the stove.

Conclusions

Most kitchens in the study appeared to provide a reasonable amount of working and storage space and with the exception of two in which the stove and sink were opposite each other, avoided gross flaws in their layout. Nevertheless, many instances were found in which kitchens deviated from recommendations made by the Standards Association of New Zealand (NZS 4101) and internationally recommended aspects of design. In particular, many kitchens were found to be sunless, not to permit the supervision of children playing outdoors, be small by overseas standards, have insufficient bench space between stove and sink, serve as a traffic thoroughfare, have a stove placed such that it obstructed an entranceway, have overly narrow sink bench units and below bench cupboards, have over-bench cupboards which were placed too high, have poor night-time illumination, lack safe provision for the placement of an electric heater, lack facilities for rubbish disposal, and a place for oven clothes.

The relevant New Zealand Standards (NZS 4101) is in the form of a set of recommendations and the law of the land does not require that the provisions contained in it be included in new dwellings. The purpose of the Standard is merely to provide guidelines for builders, architects, kitchen planners, and manufacturers of fittings and appliances. Results indicate that in Christchurch at least, builders and others involved in the construction of dwellings are either unfamiliar with the Standard, or choose not to implement its suggestions. Cost is no doubt a consideration although it is not obvious that rearrangement of a kitchen at the time of planning to permit better placement of the stove, lowering the height of cupboards, allowing for shelf adjustment, increasing bench width, making provisions for heaters, a kitchen tidy, rubbish disposal and oven clothes, and even addi-

tional light sources would incur large additional costs, unless some are themselves manifestations of insufficient kitchen area. Should attempts be made to inform builders and relevant others of the Standard and other sources (e.g. Carpenter & King, 1974) giving details of good kitchen design? Should there be some enforcement by bodies granting building permits (or other body) of the provisions of the Standard? In that some affect safety, perhaps there should.

Dwellings for which the Housing Corporation was the mortgagor contained at least as many deviations from the recommendations of the Standards Association and principles of good design as other dwellings. By lending on dwellings which deviate from the recommendations of the Standards Association this State agency could appear to be in the position of condoning poor design rather than protecting the interests of New Zealanders and their safety by encouraging observance of the Standard. Should the Housing Corporation vet plans and approve finance only for dwellings with adequate kitchen design? There were several indications that ownership flats offered an inferior standard of kitchen design. Do they constitute a suitable and safe environment for young children or are kitchen related accidents more likely in their generally smaller kitchens? Clearly more research is needed to answer these questions but in the meantime many sensible

recommendations of the Standards Association appear to receive scant observance.

References

- Carpenter, E.E., & King, J.M. *Kitchen planning* (Third edition). Dunedin, NZ: Department of University Extension, University of Otago, 1974.
- Elley, W.B., & Irving, J.C. Revised socio-economic index for New Zealand. *New Zealand Journal of Educational Studies*, 1976, 11, 25-36.
- Grandjean, E. *Ergonomics of the home*. London: Taylor & Francis, 1973.
- Hoag, L., & Van Dyke, R. A human factors evaluation of the American Kitchen. *Proceedings of Human Factors Society*, 19th Annual Meeting, Dallas, 1975.
- International Organization for Standardization. *Bulletin*, 1978, 9 (3).
- Norton, R.N. *An ergonomic evaluation of kitchen design in New Zealand*. Unpublished Masters Thesis, University of Canterbury, Christchurch, 1978.
- Reynolds, M., & Bonny, S. *Woman's world: Houses and suburbs*, Society for Research on women in New Zealand (Inc.) Auckland, NZ: The Pelorous Press, 1976.
- Standards Association of New Zealand. Recommendation for space provision for fittings, appliances and storage in domestic kitchens. Wellington, N.Z.: 1974, (NZS 4101).
- Vanek, J. Time spent in housework. *Scientific American*, 1974, 231, 116-120.
- Ward, J.S. Ergonomic techniques in the design of optimum work surface heights. *Applied Ergonomics*, 1971, 2, 171-177.