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Open sesame: exploring the 'openability' of hospital food and beverage packaging for the over 65s

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OPEN SESAME: EXPLORING THE 'OPENABILITY' OF HOSPITAL FOOD AND BEVERAGE PACKAGING FOR THE OVER 65s

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CERTIFICATION

I, Alison Fay Bell declare that this thesis, submitted in fulfilment of the requirements of the award of Doctor of Philosophy in the School of Medicine, University of Wollongong, is my own work unless otherwise referenced or acknowledged. This document has not been submitted in whole, or in part, for qualifications at any other academic institution.

Alison Fay Bell

2 December 2015

Date

DEDICATION

To my husband, Robert Edgar and our two wonderful children, Elizabeth and Callum - thank you for your years of patience and support throughout my quest for further knowledge.

In memory of my fabulous father, Reg Bell, Participant 1, Study 1 of this thesis, whose life journey ended during my PhD. Your unwavering belief in me, support and love, combined with the value of hard work and commitment, equipped me to complete this endeavour.

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PUBLICATIONS

Peer reviewed journal publications in support of this thesis

Pilot Study

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Bell, A., Walton, K. & Tapsell, L. (2015). *Water water everywhere and not a drop to drink: the challenge of bottled water provision to older users in hospitals.* In G. Lindgaard & D. Moore (Eds.), *Proceedings 19th Triennial Congress of the IEA, (pp. 1-2),* Melbourne Australia: International Ergonomics Association.

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ADL	Activities of Daily Living
ASHT	American Society of Hand Therapists
BAPEN	British Association for Parenteral and Enteral Nutrition
CEN	European Committee for Standardisation
GDP	Gross Domestic Product
g	Grams
HFE	Human Factors and Ergonomics
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardisation
kg	Kilograms
kJ	Kilojoules
lb	Pounds
MNA®	Mini Nutritional Assessment®
MNA-SF®	Mini Nutritional Assessment – Short Form®
NHS	National Health Service
NSW	New South Wales
PCA	Packaging Council of Australia
PEU	Protein Energy Under-nutrition
SIS	Swedish Institute for Standards
TS	Technical Specification
UK	United Kingdom
UN	United Nations
US	United States
WW2	World War II

GLOSSARY OF TERMS

Affordance	'An object's utilitarian function: the object tells the user how to interact with it' (Gibson, 1979).
Ergonomics	The application 'of human behaviour, abilities, limitations and other characteristics to the design of tools, machines, systems, tasks, jobs and environments for productive, safe, comfortable and effective human use' (Salvendy, 2012).
Openability	Pack ease of opening
Packaging	'All products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer.' (Packaging Council of Australia, 2005).
PE Undernutrition	'A clinical syndrome characterised by weight loss associated with significant depletion of fat stores and muscle mass.' The Australia and New Zealand Society of Geriatric Medicine [1]
Sarcopenia	Loss of skeletal muscle mass and strength associated with ageing (Bonder, 2009, p. 136).
Sociotechnical system	'Organisations that are….directly dependent on their material means and resources for their outputs. Their core interface consists of the relations between a nonhuman system and a human system.' (Trist, 1981).
Universal design	Design that is'..flexible enough to be usable by people with no limitations as well as those with functional limitations related to disabilities or due to circumstances.' (Fisk, Rogers, et al., 2009, p. 30). Also known as 'inclusive design', 'design for all.'

Usability	‘Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.’ (ISO 9241-11; 1998). Is most often used in the context of human-computer interaction but is applicable across all interactions with tools, equipment and products.

ABSTRACT

The world population is ageing rapidly. Increased life expectancy and reduced birth rates have resulted in a greater proportion of older adults (65+ years) within today's society. The forecast for Australia is that 24% of our population will be over 65 by 2051 [2]. The Report of the Special Commission of Inquiry into Acute Care Services in NSW Public Hospitals states that NSW public hospitals have 17,000 people in a hospital bed each day and 7,480 of these people are aged over 65 years, representing 44% of hospital inpatients [3]. With the projected growth in numbers of people over 65 years and the corresponding growth in the 'older old' and their complex and chronic health conditions, most hospital patients in the future will be 'older'.

The report also discussed the provision of food and food services in NSW hospitals and the move towards centralization of production with the 'cook-chill' system whereby food is pre prepared and then kept chilled in a refrigeration system at the hospital and then heated in customized trolleys on the ward. The report states: *'For reasons unexplainable, it seems that instead of treating food as part of the clinical aspect of a patient's stay; hospital administrators have treated it as an ancillary service, often provided by external service providers* [4].' This form of food provision signals the permanent use of packaged foods, and has been found to be difficult for patients and nursing staff to open [5].

My central hypothesis is that receiving and accessing food in the hospital context is problematic for the older inpatient. 'Food as medicine' is an important concept. Many older people enter hospital in a state of malnutrition, or are 'at risk' of malnutrition and several studies have found that they leave hospital in a worse state than when they entered [6]. Food in hospitals needs to be nourishing, appealing and accessible to all the patients to encourage them to eat and take in valuable nutrition to aid in their recovery from illness. Access to food must consider the total picture – the environment in which it is served, the posture of the patient and their ability to actually access the food product to harness its nutritional value.

For feasibility reasons, older community dwelling adults participated in the research involving hospital food packs. The thesis used an ergonomics approach to examine the interface of the well, community dwelling older person with hospital food and beverage package and its context of use. As the pilot study [5] within a hospital environment had established that food and beverage packaging served in hospital presented challenges to older inpatients, it was decided to explore the issue in

depth with well older people through a series of three studies. Hand function measured through grip strength, pinch strength, and dexterity and satisfaction with pack performance measured using a questionnaire. Efficiency of pack opening was also measured with time and attempts captured through video recording. Context of use was assessed by measuring hand function and efficiency of pack opening in two postures, sitting in a chair and lying down in a hospital bed. The important nutritional aspect of packaged food and beverages was captured through a comparison of dietary intake when packaging was presented as pre-opened or sealed. The studies were conducted in the community (Study 1) and a simulated hospital laboratory (Studies 2 and 3). The research used an integrated methodology and was iterative and inductive, with each study informing the next. Study 1 assessed the complete range of hospital food and beverage packs with older people in the community setting, measuring grip and pinch strength; time and attempts to open the pack; as well as overall satisfaction with the pack. Study 2 expanded the research to include patient dexterity and the environmental context of the hospital environment, lying in a hospital bed. Study 3 again built upon the research by including grip, pinch strength, dexterity, time and attempts to open packs, satisfaction with packs, measurement of nutritional status and actual dietary intake when packs were served pre-opened and sealed.

The studies consistently demonstrated difficulties with many pack types, in particular water bottles, tetra packs, cheese portions, biscuit packs and fruit cups. Grip strength was associated with efficient and successful opening of water bottles. Pinch strength was associated with efficient opening of biscuit packs. However, the most important aspect of hand function in pack openability was found to be dexterity. This is significant as pack design and assessment of packs for ease of opening use strength as the core parameter.

Greater dexterity and pinch strength could be exerted by participants in the seated posture while grip strength was consistent between sitting in a chair and lying in a semi-recumbent hospital bed posture. While some differences were found between the postures for pack opening times, overall there were no significant differences, indicating that the packs were difficult to open regardless of the posture.

Several participants in the dietary intake study (Study 3) were found to be ‘at risk’ of malnutrition. Sealed packaging had a strong negative effect on the dietary intake of these people for the breakfast and snack meals. This has implications for the use of packaged food and beverage items in hospital

and other care environments. A large hospital based study is indicated to examine the impact of packaging on intake in this vulnerable group.

Finally, the data from studies 1 and 2 was used to explore the relationship between dexterity and time taken to open packs in order to determine an alternate method of rating packaging. As dexterity is the key component of hand function in efficient pack opening, this novel approach would assist in appropriate pack design and selection.

Older people are an increasing proportion of the population and designing products and services that meet their needs is critical. This research demonstrates that food and beverage packaging poses challenges for well older users. This has direct implications for *unwell* older users in hospital where the food service delivery system must be able to deliver 'food as medicine.' It also highlights that older consumers generally experience challenges with packaging and this challenge stems from the pack relying on dexterity to open. Packaging designers and manufacturers should implement a universal design approach that is inclusive and addresses the capabilities of the whole population.

CHAPTER 1 INTRODUCTION AND AIMS

1.1 INTRODUCTION

The genesis of this PhD was an exploratory study in Illawarra hospitals reviewing the use of food and beverage packaging in public hospital food service [5]. The findings indicated real issues for older patients, many of whom had difficulty opening and accessing their packaged food and beverage items. In this thesis, well older adults were the research participants as conducting the studies in hospitals was impractical due to the patients being unwell with fluctuating medical conditions, and/or unavailable due to medical intervention or discharge from hospital. The thesis examines the person/pack interaction with well older adults in community and simulated hospital settings using an ergonomics approach.

The focus on older adults is relevant as the world population is ageing rapidly. Increased life expectancy and reduced birth rates have resulted in a greater proportion of older adults (65+ years) within today's society. In 1950 the population of over 65's Worldwide was estimated at 200 million, increasing to 486 million by 2006 and is estimated to be approximately over 1.5 billion by 2050 [7]. The forecast for Australia is that 24% of our population will be over 65 years by 2051 [2]. Importantly, significant changes in the older population will occur with the numbers of 'oldest' old (over 85 years) changing rapidly. In the UK, for example, it is estimated that by 2031 there will be twice as many females over 85 years old as now and over three times as many males over 85 years. Further, whilst medical and social progress has enabled this increase in longevity the likelihood of living with some form of chronic illness or disability is significant and prolonged. The prevalence of disability from the US Census in 2005 demonstrates that for individuals over 75 years the proportion of people who need assistance is 55.9%, rising to 71% for those 80 and over [8].

The Report of the Special Commission of Inquiry into Acute Care Services in NSW Public Hospitals [3] states that NSW public hospitals have 17,000 people in a hospital bed each day and 7,480 of these people are aged over 65 years, representing 44% of hospital inpatients. With the projected growth in numbers of people over 65 years and the corresponding growth in the 'older old' and their complex and chronic health conditions, most hospital patients in the future will be 'elderly' (65 years and over). The report also discussed the changes in both provision of food and food services in NSW hospitals and the move towards centralisation of production with the 'cook-chill' system whereby food is pre prepared, rapidly chilled to below 3°C and stored, before retherming for later food service to the ward [9]. This form of food provision signals the permanent use of packaged foods

which can be difficult for patients and nursing staff to open [5]. Further, this report, [4] specifically raised the issues of food and beverage packaging for patients and highlighted that NSW Health must address the opening of packages as well as the overall appeal of food.

The provision of food in hospital is traditionally a basic function of medical care, although this may not always be apparent. The link between food and medicine has its base in The Hippocratic Corpus: 'I will apply dietetic measures for the benefit of the sick according to my ability and judgement; I will keep them from harm and injustice'[10]. The reality for many older patients is that they enter hospital in a state of malnutrition, or are 'at risk' of malnutrition and several studies have found that they leave hospital in a worse state than when they entered [6]. If this is the case, then the medical system is failing our older citizens in a fundamental way. Food in hospitals needs to be nourishing, appealing and accessible to all the patients to encourage them to eat and take in valuable nutrition to aid in their recovery from illness. Access to food must consider the total picture – the environment in which it is served, the patient's appetite and nutritional status, the posture of the patient and their ability to actually access the food product to harness its nutritional value.

The drivers for the increasing use of packaging in food and beverages in hospitals is attributed to an intention to reduce the cost of food provision, meet food hygiene standards, maximise the longevity of the product and the ease of transporting it [11]. However, it appears that this same packaging may in fact be contributing to food waste and malnutrition among patients.

This thesis utilises an ergonomics framework to address the problem under study. As such it examines the **person**, the **pack**, the **task** (opening) and the **context** in which the interaction takes place. Ergonomics as a discipline examines the capacities and limitations of people (physical, cognitive and social) and their interaction with products, sociotechnical systems and environments in which they undertake tasks. Design is at the heart of Ergonomics. Well-designed products, systems and environments maximise the person's capacities and enable effective and efficient task performance.

The pilot research [5] for the studies in this thesis set the foundation and is conceptualised in the model illustrated in Figure 1.1. This model was developed by the PhD candidate to provide context for the issue under study in this thesis. The hospital, a sociotechnical system, provided the broader context for addressing the issue of package openability by the older adult inpatients. This

sociotechnical system has the input of ill health and the output of recovery and improved health for the patient. The food service delivery system is a sub-system within the model.

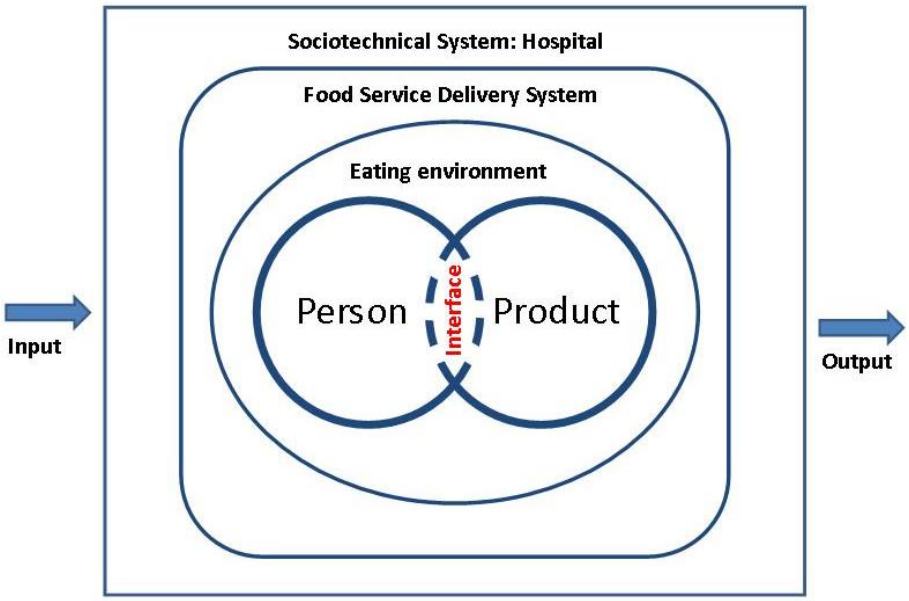

Figure 1.1 Schematic Diagram of the Ergonomics framework applied in the thesis.

Many factors can influence the recovery outcomes of the hospital sociotechnical system outlined in this thesis model. Such factors include patient personal variables (e.g pre-exisitng medical conditions and co-morbidities; socio-economic background); insufficient resources within the hospital system to effectively manage patient needs; and the socio-political environment affecting hospital operations,. While these factors are acknowledged, this research focuses on the sub system of food service within the system and its role in the provision of food to the older adult.

This thesis addresses the ergonomics framework as it relates to food consumption in older adults. The empirical component examines the four central components of the larger model in Figure 1.1, reviewing aspects of the **person**, the food and beverage **pack**, the interface (the **task** of opening the pack) and **context** (posture in hospital setting: bed/chair). Figure 1.2 demonstrates the conceptual model for the studies conducted in this thesis.

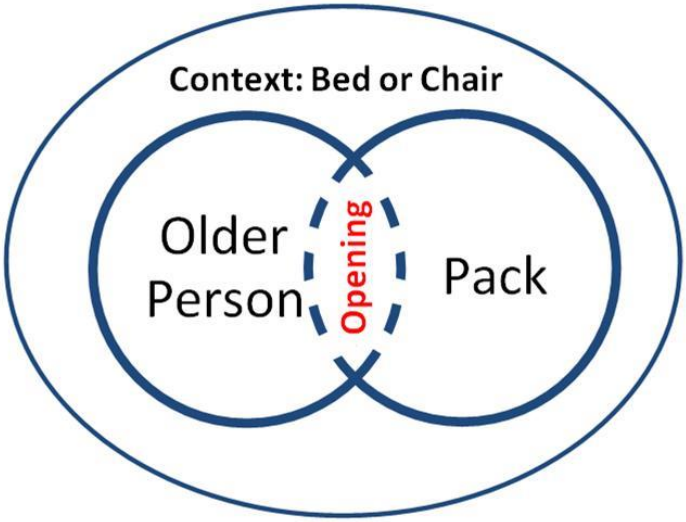

Figure 1.2 Thesis conceptual model of Older **Person: Pack** interface/**task** (opening pack) and **context** of use (posture)

The research in the thesis addresses the components of the thesis model by examining the food and beverage packaging used in hospitals with well older people in community and simulated hospital settings. This was done by measuring the time taken for well older people (independently community living aged over 65 years) to open hospital food and beverage items. Grip strength, pinch strength and dexterity were measured as well as reviewing the environmental effect of being in a semi-recumbent hospital bed posture on these physical abilities. Additionally, the effect of packaging on intake was examined in a simulated hospital/laboratory study. Neither vision nor cognition was measured as part of the consideration of the human-package interface; rather this area is intended for post-doctoral studies.

This thesis is presented as a 'Thesis by Compilation.' Chapter 2 contains the literature review, Chapter 3 the methods, and the individual studies are presented as journal articles in Chapters 4, 5 and 6. Chapter 7 outlines the development of a review system for packaging based on research findings from the three studies. Chapter 8 summarises the findings of the total research effort and proposes recommendations and areas for future research.

1.2 HYPOTHESIS

Hospitals are complex sociotechnical systems with many interwoven sub systems that include a Food Service System. Malnutrition in hospitals among older inpatients is well documented and encouraging adequate nutritional intake is essential for recovery. My central hypothesis is that receiving and accessing food in the hospital context is problematic for the older inpatient. My previous research found packaging presents a barrier to achieving and maintaining optimal nutritional status for these patients.

The focus of the research is to explore the person-pack interaction of older people (users) with food and beverage packs used by NSW hospital food services.

The sub-hypotheses of this thesis are:

- Hand strength (grip and pinch) is necessary for efficient pack opening
- Dexterity is necessary for efficient pack opening
- Laying in a hospital bed will increase the time and difficulty in opening packs
- Different pack mode of opening will determine hand function requirements
- Sealed packaging will impede intake.

1.3 AIMS OF THE RESEARCH

The broad aim of this research was to investigate the relationship of the older adult's hand strength and dexterity to the 'openability' of regularly used hospital food and beverage packaging, as well as exploring user views of the packaging. These findings can then be used to inform better package choice and design features for older users.

Specific aims are to:

- Quantify the time taken and ability to open the range of hospital food and beverage packaging by well older adults (Chapter 4, 5, 6)
- Identify the most 'difficult' packaging types (Chapter 4)
- Investigate the relationship between hand and pinch strength and the ability to open the packaging (Chapters 4, 5, 6)
- Investigate the relationship between dexterity and the ability to open the packaging (Chapters 5, 6)
- Determine user satisfaction with ease of pack opening (Chapters 4, 5, 6)

- Investigate the relationship between posture (lying in a hospital bed vs. sitting out of bed) with hand strength, dexterity and the time to open 'difficult' packaging (Chapter 5)
- Determine the relationship between nutritional status and food intake in a sample of well older people within a simulated hospital setting, when hospital food and beverages are presented with the packs either sealed or pre-opened (Chapter 6)
- Determine the significance of dexterity as a primary factor in openability (Chapter 7)

The broad context of this research is provided by describing ergonomics as well as reviewing the sociotechnical hospital system and sub-system of food service. Chapter 2 outlines these foundations and further details the four key topics under investigation in this thesis: the **person**, the **pack**, the interface/ **task** and **context** of use.

The key research questions are:

1. Do well older people experience difficulties with opening hospital food and beverage packages; and is hand strength the critical factor for efficient pack opening?
2. Is dexterity the critical factor for efficient opening of 'problematic' hospital food and beverage packs; and does lying in a semi-recumbent bed posture impede pack openability?
3. Does sealed packaging inhibit dietary intake in a sample of well older people; and does nutritional status affect dietary intake when food is presented in a sealed pack?

CHAPTER 2 ERGONOMICS APPROACH TO FOOD CONSUMPTION IN OLDER PEOPLE

This thesis utilises an ergonomics framework for the research. It reviews the interaction of the older person with the food and beverage packaging used in NSW hospitals by considering aspects of the **person** (user), the **pack**, the **task** (opening the pack and ultimately eating) and the **context** of the task/interface. The purpose of this chapter is to explain the ergonomics approach that is the driving construct of this thesis. The chapter then examines the broader context of the hospital sociotechnical system, followed by the person, the pack, the person/pack interface (task) and the context of the interaction, as described in Figure 1.2.

2.1 THE APPROACH

2.1.1 Ergonomics/Human Factors

Ergonomics is a discipline which considers the *capacity* of humans (such as physical stature, strength, reach, cognitive abilities etc.) and their interactions with tools, products, controls, technology, systems to perform activities in work and everyday contexts.

Helander (1997) states:

> *Ergonomics and human factors use knowledge of human abilities and limitations to the design of systems, organisations, jobs, machines, tools and consumer products for safe, efficient and comfortable use* [12].

An updated edition [13] states that

> *Contemporary Human Factors/Ergonomics HFE discovers and applies information about human behaviour, abilities, limitations and other characteristics to the design of tools, machines, systems, tasks, jobs and environments for productive, safe, comfortable and effective human use….in this context HFE deals with a broad scope of problems relevant to the design and evaluation of work systems, consumer products and working environments, in which human-machine interactions affect human performance and product usability.(p. 5).*

The key terms in these descriptions are design; human behaviour, abilities, limitations; performance; product usability. The aim of ergonomics is to promote productivity and ease of use by ensuring sound design of products and systems which optimize human capacity. The interface of the older person and the food and beverage package delivered to them as part of the food service sub system within the larger organisation and sociotechnical system is an ergonomics issue. Questions that

arise from this work would be: What is the usability of the pack for the end user – is the pack designed to consider the abilities and limitations of that user? Further is the pack designed for that user within the hospital ward environment?

2.1.2 Ergonomic Design Principles: Inclusive Design

When these ergonomics principles are applied to design it is commonly termed User-centered design, Inclusive design or Universal design. Products designed in this way are *'flexible enough to be usable by people with no limitations as well as those with functional limitations related to disabilities or due to circumstances'* [14]. This user-centred design approach is the opposite of the designer-centred approach often used by product designers [14].

The global ageing population is driving policy to promote the use of universal design as a principle and as a term. While a number of terms may be used, the UN Convention on the Rights of Persons with Disabilities [15] incorporates the concept of universal design as an underpinning principle. Similarly, the term Design for All has been used in Scandinavia as a way of embedding the principles of universal design [16]. The British Standards Institute [17] defines inclusive design as:

> 'The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible ... without the need for special adaptation or specialised design.'

The social message behind universal design is one of inclusiveness. Product designers not only need to consider the function of the product but the overall aesthetic – the product must be acceptable to all consumers, not one segment, such as designing an aid for a disabled person.

Ageing baby boomers have been identified as a particularly discerning group of consumers [18, 19] and accordingly marketers of products should never use the following 7 words: senior citizen, retiree, aging, Golden Years, Silver Years, mature, and prime time of life [20]. The message from these publications is that this ageing group would prefer to use well designed products that do not single them out as impaired. An everyday example of universal design is the household tap, which has moved from difficult to turn hot and cold handles to a single lever which is easy to operate and is appealing to consumers.

Coleman discussed the advantages of user centred design as providing an opportunity for growth through new products and services [21]. He outlines two factors driving universal design:

- Shifting attitudes to universal design as the population ages
- A growing movement to integrate disabled into mainstream society.

The principles of universal design are:

- Equitable use
- The design caters for users with diverse abilities
- Flexibility in use
- Design accommodates wider range of individual preferences and abilities
- Simple and intuitive use
- Design is simple to understand, regardless of user experience, knowledge, language skills or concentration level at time of use
- Perceptible information
- Design communicates necessary information effectively to the user, regardless of ambient conditions or user's sensory abilities
- Tolerance for error
- Design minimizes hazards and adverse consequences of accidental or unintended actions
- Low physical effort
- Design can be used efficiently and comfortably with a minimum of fatigue
- Size and space for approach and use
- Appropriate and adequate size and space provided for approach, reach, manipulation and use, regardless of user's body size, posture or mobility [22].

This concept of universal design is an inclusive design concept and subtly different to accessible design for the disabled. Accessible design is '..focused on principles of extending standard design to people with some type of performance limitation to maximise the number of potential customers who can readily use a product, building or service [23].' It relies on three strategies: universal design; adaptive design; and the use of special products for people with disabilities. Accessible design is often imposed by regulation [24].

Farage has developed design principles to accommodate older adults within the universal design framework, aimed at respectful inclusion allowing seamless integration into the wider society [25]. The design principles include information on functional changes that take place with ageing, such as

changes in odour and flavour perception. Specific guidance is provided on visual and auditory presentation; accommodating altered touch sensation, temperature perception, restricted mobility and balance; and suggestions for accommodating cognitive changes in ageing adults. This universal design concept incorporating older adults has also been termed transgenerational design by other researchers [26] [27].

As the population is ageing rapidly, incorporation of universal design principles are critical to cater for the new older generation – the baby boomers. These older adults are differentiated from the previous generation by their attitude towards products and services. They will not accept designs that are 'accessible' as these indicate disability. Instead these consumers will demand well designed products and services which do not imply impairment with their use.

2.1.3 Usability

Usability is another important concept to define and consider when discussing design. The definition of ergonomics in the previous section refers to product usability. Usability is defined in ISO 9241-11 as the 'extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.' Usability, unlike accessibility is used to improve products and competitiveness [24].

Efficiency and effectiveness used in the definition above implies safety. In fact a review of packaging safety by Loughborough University [28] found that 49,000 consumers in the UK attended hospital for treatment following injury from interacting with packaging. Three key pack formats were identified as the problem packs: tin cans (cuts); carbonated bottles (eye injuries); hard to open plastic packs (knife injuries). While this report does not categorise the injuries according to age group, it does highlight particular issues for older or disabled people, reporting that almost 20% of people over 55 years have stopped purchasing packs they consider problematic. The recommendation from this study was that packaging should be inclusively designed and tested on consumers.

A consumer survey on packaging conducted across 4 UK supermarkets focussing on packaging openability, found that people wanting to be independent and not seek help as well as those who were left handed were more likely to suffer packaging injuries [29]. The mean age of these consumers was 48 years and no significant relationship was found between older age and dissatisfaction. The authors attributed this to the use of tools to assist older people to open packs. However, this was not measured specifically and it is likely there was insufficient number of older people in the study to draw a conclusion about older users and specific issues with packs.

Another survey of packaging users was conducted by researchers to explore injuries from consumer packaging, with participants were aged 17-62 years [30]. Tin cans and in particular those requiring a tool, were most associated with injuries. Participants wanted more information on how to open packs. The packs found to be the most difficult to open were brick (tetra) type packs where spillage was a major issue for the users.

A novel approach to assessing products and environments for suitability for the older user has been used by the Centre for Applied Gerontology at the University of Birmingham. They established a group of older people across the UK aged 50 years and over to test products and environments for usability and safety. Once products are approved by this panel, they are given the Owl mark to identify their suitability for use by older people. This panel of elders were surveyed about packaging openability in 1992 and 40% had been injured opening packaging and 66% spilt the contents while opening packs [31]. While useful as a strategy, this mark does differentiate the needs of older consumers compared to the rest of society. A better approach would be a universal design tick indicating that the products were suitable for the largest number of people in all different environments.

Figure 2.1 Owl Mark Trademark
(now expired), Centre for Applied Gerontology, University of Birmingham.
[https://tmdb.eu/trademark/000032722/eu]

De la Fuente and Bix developed a model to describe the person-pack interface using four components of usability – the user, the pack, the context and the task [32] . The model includes the concept of affordance by Gibson [33]. Gibson defines affordance as an object's utilitarian function – the object tells the person how to interact with it. Affordance has also been used by Norman [34] as

the relationship between an object and a person or the communication of the designer to the user through the object as follows:

> *The power of visual, perceivable affordances is that they guide behaviour, and in the best of cases…without the person's awareness of the guidance – it just feels natural.* (p.69).

2.1.4 Openability

The term **openability** has been used in the packaging literature to describe the ability of retail workers to open large boxes of products for shelf stacking in supermarkets [35, 36]. More recently it has been used to describe the opening of individual packs by consumers [37]. It is in this sense that openability has been used throughout this thesis to describe the extent to which the food or beverage package could be used by a specified population (well, independently living older people aged 65 years and over).

De la Fuente and Bix describe the importance of perceptual aspects of affordance – intuitive design requires little mental processing to understand how to open and use the product [32]. Their model is in Figure 2.2 below. Openability is described as an affordance (usefulness) while the perceptual information is described as usability.

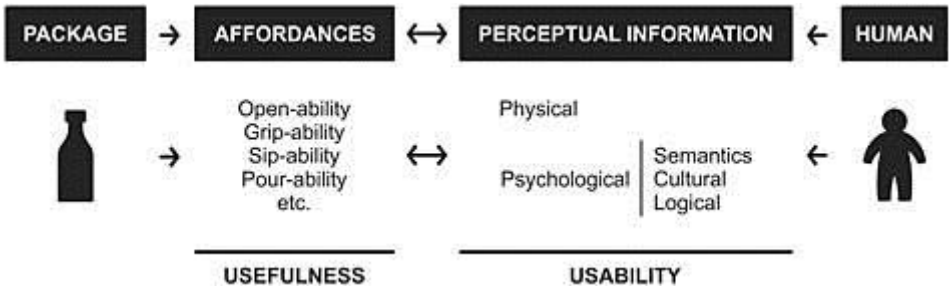

Figure 2.2 An affordance based method for package design

(Packaging Technology and Science Volume 28, Issue 2, pages 157-171, 17 JUN 2014 DOI: 10.1002/pts.2087 http://onlinelibrary.wiley.com/doi/10.1002/pts.2087/full#pts2087-fig-0001)

Affordances are described as intuitive 'abilities.' The ability of the product design to reveal its use through features which the user discerns without conscious thought. In this way, open-ability like grip-ability and sip-ability are components of usefulness of a pack design. The model presented in Figure 2.2 is very helpful in describing the interface between the pack and the user, but misses the aspect of environment, though this could be implicit in the cultural aspect. Linking this model back to the overall model of approach in this thesis, the interaction of the person, the product, the task

and the context, openability is an aspect of food package design that will influence the time taken and ease of opening for the older adult to actually undertake the task of eating (Figure 2.3).

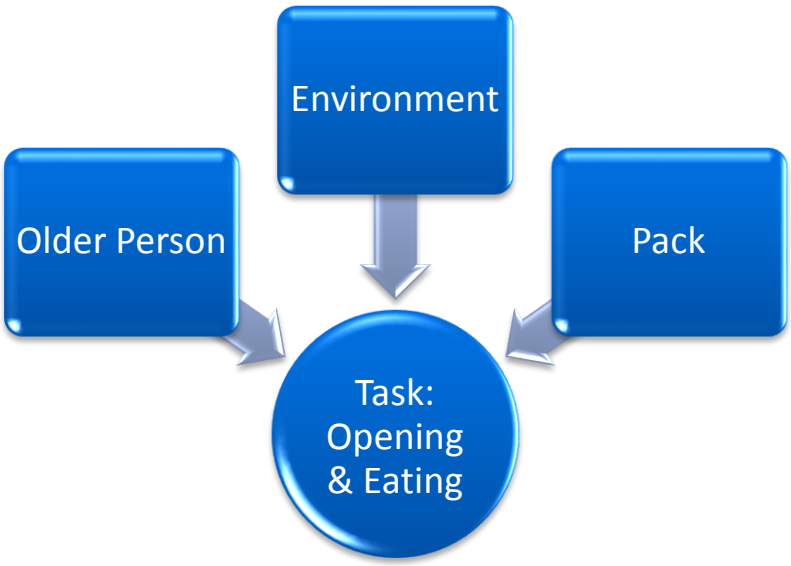

Figure 2.3 The older person, package, openability, task and context of thesis

2.2 THE BROAD CONTEXT

2.2.1 Sociotechnical systems

The term sociotechnical system is associated with Trist [38]. Trist observed a fundamental change in the way in which organisations operated after WW2 when technology development and use expanded. Prior to WW2 technology drove the development of organisations. After WW2, organisations determined their technological needs according to their goals/outputs. This change meant that both the people and equipment requirements of the organisation had to be combined effectively to achieve the desired goals/outputs. This is a sociotechnical system [38]. Trist describes three levels in a sociotechnical system:

- Primary work systems (e.g. Food Service)
- Whole organisation systems (e.g. Hospital)
- Macrosocial systems (e.g. Health System/wider society)

Trist defines sociotechnical systems as:

> *Organisations that are …directly dependent on their material means and resources for their outputs. Their core interface consists of the relations between a nonhuman system and a human system.* (p. 12).

He then singles out hospitals as an example:

> *Hospitals are inherently sociotechnical.* (p.12).

The concept of sociotechnical systems has been used by ergonomists for describing organisations [39-44]. Indeed, the overall US healthcare system has been described as a sociotechnical system' which is *…all about people; patients, families and friends, and various healthcare professionals and workers* [41].

The concept has been used to design new systems and improve existing systems by treating the two key components of the sociotechnical system – social and technological together as interdependent elements [39]. With changing technology and increasing complexity of systems, the concept has been modified and an alternate but complementary area of ergonomics developed, that of *macroergonomics* [45], which has a focus on the interface between organisational design and the technology/job/operator.

The sociotechnical system description for a hospital assists in understanding the complexities of the organisation. Food service is a sub-system within the hospital sociotechnical system. Further, the outer driver for the larger hospital system is the overall health care system determined by government policy and funding. This definition and description of sociotechnical systems is core to understanding the complicated nature of the hospital and the food service sub-system, which is influenced from within and without.

At the heart of the sociotechnical system concept is **design,** and this is also the core of the discipline of ergonomics/human factors.

2.3 THE SUBSYSTEM AND ENVIRONMENT

2.3.1 Hospital Food Service

The purpose of food service in hospitals is to deliver nutrition required for recovery and to encourage patients to eat. This is a challenging proposition with cost pressures from government, large numbers of patients [3], conflicting priorities of medical procedures over meal times, lack of menu choice, increase use of cook-chill options, lack of assistance to eat and open packaging [46]. Hartwell describes the history of hospital food service in the UK. She outlines the Nutrition Guidelines for Hospital Catering, developed by the Department of Health in 1995 as:

- Food should be regarded as an integral and important part of total hospital care
- Menus should offer a variety of nutritionally appropriate meals and allow for a range of portion sizes
- Foods not eaten are of no nutritional value to patients
- Taste, colour, smell, temperature, presentation and timing of meals are important [47].

Food service in hospitals both in Australia and the UK have seen a dramatic change from the 1950s centralised kitchen with nursing staff serving patients from bulk trolleys on the wards, to fully centralised systems with production decoupled from consumption [48, 49]. This decoupling is further compounded when food service is contracted out to external providers. Guidelines have been developed for the prevention of under nutrition in the UK and stated:

> *Management does not…consider food service to play…important role...and food service is not always seen as an important therapeutic aspect of patients' hospital stay…. the provision of meals should be regarded as an essential part of the treatment of patients* [50].

Additionally, the Report of the Special Commission of Inquiry into Acute Care Services in NSW Public Hospitals [4] highlighted this issue as a major concern for NSW hospitals, saying:

> *For reasons unexplainable, it seems that instead of treating food as part of the clinical aspect of a patient's stay; hospital administrators have treated it as an ancillary service often provided by external service providers.*

This decoupling of food from treatment is critical to the issues discussed in this thesis. Food is or should be at the centre of patient care, but instead has been outsourced as an add-on service. Instead of viewing food service as care, the delivery of hospital food has been termed the Food Chain in the literature [51, 52]. It refers to the whole process of catering to patients – patient assessment; ordering meals; preparation; transport; serving; presentation; quality and palatability as well as portion size, food consistency, temperature, need for assistance (to eat), special utensils and the eating environment.

The centralised approach to food service delivery has also been termed industrial cuisine, as the concept/system of hospital food moves to a catering function, rather than a treatment function [48]. This approach to catering is also seen in other large institutions/businesses such as universities, hospitality venues and airlines. Hartwell summarises the 4 main systems of food service delivery as:

- Cook serve (traditional hospital model)

- Cook-chill
- Sous vide (food placed in vacuum sealed plastic pouch and slowly cooked in hot water)
- Cook-freeze [47].

Food service in NSW hospitals is moving to a completely centralised model with hospital designed, pre-packaged complete meals using cook-chill and cook-freeze methods with 5 production centres for the state, serving 22 million trays of food/annum at a cost of $260 million [11]. The approximate energy and protein supplied in meals each day in a standard full diet is 8,000kJ with 90g protein, 2.1-2.6 litres fluid/patient/day [11]. Commercially packaged food and beverages are commonly used in NSW hospitals in attempt to provide a consistent, standard portion sized and economically viable range of choices [53].

Research comparing the different food service delivery systems is scant. Rodgers compares all except sous vide [54]. The author reports all have varied benefits but there is no objective data available to choose between systems, and suggests the decision should be made using 3 main criteria:

- Operational: cost and training; logistics implications
- Technological issues: microbial risks, strict process control and development
- Environmental: non-reusable multi-layer packaging and relatively high energy costs.

In fact, the environmental implications are now being targeted by UK National Health Service (NHS) Trusts, following a focus on procurement and sustainable food in the 2000's [55]. The suppliers of food and beverage to the NHS are scored on three key criteria:

- Commitment to reduce food miles, carbon reduction and unnecessary packaging
- Safer farming practices (including pesticide use, animal welfare and fish sourcing)
- Seasonal produce availability and optimum shelf life.

Russell discusses the impact of this sustainability focus on the Cornish NHS Trusts that have worked with local suppliers and reduced waste and packaging as well as saving 110,000 road miles/annum [56]. Forty-one percent of the hospitals combined budget has also been spent with local Cornish suppliers. It is likely that this focus on sustainability will be taken up by Australian hospitals in coming years and this will impact on the type of food service system and the products and packaging used within it. Perhaps in time, this movement toward green sustainability will once more see food as more than an ancillary service and instead part of patient care and treatment.

2.3.2 Intake and waste

One of the biggest challenges for food service is patients eating sufficient food to assist in their recovery. Patients are a captive audience and have been described as unwilling customers [57]. Despite the attempts to improve hospital food in the UK, Johns reports that it is still viewed as institutional food: bland, dominated by the majority culture, with poor texture and temperature; with poorly timed and administered food service [57]. This is also the experience in Norway [58] and Iran [59].

Plate waste has been investigated by a number of researchers. An observational study of a large teaching hospital over a 28 day period with a plated meal service found 40% of food was wasted at an estimated cost of £140,000 [60]. Energy and protein intakes were low and the highest waste was found in the elderly ward, where 42% of food was wasted. In 2001, food wastage for the NHS was estimated at £18 million [52]. A review of the plate waste in hospitals was also undertaken in Australia by Williams and Walton [61]. The median plate waste across 32 hospital studies was found to be 30% with a range of 6-65%.

Older adults have smaller appetites and are less able to discern taste and smell [62, 63]. As such they have specific requirements in food service and meeting these needs will enhance their intake to promote recovery. Smaller, energy dense portions have been found to be better for older people [64-66]. Walton [67] in a comprehensive review outlines a number of strategies to encourage older patients to eat in hospital and in aged care facilities, and these included smaller serving sizes; flexibility of menu choice; food fortification; protected mealtimes, additional mealtime assistance; nourishing snacks and improved variety of menu options.

2.3.3 Packaging in food service and older adults

Issues for older patients with food and beverage packaging in hospitals were raised by Tiivel and Davidson in 2002:

> *Difficulty opening packages can make them more dependent and decrease their ability to get adequate nutrition* [68].

The authors described the experience of patients struggling with packaging and suggested a number of changes to the packs: larger tabs on lids; extending one side of the cheese portion wrap to allow better grip or placing a notch in the edge of the wrap. They also noted that instructions needed to be more legible [68].

Although more recent research has also reported concerns regarding the increasing use of food and beverage packaging in Australian hospitals [46, 69, 70], few studies have examined the issues related to food and beverage packaging for hospitalised patients. Wilton [69] in an observational study found that patients were required to open between five and nineteen items at each meal; and that 31% of these patients had difficulty opening the items. The most problematic types of packaging for patients were identified as tetra packs which were found particularly difficult. Tetra packs usually contain nutrition supplements for patients with reduced appetite or who are 'at risk' of malnutrition or who are experiencing eating or swallowing difficulties.

Earlier pilot research conducted with University of Wollongong Dietetic students and an Occupational Therapist from Wollongong Hospital found that an inpatient in a NSW hospital could encounter up to 26 different types of food and beverage packaging per day [5]. This study reported several food and beverage packages that were found difficult to open by at least 40% of patients. The products included milk and juices (52% found difficult), cereal (49% found difficult), condiments (46% found difficult), tetra packs (40% found difficult) and water bottles (40% found difficult). Additionally, nursing, dietetics and food services staff who were interviewed reported they had all been asked to assist patients to open products, and 39% of them reported having difficulty with some items.

An Australian study including dietitians, food service managers and rehabilitation nurse unit managers identified food and beverage packaging as one of the top five major themes of concern affecting food service in institutions [70]. Studies have shown that food service and ward environmental factors, such as menu cycle, food service system, amount of packaging, level of mealtime assistance have an impact on the dietary intakes of patients [46, 50, 68-73]. Clearly the system of food service delivery is multifaceted and must be well considered to ensure adequate intake by patients for achieving or maintaining good nutritional health. An important part of this picture is ensuring that food and beverage packaging is able to be opened with ease.

These studies highlight the issues of declining functional ability associated with ageing and how this impacts on the everyday task of pack opening. This thesis focusses on the interaction of the person and the pack. Hand function is a core aspect of functional ability related to pack opening and a focus in this thesis. The following sections will discuss ageing and the associated functional decline.

2.4 THE PERSON

2.4.1 Ageing population

The global population is ageing. The United Nations predicts the world population of people aged 60 years and over to grow from 841 million in 2013 to more than 2 billion in 2050 with older people outnumbering the number of children for the first time in 2047 [7]. Figure 2.4 outlines the global ageing population, comparing 1970, 2013 and projections for 2050 in both less and more developed regions of nations.

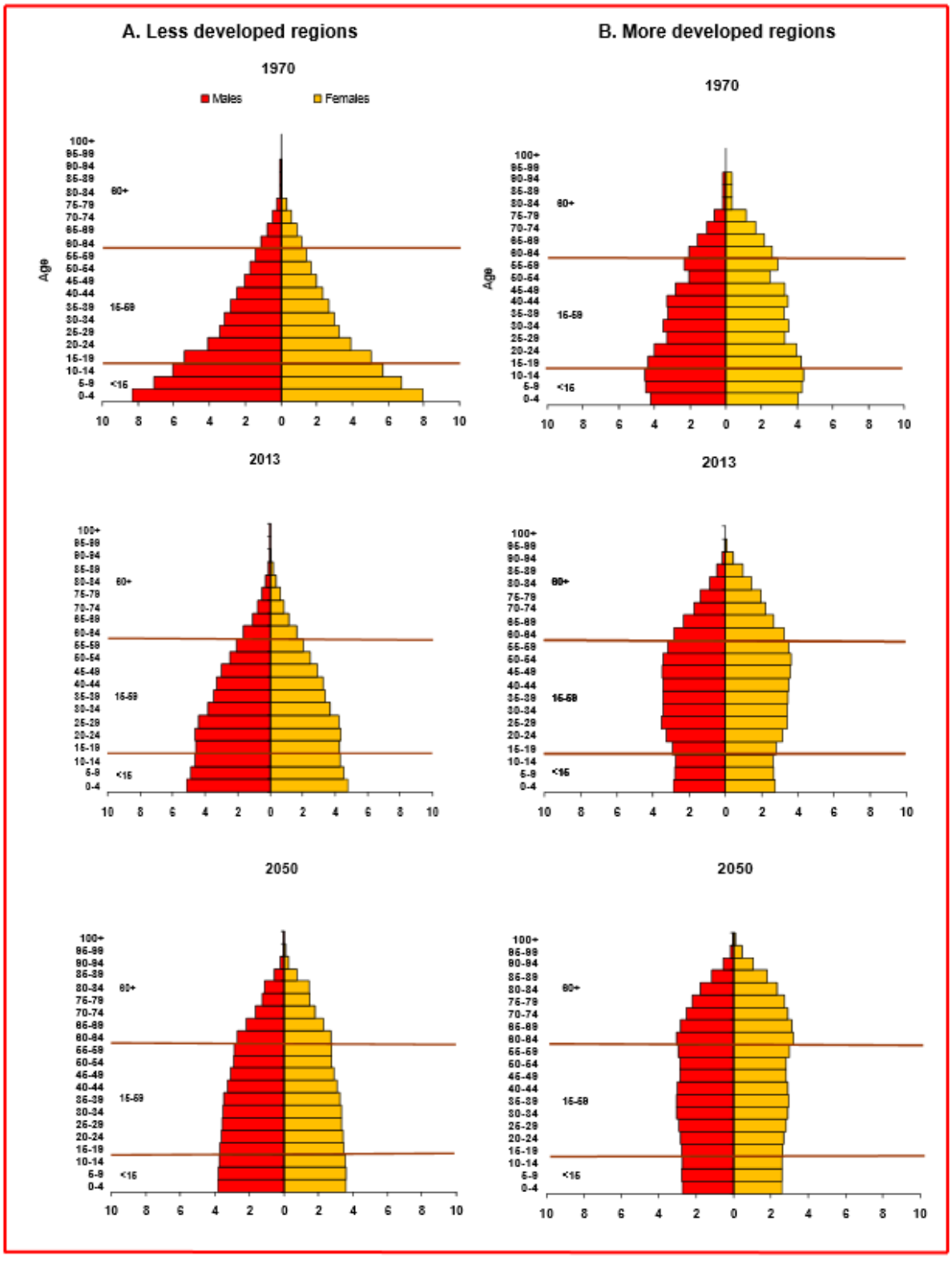

Figure 2.4 Population pyramids for less and more developed nations, 1970, 2013, 2050. (World Population Ageing, United Nations, 2013, p.10).

The Australian population aged 65 years and over is estimated to increase from 3.2 million (14% of population) in 2012 to 11.1 million in 2061 (22%). This increase in older people in the population will

mean an even larger number of older old people (85 years and over). In 2012, there were 420,300 people (1.8% of population) in this age group, and the projected number is 1.9 million by 2061 (4.5%), the highest growth rate of all groups, with a peak in 2032. As life expectancy for men will increase, the percentage of males in this 'older old' age group will change from 35% in 2012 to 43-46% in 2061. (The Australian data is based on Series B from the ABS).

This ageing population domestically and globally has direct implications for health care provision as ageing is accompanied by a decrease in functional ability and an increase in chronic health conditions and other age-related pathologies. For example, ageing leads to a loss of strength and dexterity, reduced visual acuity, changes in hearing, changes in odour and flavour perception, decline in cognitive function, impaired immune function, increased susceptibility to infection and increased risk of heart disease and cancer [25, 74, 75].

There is also evidence that many of the biological changes and risk of chronic disease attributed to ageing are due to poor diets [76, 77]. As nutritional status influences the age-related rate of functional decline in many organ systems, diet and nutrition are directly linked to many of the chronic diseases afflicting older adults [78] and malnutrition in older people has been identified as a significant problem.

2.4.2 Older adults and malnutrition

The Australia and New Zealand Society of Geriatric Medicine [1] define malnutrition as:

1. Under-nutrition resulting from reduced food intake;
2. Over-nutrition from excess food intake;
3. Selective nutrient deficiencies and
4. Imbalances because of disproportionate intake.

Of particular concern is **Protein-Energy Under-nutrition (PEU)..."** a clinical syndrome characterised by weight loss associated with significant depletion of fat stores and muscle mass." The Australia and New Zealand Society of Geriatric Medicine [1]. This will be referred to as malnutrition throughout this thesis.

A report published by BAPEN [79] estimates that nearly 3 million people currently suffer malnutrition in the UK costing more than £13bn a year and is actually more than double the bill for treating obesity. An earlier report by this organisation "Malnutrition among Older People in the community: Policy Recommendations for Change" [80], estimated that nearly 10% of the population over the age

of 65 in the UK, currently suffer some form of malnutrition, approximately 1 million people. Studies of malnutrition prevalence in the community have also been conducted in other countries. A Swedish study found that 14.5% of older people in the community were at risk of malnutrition [81]; while a Belgium study found 57% of older people at risk [82]. An Australian study found 34.5% of vulnerable community dwelling older adults who were receiving home nursing services were at risk [83]. These researchers conclude that generally, 8-10% of community living older adults are likely to be at risk of malnutrition [80, 83, 84]. The implications of this level of risk of malnutrition has been found to be decreased mobility, greater susceptibility to other illnesses and falls, as well as higher levels of depression [81, 85, 86]. This level of malnutrition in the community has direct implications for the research within this thesis. While the study population will be well, community dwelling older adults, it is likely that some of them may be inadequately nourished.

It is not just in the community that malnutrition is seen to have a significant impact on the health of older people. A review paper by Schenker [6] estimated 40% of UK hospital patients were malnourished with 60% at risk, with the…' average food intake less than 75% of that recommended, particularly among the elderly.' Studies have shown that elderly patients are five times more likely to be at risk of malnutrition than younger patients [87, 88]. In 2007, a metropolitan NSW Health Service conducted a one-day malnutrition prevalence audit across its sites and showed 51% (n=777) to have some degree of malnutrition[89]. Malnutrition causes surgical complications, greater morbidity and increasing hospital stays as well as higher rates of mortality over 12 months [90].

These flow on effects of malnutrition in the older patient also lead to increasing costs. UK data suggests that malnutrition related costs are more than €9.2 billion per year treating malnourished patients in hospital and long-term care facilities such as nursing homes [91]. The European Nutrition for Health Alliance found that inadequate nutrition may increase length of hospital stay by 50% (6-7 days on average), and triple mortality rates [92]. An Australian study of malnutrition in hospitals found 23% of patients (all ages) to be malnourished with the consequence of increased medical complications, infection rates, mortality and up to 5 extra days in hospital [93].

The reasons for malnutrition are complex and multifactorial [94-96] and require a range of strategies to manage. Malnutrition in the older population has three main risk factors: medical factors, lifestyle/social factors and psychological factors. Medical factors can include difficulty eating due to chewing and swallowing difficulties; physical disability; and poor appetite from other diseases such as cancer [97]. Lifestyle factors include living and eating alone, poor food literacy and lack of cooking

skills [98]; while psychological factors can include depression, dementia, confusion, and bereavement [86]. In hospitalised older adults there are the additional risks related to the hospital food service (limited choice, timing not convenient, inability to reach food, use cutlery or open packages), medical interventions (tests at meal times, nil by mouth) and environmental deterrents (unpleasant smells, sounds or sights)[97].

The 2007 NSW Health Service malnutrition prevalence audit highlighted the difficulty experienced by some patients in opening food and beverage packaging with a number of these patients indicating that they did not eat the food because they could not open it. Other researchers have also identified inability to access food and beverage packaging as a contributing factor to malnutrition among the elderly and disabled in hospitals [6, 46, 70, 99]. These study findings demonstrate the importance of undertaking the research in this thesis, examining the interaction of older people with packaged food and beverages used in hospital food service. Why are the packs problematic for people to open? How can the pack and the food service be improved to promote dietary intake?

Ageing impacts the human body – there is a decline in muscle strength, muscle mass, cognition, vision, hearing; decreased reaction times and changes in sensory perception as well as increased risk of cancer, heart disease and other age related pathologies [100]. While ageing does involve an inevitable decrease in physiological capacity, it does not always lead to dependence. Spirduso describes a hierarchical continuum of function in the older adult from Physically Elite to Physically Fit, to Physically Independent, Physically Frail and Physically Dependent [101]. These categories are characterised by level of physical fitness and can be assessed with specified functional tests. For example, Physically Elite older adults train and compete in senior sports tournaments. Physically Independent older adults are mobile and independent in their activities of daily living; while Physically Dependent older people require assistance from mobility aids. With the increasing numbers of ageing adults over the next few decades, the number of adults in each of these classifications will increase dramatically.

Reduced function in the ageing adult is primarily due to sarcopenia, which is a decrease in muscle mass and strength [102]. The incidence of sarcopenia increases with age and prevalence is higher in older males [102, 103]. Poor nutrition is associated with higher rates of sarcopenia [103]. This is particularly relevant to the aims of this thesis. Food provision in care and in the community is often a packaged commodity. Older people must be able to open packs to access nutrition required to optimise their health. A model of the factors leading to muscle and strength loss in the ageing

process is influenced by body structure and function changes (hormonal and immunological, muscular and nervous system), in combination with environmental and personal factors (age, gender, activity levels, general health and nutritional status) as shown in Figure 2.5.

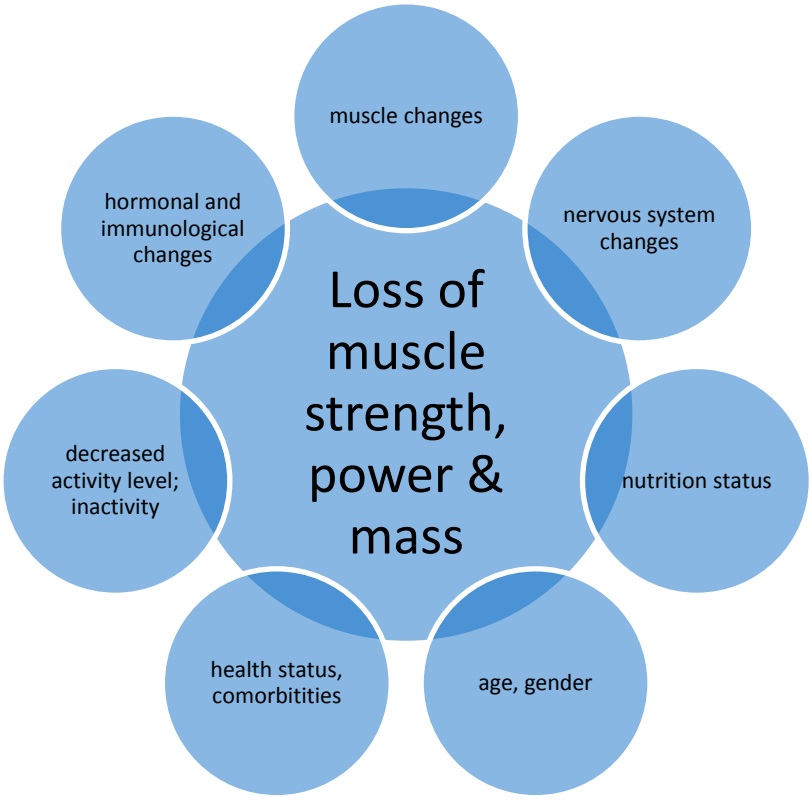

Figure 2.5 Factors leading to loss of muscle strength, power and mass in the ageing process (adapted from Spirduso [101], Chapter 5).

2.4.3 Older adults and hand function

As the focus of this PhD thesis is on the **interface** of the **person** and the **pack**, the hand function of the user is a central issue. It is relevant to review the effect of ageing on hand function as well as having a clear understanding of the taxonomy used to describe the different gross and fine grips used by people when manipulating objects such as packaging.

Human's use of their hands is a day-long activity. Kilbreath and Heard [104] undertook a study with well older adults to observe the use of hands while performing everyday tasks. They found that while participants favoured their dominant hand, they used both hands simultaneously (and cooperatively) on tasks regardless of the varying types and characteristics of objects. Similarly, Vergara [105] observed the common grasps used by adults in their activities of daily living such as food preparation, feeding, personal care, housekeeping and shopping. They found that participants used their hands during most of their waking hours and for more than 50% of the time, both hands were

used simultaneously for the same or different tasks. This is relevant to the thesis studies as efficient pack opening also requires cooperative use of both hands.

The effect of age related decrease in muscle strength on overall grip strength has been investigated by a longitudinal study on men [106]. The study found that 80-90 year olds had 37% of the grip strength of 30-39 year old males. However, as the study provided the opportunity to look at individuals over time, interestingly, there were some older participants who did not experience a decrease in grip strength over the 13 year study period.

Overall, however, the loss of grip strength was reported to be consistent with other studies at 30-40% decline in back, leg and arm strength from age 30 to age 80, with an acceleration in the decline after age 50 [106]. In another study pushing, pulling, twisting and grip force were measured in order to determine a score for total body strength. Strength reduced at similar rates for men and women between the ages of 50 and 90 years[100].

Maximum grip strength and dexterity measures differ between the genders. Males have stronger grip strength than females, and the dominant hand is stronger than the non-dominant hand [107-111]. The standardised data for dexterity shows females have greater dexterity than males [112-114].
Researchers have investigated the effects of ageing on hand function [113, 115]. Desrosiers [115] undertook a longitudinal study over 3 years of 264 community living older participants to measure upper extremity performance. They investigated gross and fine manual dexterity, grip strength and tactile perception measures. A loss of 8.6% was found for overall upper extremity performance for both genders. Ranganathan [113] reviewed gross grip, finger pinch strength and dexterity across different age ranges. Older participants had 30% less grip force and 26% less pinch force. Older women took 20% longer than younger people for dexterity tasks, while older men took 30% longer than their younger counterparts. The study concluded that ageing is associated with a decrease in hand and finger strength, fine motor speed (dexterity task) and hand sensation. Similarly, Pennathur [116] found that dexterity decreases with age. Reduced hand function in ageing has been shown to result in difficulties carrying out activities of daily living such as writing, managing buttons on clothing and fine tasks such as handling coins and earrings [117]. This thesis will examine the role of hand strength and dexterity in opening packages. Packs are designed around human strength parameters. By investigating the role of dexterity in pack openability, new design parameters may emerge.

Another important aspect of hand function is hand preference or 'hand dominance.' Distinguishing between left or right handedness is traditionally determined by writing hand preference [118]. The distribution of left handedness in the population is generally considered to be 10%, however a reduction in this distribution takes place with age [119]. It is thought that handedness is on a continuum from left handedness to bilateral handedness to right handed [118]. Further, as the percent of the population who are left handed decreases with age, it is postulated that the left handed people move more towards the right of the handedness continuum because they learn to accommodate their handedness to the right handed world [118]. Hand dominance determined which hand was tested for strength in this thesis.

2.4.3.1 Taxonomy of grips

Understanding grip and pinch nomenclature are essential when conducting research on hand function. Different disciplines refer to the range of human grip and pinch movements with different terms. To determine the terms used and grips assessed for this thesis, it is important to start with the basic concepts of movement. Napier [120] outlines the need to categorise human grips from anatomical and functional perspectives. The movements of the hand are described as either *prehensile movements* (object is picked up and held or partly held by the hand), or *non-prehensile movements,* where objects are manipulated by pushing, pulling, lifting etc. by the hand and or fingers. Prehensile movements require stability of the hand and this is achieved in one of two ways: by a power grip (see Figure 2.6) or a precision grip (Figure 2.7).

The grip selection by the user will be determined by two key attributes: the characteristics of the object (including the environment for the use) and the intended use/action of the object. Object characteristics include: the shape, the size, the weight, temperature, texture, wet or dry surface of the object, as well as like/dislike, attraction/repulsion for the object.

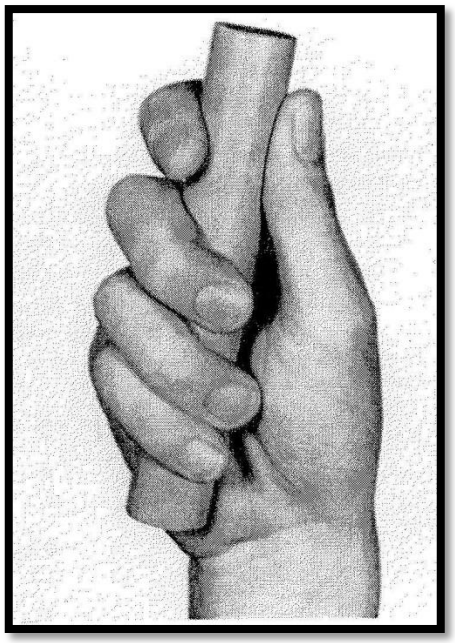

Figure 2.6 Power grip
(Napier, 1956, p. 903)

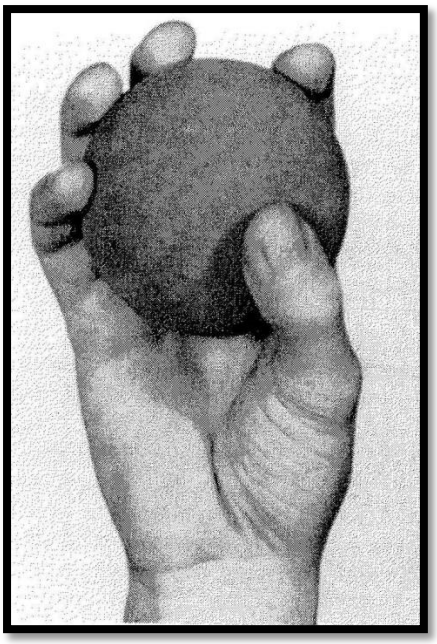

Figure 2.7 Precision grip
(Napier, 1956, p. 903)

MacKenzie and Iberall [121] have comprehensively reviewed the prehensile classifications used across the different disciplines to describe the power grip and the range of precision grips adopted for using objects. Anthropology, medicine, biomechanics, robotics and occupational therapy all have different terms to describe these grips [121]. In Ergonomics, the grips have been termed 'couplings' [122] and these are illustrated in Figure 2.8 below.

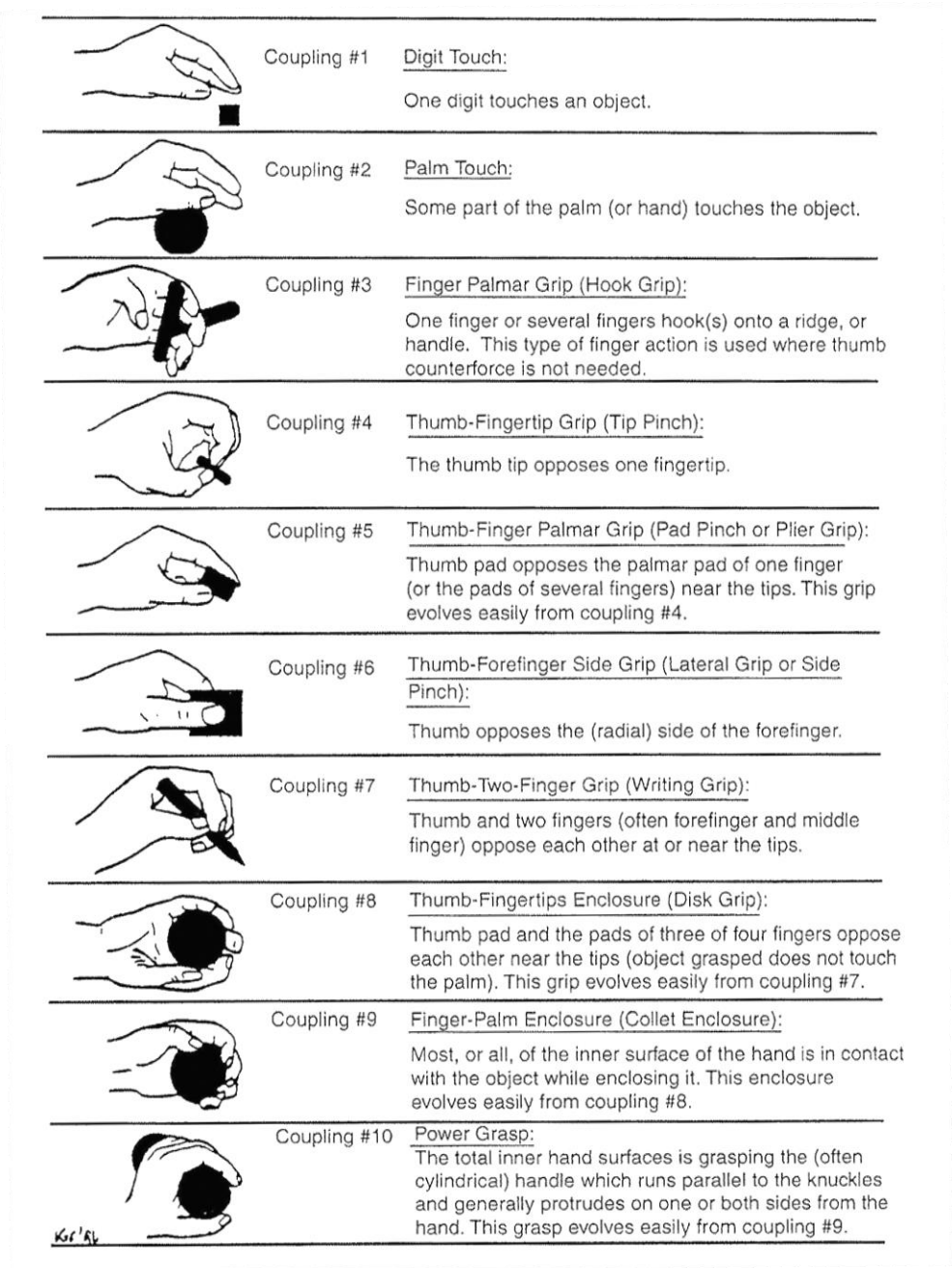

Figure 2.8 The 10 categories of grips.

(Kroemer, (2006) in Marras & Karwowski, p. 10-15).

In orthopaedics and occupational therapy, the terms power grip, pinch grip, lateral /key pinch and 3 point tip/chuck/palmar pinch are used [108, 123, 124]. The common grips measured in hand therapy for function are gross grip (power grasp), tip pinch grip, lateral pinch and 3 point pinch grip [125]. Standardised assessments and normative values are available for these grips for older populations are further described in the Methodology (Chapter 3).

The gross grip is equivalent to coupling #10 above, the power grip; tip pinch grip is coupling #4 above; lateral pinch is equivalent to coupling #6; and the 3 point pinch grip is equivalent to coupling #5, the pad pinch or plier grip. This thesis will report on these four hand strength measures: gross grip; and three pinch strength measures, tip pinch, lateral pinch and 3 point pinch grip.

2.4.3.2 Dexterity

Dexterity is defined by Backman [126] as:

Fine voluntary movements used to manipulate small objects during a specific task.

Dexterity is a summation/outcome of neuromuscular control, eye-hand coordination, sensory and kinaesthetic feedback and strength, and results in functional use of the hand with accuracy and speed [127]. It is essential to successfully undertake fine hand movements such as opening packaging and eating.

Manual dexterity is further broken down into two types: Manual or gross dexterity and fine motor dexterity [114, 126, 128]. Manual dexterity (or gross dexterity), refers to the use of the whole hand to manipulate an object [114]; while fine dexterity (or finger dexterity, fine finger dexterity) is the ability to manipulate objects using the distal sections of the fingers [114, 129, 130]. Both forms of dexterity are required to successfully manipulate and open hospital food and beverage packaging.

2.4.4 Strength data for older adults

Designing effective products requires an understanding of the end user and their capacities and capabilities as well as the properties of the product. Norris and Wilson [131] state that ergonomics data is fundamental to the design of safe and usable products. Yet, as Carse [132, 133] highlights, this data is often found difficult to use or interpret by designers. Additionally, the data may not be useful as it does not take into account the context or mode of product use by the consumer [37, 111].

Smith [110] surveyed 850 designers to determine what datasets were required by them to assist in design decisions. Eighty designers responded to the survey reporting they required physical strength data for finger push; pinch/pull; hand grip; wrist twist; opening strength; and push/pull strength. Data for older people was collected from 34 participants in the 61-90 year age groups. The result of this study was 'Older Adultdata: The Handbook of Measurements and Capabilities of the Older Adult: Data for Design Safety' developed for the UK Department of Trade and Industry [110]. This data is valuable for determining some guidance on functional finger movements such as push, pinch and pull as well as opening strength for lidded jars. However, as all the testing was done in the standing

position, it is valid only for that posture. Additionally, the numbers of participants was low with only 4 participants aged 81-90 years. Consequently, this dataset is not relevant to the design of packs for older people. A greater number of subjects and relevant strength tasks are required to inform design of packaging.

Grip and pinch strength measurements require a standardised protocol and this is done in the seated posture [108, 109, 134]. Limited studies have assessed hand function in other postures. Teraoka [135] reviewed grip strength in 3 postures: sitting, standing and laying down. He found that grip was strongest in sitting, followed by standing and then laying down. Richards [136] reviewed grip strength in sitting and supine and concluded little difference between the postures. Boadella [137] also measured grip strength in sitting and standing and found standing results slightly higher for maximal effort.

To summarise, biomechanical data is available for designers to use to assist them determine design limits, however it is situated in discipline areas of medicine and rehabilitation as well as ergonomics. Additionally, the data may not reflect the action required to use a product in the person/pack interface; nor the position of the person or orientation to the product (such as in a hospital setting). Therefore, there is a need to assess the interaction of the older person and the pack in the context of use. Examining the person/pack interaction requires an understanding of the person, the pack, the context/environment and the interaction, as shown in Figure 2.9.

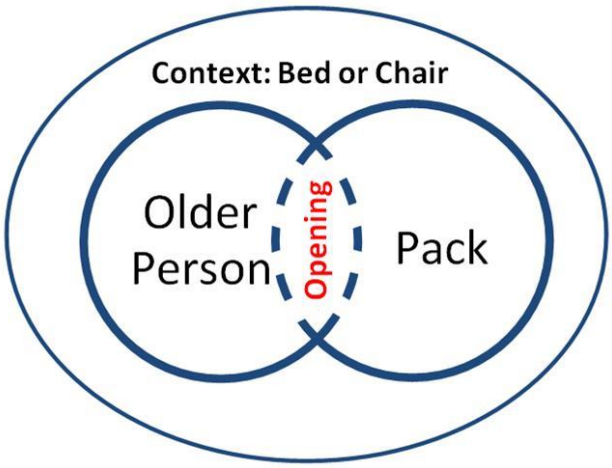

Figure 2.9 Thesis conceptual model of **Older Person: Pack interface task** (opening pack) and **context** of use (posture).

2.5 THE PACK

2.5.1 Packaging

Packaging is part of everyday life. Lutters and ten Klooster [138] report that the average person in Western-European countries opens seven packages a day; across Holland this would equate to 43 thousand million packages/year. The peak body for the packaging industry in Australia is the Packaging Council of Australia (PCA). The packaging industry is an important part of the domestic economy. The PCA report the following [139]:

- Value of packaging in Australia is $AU10-10.5 billion; globally $US300billion
- Packaging industry in Australia ~ 1% GDP
- ~ 30,000 people directly employed in packaging production
- 65-70% of the Australian packaging is used by the food and beverage sector
- The two major packaging manufacturers are Australian owned
- Packaging is generally a high volume/low margin business
- Packaging is a rapidly changing industry
- Greatest demand on packaging is to improve the environmental performance.

Packaging is defined by the PCA as:

> *All products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer.*

Key elements are seen as product security; convenience; and marketing. The report makes reference to the 'greying' of the Australian population and their specific needs in design and labelling of packaging; the importance of marketing to this group of the population is noted:

> *Given their numbers and affluence, marketing will reflect this changing composition of the population.*

This data highlights the importance of food and beverage manufacturers to the packaging industry; and the focus of change in the packaging industry to be towards greater environmental responsibility both domestically and internationally.

Packaging offers convenience for older people living alone through single serve portion packs which reduce food waste. Joutsela and Korhonen[140] reported that consumers wanted smaller sized containers to reduce waste. They include this quote from a participant:

The retailers; price policy for small packs is unfair. ….the greying of the population is a real issue…elderly households do not need super sizes. Small is smart and beautiful.

This is particularly relevant as single person households in Australia is a growing trend with 24.6% of the population living alone in 2001[141]. This trend is marked in the older age groups with 23% of 65-74 year olds living alone; 37% of 74-84 year olds; and 36% of 85 years and over (with 31% of this age group in an aged care facility). These single person households will be significant consumers of single-serve packaged food products. The data for 2001 and projected for 2021 is seen in Figure 2.10.

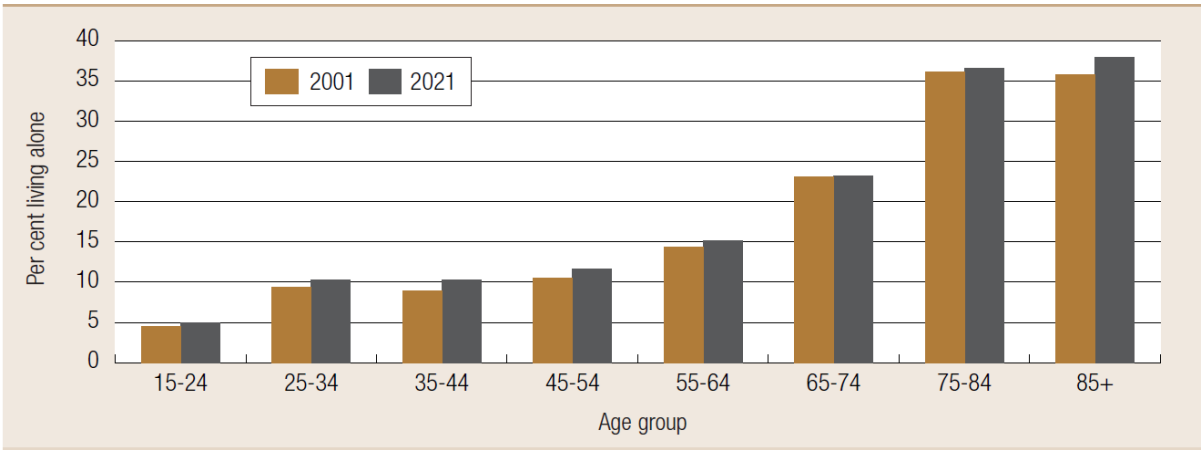

Figure 2.10 Australians living in single person households in 2001 and 2021 (de Vaus, 2010, p.101)[141].

2.6 THE PERSON-PACK INTERFACE

A number of interventions have been introduced to address the issues around packaging and ease of opening. The European Committee for Standardisation has developed a technical specification (TS) regarding packaging and ease of opening (SIS-CEN/TS 15945: 2011)[142]. The specification recommends that packaging is tested for ease of use by a testing panel of up to 100 people aged 65-80 years and 70% of the panel is to be female (as females have less grip strength). The test is for 3 main criteria: effectiveness, efficiency, and satisfaction.

The NSW Department of Health has instituted a tender checklist for packaging purchased as part of its food service provision; as well as Accessibility Guidelines and Benchmarking Scale to encourage more accessible design of products provided to NSW Health [11]. The guidelines require 'expert' staff

members to rate the packaging according to guidelines; user testing does not appear to be part of the review [143].

Research into the person-pack interface has also been undertaken. Satisfaction with packaging is one of the measures in the Technical Standard on Packaging and Ease of Opening (SIS-CEN/TS 15945). Researchers have surveyed users from different age groups and found that the key factor informing satisfaction with the pack was the ease of opening. Packaging that was rated as poor on openability invoked '*outspoken dissatisfaction'* among users. Three areas for future research are suggested by this research team: comparison of different modified test protocols; usage of different age groups in the tests; studies on openability versus usability [144].

Duizer [145] conducted a mixed method packaging study with 99 people aged 60 and over in New Zealand. Researchers in this study found the most difficult aspect of packaging were tight lids, small print and spillage during opening. Participants were asked about common pack formats: glass bottles and jars; bags with sliding resealable closures; tin cans; foil packages; plastic packaging; cardboard boxes; tetra packs; aluminium cans; plastic bottles and cellophane wrapping. Opening packaging was found to be the most common issue across all respondents, with 61% of them requesting assistance for pack opening [145]. The recommendations from this study included larger lids, larger ring pulls and larger tabs on packs.

Literature in the Occupational Therapy field has examined the hand strength of people and the forces required to open a range of everyday items in two groups, college students [146] and well older people [147]. The minimum functional hand strength has been determined as a grip strength of 20lb (9.1kg) and pinch strength of 5-7lb (2.3-3.2kg) [148]. These studies compared the grip and pinch strength forces generated by the participants with the force required to open 6 common household items: a dual pinch safety squeeze bottle, small and large prescription medicine bottles (rotation and push down to open), medicine bottle with alignment of arrows and flip off lid, an aerosol spray can and a trigger pump spray bottle. Forces were determined by force sensors. Participants stood for the testing of the products. No relationship between grip and strength and the opening forces for the containers was found for the college students [146]. The older (60-84 years) cohort in the second study had a moderate relationship between grip and pinch strength and the ability to open the dual pinch safety squeeze bottle. Overall, the findings were similar for both groups across the studies, that is, strength was not strongly correlated with the opening of these 6 containers.

Specific pack types and their interaction with users have been studied. These studies are on five main types of packs:

- Medical packaging (a combination of flexible packaging, bottles and pill packs): Research in this area has focussed on usability of packs [149] and patient safety in terms of dosage (instructions, legibility) [150]; as well as developing criteria for better design [151] and methods to rate accessibility incorporating dexterity [152].

Figure 2.11 Examples of medical packaging

- Jar and bottle lids: Research in this aspect of packaging has focussed on anthropometrics and wrist strength [153-155]; acceptable opening forces for lids [156]; biomechanical analysis of the hand and lid [157]; modelling grip and lid size interactions [155, 158-163]; and modelling finger friction and grip [164]. Inclusive design [165]; and analysis of consumer grips when handling products [166].

Figure 2.12 Examples of bottle and jar lids

- Semi rigid packaging: Research with this type of packaging has focussed on the tab to access the pack such as: angle of force, type of pinch grip used and optimising tab length to force ratio [167, 168].

Figure 2.13 Examples of semi-rigid packaging

- Flexible packaging: Flexible pack research is limited and centred around universal design principles, peel force, finger friction [164] and prototype easy peel packs. Yiangkamolsing [169]conducted a survey to review Universal Design principles to assist designers, distilling the seven principles to 5: convenient, intuitive and simple use, perceptible information, structure and graphic design, easy opening, equitable use. Liebmann [170] developed a technique for measuring peel force on flexible packs; while Hensler [171] tested standard and 'easy open' prototype packs on people with hand disorders to review pack suitability.

Figure 2.14 Examples of flexible packaging

- 'Squeezable' packaging: Research focussing on squeezable containers only is limited to two associated papers by Yoxall [172] and Blakely [173]. These studies examined the forces exerted by users and the grips used to access the containers; findings can be used to design better containers taking into account the material used in the bottle, the bottle design and the opening size.

Figure 2.15 Examples of squeezable packaging

Whilst very little research has been identified examining the person-pack interface for hospital food and beverage packaging with the exception of the studies previously mentioned by a small number of researchers, [5, 68, 69] there is research around the person-pack interface in terms of general principles [132, 133].

Carse [132] outlines the need for designers and scientists to work together to develop effective packaging. In a survey of designers, the researchers found that their priority was appearance and not openability; universal design was not put in place as customers did not request it. Design for older users took place by discussion or consumer testing and normative strength data was not understood or used. The researchers also highlight that much of the research around openability has concentrated on one factor such as strength or hand size and not the whole aspect of hand function including dexterity or use of the product in context. Carse [133], reporting on the same study, found that designers preferred user trials and focus groups to test product usability but that these groups usually consisted of relatives and friends, and may not include older users at all. The study concluded that designers preferred video-based evidence of usabability rather than quantitative

motion and force data. In depth case-studies were suggested as a useful tool for designers to evaluate product usability. The study concluded by stating:

> *..if product design is to be truly inclusive.(there is a) need to ensure that the product.can be used by the widest possible populations. Quantitative knowledge of the strength and abilities of people across the population age range will provide information that could be used to develop standards for the specification of designs to allow inclusion. Perhaps it is the role of the biomechanical research community to develop these standards and to find ways of making them more accessible to designers. This way of using biomechanical testing results would overcome the need for intensive testing of each person-product interaction and instead provide clear guidance for the designer with standardised tests to apply to their designs to assess 'inclusiveness.'* [133]

2.7 SUMMARY

This chapter has summarised and discussed the relevant literature for the research in this thesis, outlining the overall approach taken to review the issue of hospital food and beverage openability by the older person. Hospital food service provision has been decoupled from treatment and is now viewed as a catering function. This significant change impacts on the growing numbers of older people in hospital by introducing packaged food and beverages as core components of food service. Older people experience functional decline in their abilities and this impedes their ability to open packages.

The broad aims of this thesis were to investigate the relationship of the older adult's hand strength and dexterity to the openability of regularly used hospital food and beverage packaging and to explore the user views of that packaging. This chapter has discussed the broad issues surrounding packaging from design to assessment of the user experience, highlighting the deficits in the research: paucity in relevant datasets for strength; disconnect between designers and use of biomechanical datasets; and lack of useful data on older adults opening packs in contextual environments.

Details of each layer of the 'problem' model has been explored, from the sociotechnical system through to the person/pack interface, as shown in Figure 2.16. Chapter 3 will now discuss the methodology undertaken in this thesis to address the critical aspect of the thesis question: the

interaction of the older person and the pack in the context of a hospital environment. Chapters 4, 5,6 and 7 will outline the individual thesis studies and further interrogate the literature presented in this chapter.

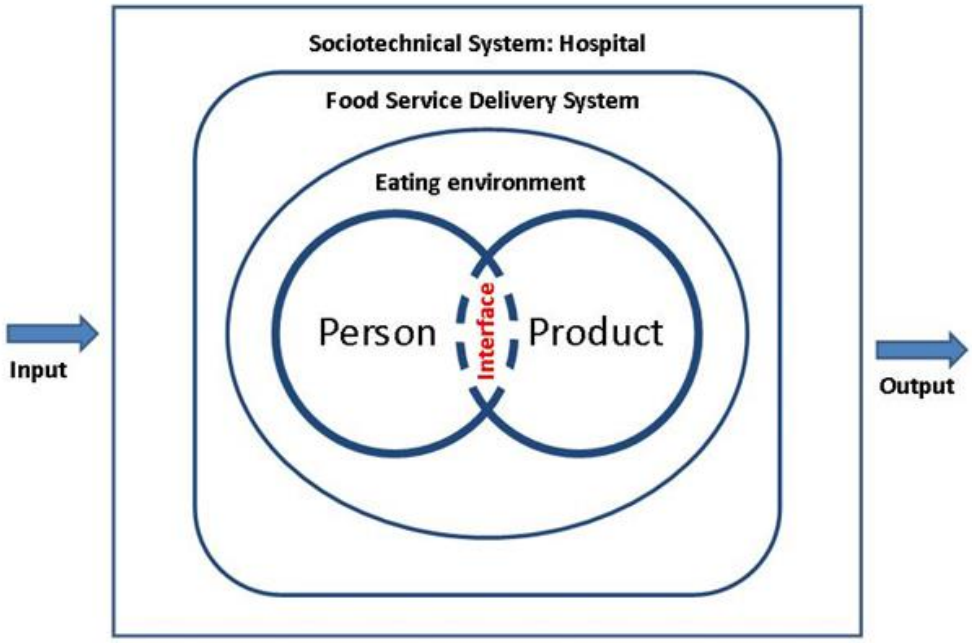

Figure 2.16 Schematic Diagram of the Ergonomics approach applied in the thesis

CHAPTER 3 METHODOLOGY

3.1 INTRODUCTION

This chapter describes both the approach and specific methodology used to review the person, pack, task and context of hospital food and beverage package use. The research was a mixed methods, integrated approach with an ergonomics basis. Quantitative measures were used to collect strength and dexterity data as well as the time to open packs, measurement of intake/plate waste, nutritional status and aggregate measures of satisfaction with the packaging openability. Qualitative data was also collected for packaging openability, in the form of interviews, ratings of ease of opening and video recording of the person/pack interaction.

3.2 POSITION OF THE RESEARCHER

It is essential to review the position of the researcher at this stage, as it informs the overall integrated approach taken in this thesis to address the question of how does the older person open hospital food and beverage packaging? As an Occupational Therapist and Certified Professional Ergonomist, discovering the extent of the issue of openability of food and beverage packaging served in NSW public hospitals was a call for action. An ergonomics approach to exploring this issue was an intuitive 'fit'. The topic and approach was discussed with potential supervisors locally and interstate before coming to decide on the developmental approach of three studies, replicating data collection and building new levels of enquiry with each additional study. The decision to use well community dwelling older adults as the participants for this PhD was deliberate. The Pilot Study had established that hospitalised older adults experienced issues with packaging. Examining well older adults provided a 'best case scenario' older person to interact with the packaging and enabled more controlled data collection methods and greater reliability and validity. Additionally, conducting research in hospital settings is complex and access to participants unreliable due to illness or unavailability due to a medical procedure or discharge from hospital.

Ergonomists aim to match tasks to people – maximising human performance by ensuring systems, products, tasks and jobs are designed for the user and their capabilities; as well as examining sociotechnical systems to evaluate the extent to which human performance is optimised through system design. The issue of food and beverage packaging openability is one of function and design in order to deliver adequate nutrition to hospitalised older people, and facilitate easy openability for everyone. In this sense, the question under review is multi-disciplinary by its very nature. The two

PhD supervisors are both experienced dietitians and eminent academics. To adequately address the scope of the **person, pack, task** and context, a number of different skill sets were required in the team of research assistants that enabled the implementation of these studies. The PhD candidate was ultimately responsible for the study design process, management and supervision of each study, and undertook the data analysis and reporting in this thesis. All stages of thesis were discussed with the PhD supervisors. Study design and data analysis was discussed with the University Statistical Consulting Service with a senior statistician who was also a Dietitian.

A Hand Therapist was recruited to assist with the hand function data collection. The same therapist (Jacqueline Chevis, Occupational Therapist and Hand Therapist) worked consistently across all three studies (Chapters 4, 5, 6) and was also integral to the pre-PhD Pilot Study [5]. Additionally, she provided training and supervision to other research assistants for data collection for grip strength, pinch strength and dexterity measures. A number of student dietitians from the University of Wollongong were also involved in this research, two students in Study 2 (Chapter 5); and two in Study 3 (Chapter 6). The two students in Study 2 also participated as research dietitians in Study 3 (Chapter 6); again providing consistency in research data collection. Inter-rater reliability was conducted with all researchers for Study 2 on a sample of four subjects. All of these research assistants had recent experience in hospitals and were familiar with the hospital food service systems and products. Study design, ethics applications and research assistants' preparation for the studies were completed by the PhD candidate.

3.3 THE APPROACH

3.3.1 Ergonomics

Ergonomics is a discipline that aims to study and understand people interacting with objects within sociotechnical systems. In this way, Ergonomics is contextual, concerned with the person interacting with an object in a specific context. Ergonomics can therefore be considered a socially situated practice [174]. It is also '…the holistic approach to understanding complex interacting systems involving people [175].'

Because ergonomics addresses the interaction of people with artefacts within specific contexts, it is by its very nature ethnographic. It is also rooted in the traditional scientific, quantitative tradition. In fact, as Hignett & Wilson [174] illustrate in Figure 3.1, it is a balance between qualitative and quantitative approaches.

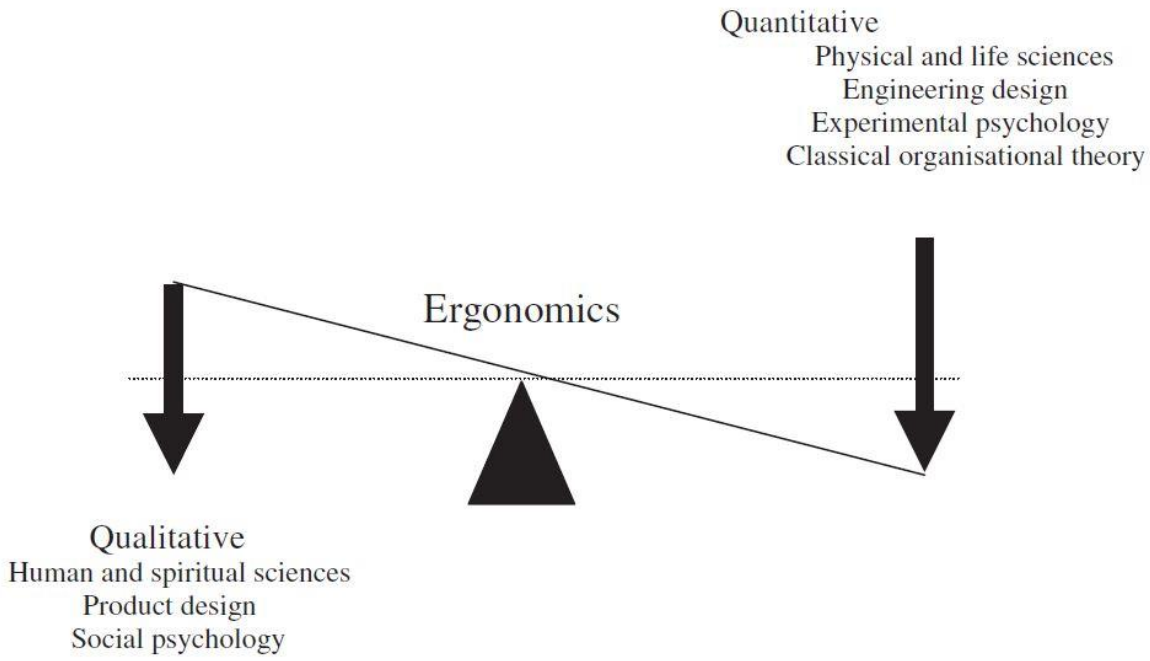

Figure 3.1 Ergonomics is a balance of qualitative and quantitative approaches[174]

This thesis uses an integrated, mixed methods approach, incorporating qualitative data regarding the user's experience of the packaging interaction as well as quantitative strength, dexterity, time and nutritional status data to inform the research question. In this way, data is triangulated, a common methodology incorporated in ergonomics research [176]. Triangulation of data refers to the extent to which results found in one method (e.g. quantitative) agree with results found using another method (e.g. qualitative) with the aim of validating findings with data convergence, inconsistency or contradiction [177]. Denzin [178] describes this approach as a between-methods, methodological triangulation. In this thesis, the triangulation is used for data convergence.

3.3.2 Ethnography

Ethnography is a research philosophy that aims to understand the interactions of people within their social environment. As a methodology, ethnography asks questions and gathers data through interviews and/or observation and has its roots in social anthropology [179]. This is an interesting link with ergonomics, which as Wilson puts it, 'has more in common with anthropology (than psychology) as the unit of analysis is often at the level of the interaction (and not the individual)' [175]. Ethnography is iterative-inductive research, evolving in design throughout the study. This thesis was in fact developed in an iterative-inductive way – commencing with the findings from the Pilot Study with hospitalised older adults and developing throughout the thesis to include different aspects of

the person, the pack, the interaction and the context of that interaction. Grip and pinch strength were the primary focus in Study 1, yet we found little correlation with strength and openability. Dexterity; another hand function element was added for Study 2, along with laying down in a hospital bed to see if these factors were involved in making the opening of the packages more difficult. Findings confirmed these two factors were indeed involved, so Study 3 included all of these and added in additional elements, such as nutritional status and dietary intake to test developing hypotheses.

Ethnography is a social science approach, purposive and systematic in its observation of human action and interaction within a societal context [180]. Traditionally, this observation takes place as field work and can be overt or covert [179]. There are four types of observation for ethnographers; the complete participant, the participant as observer, the observer as participant and the complete observer [181]. The observation in this research is that of complete observer, using video-recordings as visual ethnography [180]. The traditional ethnographic approach would be to video people opening packaging in their own home environments. The approach taken in this thesis could be viewed as an integrated qualitative/quantitative one, whereby the observation has taken place in a community setting (Chapter 4) and simulated hospital settings (Chapters 5 and 6) providing greater standardisation and control than the true ethnographic complete qualitative approach. This integrated methodology is consistent with the theoretical basis for ergonomics research, which involves balancing qualitative and quantitative methods to understand human interactions with artefacts. For this reason, an integrated methodology was adopted to examine the interaction of older users and packaging within an ergonomics framework in this thesis.

Ethnography is an approach favoured by product designers as it provides insight into the person/product interface in daily life [159, 182]. Wasson [182] describes the growth of ethnographic approaches in the field of design over time, outlining the move from cognitive psychology (examining how the person thinks about a product), to large scale market research approaches and increasing use of ethnographic methods such as videotaping. These ethnographic methods allow the designers to view the way a product was actually used by people – sometimes in very different ways to those the designer intended [182]. Further, Wasson [182] states that while the design community are keen to use visual ethnography, they are not well equipped to analyse the data collected and consequently potential insights into the person/product interface are not realised; she calls for the use of anthropologists in the design field. These observations indicate that the ergonomics

approach adopted in this thesis, an integration of qualitative and quantitative methods and resultant analysis, would be a very useful source of information for product designers.

3.4 INTEGRATED METHODOLOGICAL DESIGN FOR THIS RESEARCH

This research integrates qualitative and quantitative research methods to address the problem under study: the interaction of the older person with hospital food and beverage packaging (openability) in a community setting. Combining the traditional qualitative and quantitative approaches to research in an integrated way provides an optimal approach to health research [183].

This section will outline the iterative nature of the three studies within this thesis research and describe the qualitative and quantitative tools and methods adopted across the studies. The chapter is organised around the thesis model: The **context**, the **person**, the **pack,** the **person/pack interaction (task)** as shown in the conceptual model below.

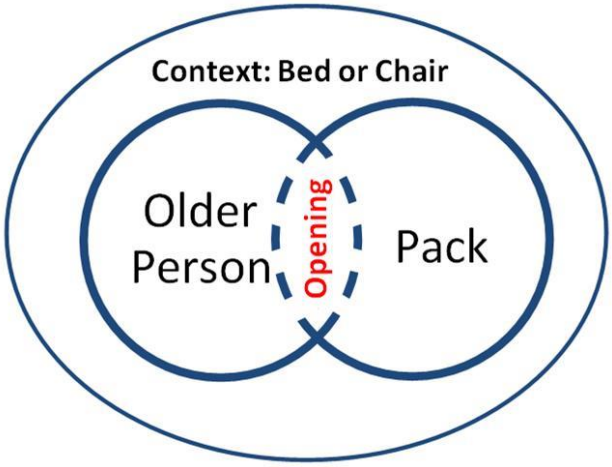

Figure 3.2 Thesis conceptual model of **Older Person: Pack interface task** (opening pack) and **context** of use (posture)

The earlier Pilot Study established that hospitalised older people experienced difficulties with the food and beverage packaging used in the food service system [5]. That pre-PhD study measured hand and pinch strength, time taken to open the packs (Quantitative data); as well as asking the participants to rate the 'openability' of the products, and outline reasons why they thought it was difficult (Qualitative data). The thesis research used this as a starting point – if the same packs were opened by well older people in a non-hospital setting, would they also experience issues with the pack openability? Thus, it was decided to repeat the methods used in the hospital study in the

community setting with well older people as Study 1 of the thesis. Table 3.1 shows the iterative and inductive nature of the thesis studies, with new levels of enquiry built into each subsequent study.

Table 3.1 Description of the Thesis Studies, showing the iterative nature of enquiry

Study	Chapter	Pack	N	Methods Applied						
				Video Timing	Q'nnaires	Grip + Pinch	Dexterity	Bed Posture	MNA	Food Intake
1	4	Full range hospital F&B packs	40	✓	✓	✓				
2	5	Problematic packs	34	✓	✓	✓	✓	✓		
3	6	B'fast, snack & lunch packs	62	✓	✓	✓	✓	✓	✓	✓

In this way, study 1 began the ethnographic exploration of the issue of hospital pack openability by older people by assessing the full range of hospital food and beverage items encountered by hospital inpatients in a day on the ward, as identified in the Pilot Study [5]. Study 2 expanded on the research to include dexterity measures and lying in a semi-recumbent hospital bed posture, as hand strength was not found to be strongly associated with efficient pack opening in study 1.

Study 3 again developed from studies 1 and 2 to include all previous measures (dexterity had been found to be implicated in efficient pack opening), include a wider range of products than study 2, and importantly to include characterisation of the older person's nutritional status and to investigate if packaging impacted on how much food an older person consumes in a simulated hospital environment.

Specific aims of each study were:

Study 1

To determine if well older people experience difficulties with opening hospital food and beverage packages; and to determine if hand strength is the critical factor for efficient pack opening.

Study 2

To determine if dexterity is the critical factor for efficient opening of 'problematic' hospital food and beverage packs; and to determine if a semi-recumbent bed posture impedes pack openability.

Study 3

To determine if sealed packaging inhibits dietary intake in a sample of well older people; and to determine if nutritional status impacts on dietary intake when food is presented in a sealed packed form.

Throughout the series of studies a combination of qualitative and quantitative methodologies was purposefully used to more fully inform the issues under investigation. This chapter will now outline the detail of this integrated methodology.

3.5 ETHICS

Ethics applications were prepared for each study and reviewed by the Human Research Ethics Committee at UOW. Copies of the approvals for all studies can be found in Appendix 1 and further details are provided in the relevant study chapters.

3.6 THE SETTINGS (CONTEXT)

As discussed in the Introduction, this research follows on from a Pilot Study conducted in hospitals[5]. To investigate the experience of well older adults with the same food and beverage packaging previously observed as problematic. The first study took place in the community setting. Participants were tested at two community hall settings and a private home. In this way, participants were in comfortable surroundings with their peers. All data were collected in an upright seated posture on chairs without arms to ensure that the protocol for hand function testing was adhered to [134, 184].

The next study then moved the setting to a hospital context. Participants attended the University of Wollongong nursing simulation suite of individual hospital bed rooms and interview rooms. In this way, the hospital setting was simulated during data collection and a semi recumbent bed posture was introduced to the research. The simulation suite allowed for standardisation of bed height and angle as well as table height from the bed for hand function testing and observation of pack opening. Standardised desk and chair heights were used for the seated part of the study, again to comply with hand function testing protocols [134, 184].

Study 3 was again conducted in the nursing simulation suite at the University of Wollongong. For this study, however, participants were placed in 3 bed shared wards for the food opening and intake aspect of the study. The remainder of testing was conducted in individual interview rooms as used in Study 2. All protocols established for the hospital bed and chair positions in the previous studies were replicated for Study 3.

The bed angle was set at 60%, a modified Fowler's bed position as described by Metzler [185]. Hospital pillows (2 in Study 2; 1 in Study 3) were supplied for comfort and optimise pack ease of opening. It was decided to reduce the number of pillows to 1 in Study 3, as most participants only used 1 pillow in Study 2, although two were available. Figures 3.3 and 3.4 show the bed angles and simulation environments for Studies and 3 respectively.

Figure 3.3 Bed in modified Fowler's position, single bed room, Study 2 (Chapter 5)

Figure 3.4 Beds in modified Fowler's position, 3 bed shared ward, Study 3 (Chapter 6)

3.7 THE PERSON

This research used an experimental boundary setting design to select suitable participants to study [183]. The population under study were adults aged 65 years and above.

3.7.1 Inclusion and Exclusion criteria

Inclusion and exclusion criteria were established as follows:

Inclusion:	Well and independently living in the community
	Managing own meals: shopping, preparation
Exclusion:	Upper limb weakness from CVA, etc.
	Diagnosis of dementia
	Visual deficits (apart from wearing glasses for normal vision)

3.7.2 Sampling

As the research question involved hypothesis testing and the need to understand the experiences of the user, a non-probability convenience sampling method was utilised across the three studies. This approach is also known as volunteer, opportunistic or accidental [186]. A more recent text, describes this sampling method as a 'non-probability convenience or purposive sampling approach' [177]. Non probability sampling is not random. Participants are recruited from a broader population in a targeted way, endeavouring to have a representative sample of the broader population under study

(well community living people aged 65 years and over). Random sampling would not have been a practical approach to this research due to the research design, time and resource constraints.

Sampling also relied on snowballing as a recruitment strategy. Snowball sampling is also known as networking [183] and occurs when participants are asked to provide names of other people interested in the study who fit the inclusion criteria. This approach was successful for recruiting participants in all three studies.

By using non-probability convenience sampling, the research is purposive in its sampling approach. The participants have been deliberately selected based on inclusion and exclusion criteria from targeted sample groups. This type of approach is also known as judgemental sampling [183] as the inclusion and exclusion criteria were pre-defined by the researcher.

Participants in Study 1 were recruited via a friendship group and community groups with interested participants recruiting friends and partners. Participants in Study 2 were recruited via University of Wollongong email with interested participants encouraging friends and partners to volunteer. Participants in Study 3 included participants from the previous study as well as snowballing of recruitment via community groups and a local GP surgery. The same biostatistician was consulted before, during and after the research providing consistency in statistical advice and methods.

3.7.3 Grip and Pinch Strength

Standardised assessment methods, which have well- established validity and reliability were used to test grip and pinch strength. The American Society of Hand Therapists (ASHT) have established standardised testing protocols for grip and pinch strength, which are used by most therapists when assessing hand function and were applied for this research [134, 184]. Using consistent and standardised assessment protocols allows for comparison with other studies and normative data.

3.7.3.1 Instruments

Instruments with the best calibration for accuracy and reliability as used by the standardised protocol are the Jamar Dynamometer (Lafayette Instruments, Indiana, USA) and the B&L Pinch Gauge (B&L Engineering, California, USA) [108]. These two instruments and the standardised seated protocol were utilised in the thesis studies. All equipment was calibrated prior to use in all studies.

3.7.3.2 Testing posture, handle position and number of trials

The standardised protocol as recommended by the ASHT is as follows:

> *The shoulder abducted and neutrally rotated, elbow flexed at 90 degrees, forearm in a neutral position, and the wrist between 0 and 30 degrees extension and between 0 and 15 degrees ulnar deviation. In all cases the arm should not be supported by the examiner or by an armrest.*

Figure 3.5 shows the testing position for hand grip measurement during researcher training for Study 3.

Figure 3.5 Hand grip testing with research assistants for Study 3 (Chapter 6)

The Jamar dynamometer has 5 handle positions, however the standardised protocol recommends using position 2 and this was the testing position for the thesis research. The protocol also recommends 1-3 trials of grip strength testing and if using more than one trial, taking the mean of the measures. Researchers have investigated the effect of varying the trial number on reliability and found that for healthy subjects, one trial is suitable [187-189]. Consequently, 1 trial was utilised in the thesis studies.

3.7.3.3 Assessor training

As outlined in Chapter 1, the Introduction, the research team for all three studies had consistent lead personnel. The hand therapist supervised all training of researchers for the three elements of hand function assessment (grip, pinch and dexterity) to ensure competency and reliability of results; and was involved in testing for all three studies. Excellent inter-rater reliability has been found for

both health science students [190] and people with a non-health-background conducting hand assessments following training [191].

All hand assessments for Study 1 were conducted by the hand therapist and the PhD student (with an extensive Occupational Therapy background). Hand assessments in Study 2 were conducted by the hand therapist, the PhD student and two student dietitians (following competency training and inter-rater reliability assessment). Hand assessments in Study 3 were conducted by the hand therapist and two graduate research assistants, one with a physiotherapy background. Again, competency training prior to the study and supervision during the study was conducted by the hand therapist to ensure reliable and consistent assessment.

3.7.4 Dexterity

A number of tools are available to assess dexterity. As discussed in Chapter 2, dexterity can be described as fine or gross dexterity. While the task of opening a hospital food and beverage pack requires both forms of dexterity for success, fine dexterity is the key component to be able to access and lift tabs, etc. Consequently a reliable and valid tool to assess fine dexterity was required.

The Purdue Pegboard test (Lafayette Instruments, Indiana, USA) was selected as this tool has been shown to have proven reliability and validity [114, 129, 192], and specifically measures fine dexterity [126]. The Purdue Pegboard test was initially developed in the 1940s to assess applicants' suitability for industrial work [114]. It has since been used to identify cerebral lesions [112], and is now mostly used in rehabilitation as an assessment tool [114].

The Purdue Pegboard measures both unilateral and bilateral fine manual dexterity. The tool itself consists of a board, pins, collars and washers. The board has two parallel rows of 25 holes with pins, collars and washers in cups at the top of each row on the board. Four tests comprise the complete assessment. The standardised protocol allows for familiarisation with the task prior to assessment. A summation of the first 3 tests with the dominant, non-dominant and then both hands (RLBoth) determines a macro-dexterity score and this score is utilised in the thesis studies when reporting dexterity ability.

The Purdue Pegboard is shown in Figure 3.6, along with the grip and pinch testing tools. All hand testing protocols can be found in Appendix 2.

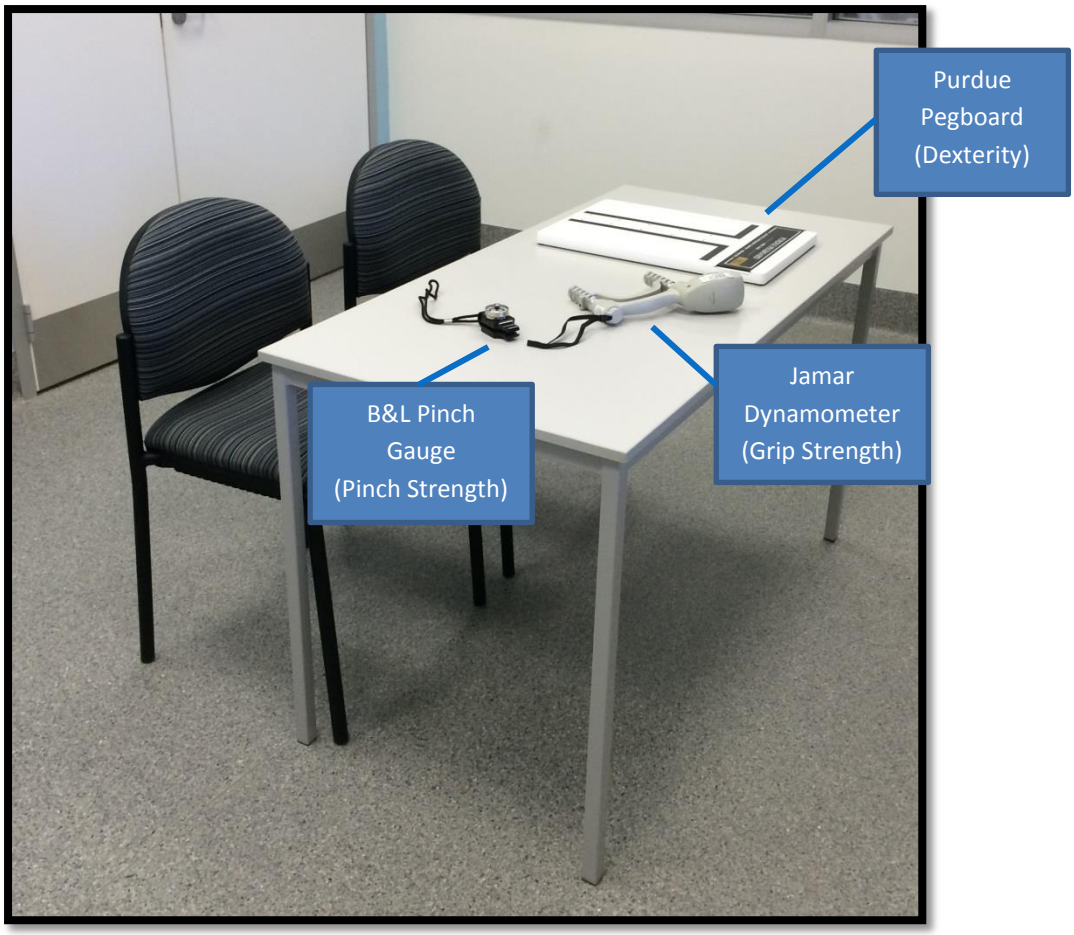

Figure 3.6 Seated hand testing room with grip, pinch and dexterity assessment tools

3.7.5 Nutritional Status

Study 3 included nutritional assessment as one of the measures, specifically to investigate any possible relationships between the person, packaging (sealed or pre-opened) and intake. While there are many nutritional status assessment tools [193], the Mini Nutritional Assessment – Short Form (MNA-SF®) was selected as this tool is specific for adults aged 65 years and over and can be used for community dwelling older adults.

The MNA® is commonly used by Dietitians in practice and has good validity and reliability [194, 195]. A shortened version of the MNA®, the MNA-SF® was developed as a quick, efficient and reliable screening tool for nutritional status among older adults [196]. This tool has been shown to be valid and reliable [196, 197]. The MNA-SF ® consists of 6 sets of questions on appetite, weight loss, mobility, psychological and neuropsychological issues and determination of BMI. The maximum score is 14. A score of 12-14 indicates normal nutritional status, a score of 8-11 at risk of malnutrition; a score of 0-7 indicating the person is malnourished [195, 196, 198].

3.7.5.1 Assessor Training

The MNA-SF ® was administered in Study 3 by two dietitians who were familiar with the form and assessment process. As these two research assistants had already been involved in Study 2 as student dietitians, they were also very familiar with the research, setting and associated protocols. A copy of the MNA-SF ® can be found in Appendix 3.

3.8 THE PACK

The food and beverage packs used for the studies in this research thesis were primarily sourced from the former South Eastern Sydney Illawarra Area Health Service (now Illawarra Shoalhaven Local Health District). As such, there was some variability between studies due to type of pack being used at the hospital at the time. One change of product type (boxed cereal) occurred between Study 2 and Study 3. Consequently, for consistency with this pack (which had been found to be problematic over the Studies 1 and 2) boxed cereal was purchased through the University supplier for Study 3. The sandwich triangle packs for Study 3 were sourced from the hospital, while the actual sandwiches were prepared in the University teaching kitchen for food hygiene reasons.

Study 1 included all packaging forms encountered by a patient in Illawarra hospitals in one day with the exception of the hot meal which was usually served on crockery plate, with a plastic lid placed over the top. As such, this study analysed all possible packs a patient may encounter. A sample tray is shown in Figure 3.3. Products are listed in Table 3.2, and sample tray shown in Figure 3.7.

Table 3.2 Packages tested in Study 1

Meal	Products	Pack type
Breakfast	Individual cereal serve (box)	Cardboard + plastic liner
	Weetbix serve	Plastic sealed pouch
	Milk serve (150ml)	Small bottle
	Juice	Plastic cup with peelable seal
	Condiments, vegemite, margarine	Plastic with peelable seal
	Butter	Foil envelope
	Cutlery	Sealed paper bag
	Tea bag	Sealed paper bag
	Coffee sachet	Sealed paper and foil sachet
	Sugar, salt, pepper	Sealed paper sachet
	Milk portion	Plastic with peelable seal
Snack	Cheese portion	Plastic sealed sachet
	Biscuits portion	Plastic sealed pouch
	Yoghurt serve	Plastic cup with peelable seal
	Water bottle (600ml)	Plastic bottle with screw top
Lunch	Soup serve	Plastic container with peelable seal
	Sandwich triangle	Plastic container pull opening
	Jelly	Plastic cup with peelable seal
	Mousse dessert	Plastic cup with peelable seal
	Dessert	Plastic sealed pouch
	Fruit pieces in syrup	Plastic cup with peelable seal
	Flavoured milk	Tetra pack

Figure 3.7 Sample tray for Study 1

Study 2 reviewed the packaging types found to be the most difficult for the participants in Study 1. The items included: containers with peelable foil seals, tetra packs, condiments, boxed cereals, cheese portions and dessert pouches. These items are shown in Figure 3.8.

Figure 3.8 Food and beverage items, Study 2

Study 3 expanded the research to include intake. Packaging was sourced for breakfast, snack and lunch meals. Study 3 contained the most problematic pack types found across all three studies. These products are listed in Table 3.3 and sample trays are shown in Figures 3.9, 3.10 and 3.11.

Table 3.3 Packages tested in Study 3

Meal	Products	Pack type
Breakfast	Individual cereal serve (box)	Cardboard + plastic liner
	Milk serve (150ml)	Small bottle
	Juice	Plastic cup with peelable seal
	Condiments, vegemite, margarine	Plastic with peelable seal
	Butter	Foil envelope
	Tea bag	Sealed paper bag
	Coffee sachet	Sealed paper and foil sachet
	Sugar	Sealed paper sachet
	Milk portion	Plastic with peelable seal
Snack	Cheese portion	Plastic sealed sachet
	Biscuits portion	Plastic sealed pouch
	Water bottle (600ml)	Plastic bottle with screw top
Lunch	Sandwich triangle	Plastic container pull opening
	Custard dessert	Plastic cup with peelable seal
	Fruit pieces in syrup	Plastic cup with peelable seal
	Flavoured milk	Tetra pack

Figure 3.9 Breakfast Tray, Study 3*

Figure 3.10 Snack Tray, Study 3*

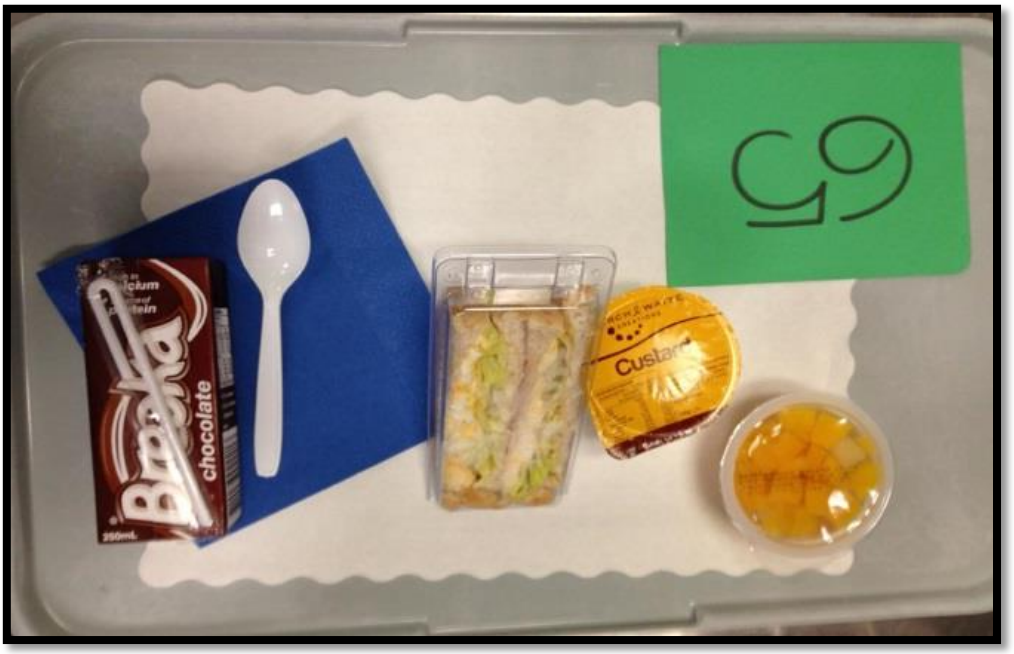

Figure 3.11 Lunch Tray, Study 3*

*Numbers on tray are oriented for camera view at foot of bed in testing setting.

3.9 THE PERSON/PACK INTERACTION

3.9.1 Observation

Video recordings were used in all three studies to capture both time taken to open packs and the number of attempts at opening each pack. Videotaping and audiotaping are common techniques used in qualitative research [183]. Video recording has consistently been used in ergonomics research to evaluate musculoskeletal load during tasks [199, 200]; and has been used by the author for research to review manual handling loads of cleaning workers [201]. The use of video recording for this type of ergonomics research is quantitative in its approach, integrating the traditionally qualitative method of video recording with quantifiable measures of time and attempts.

Digital video cameras (Samsung VP-D130i; Canon 51X Legria HFR 506) on tripods were used for Study 1 (Chapter 4). The Canon digital video cameras (51X Legria HFR 506) on tripods were also used as a back-up in Study 3 (Chapter 6). These 'reserve' cameras were required on one day of testing when the in-situ system failed. Figure 3.12 shows the 'reserve' cameras being set up for Study 3 (Chapter 6).

Figure 3.12 'Reserve' cameras being installed in shared ward simulation suite for Study 3 (Chapter 6)

The University of Wollongong Nursing Simulation Suite had in-situ cameras positioned at the head and foot of each hospital bed for recordings using the following equipment, and researchers were trained in their use:

Cameras:	Vaddio PTZ18 High Definition cameras
Integrated camera controller:	AMX Touch Panel NXT-CV10
Recording Device:	V Brick Encoder 9000

Participants consented to their hands being filmed during the study and the footage being used for later analysis. For each study, two researchers initially reviewed video footage of specific participants independently to determine the number of attempts at pack opening. Pack opening was determined to commence from the first contact with the opening mechanism, for example, lifting a tab, pulling straw from tetra pack. The researchers then compared results andjointly reviewed any footage that was uncertain due to obstructed view of hand actions, for instance. No formal inter-observer ratings were assessed. This is a weakness of the research.. Accuracy in data collection from the videos, however, was enhanced through consistent researchers across all three studies (Chapters 4, 5 and 6).

3.9.2 Questionnaires

Questionnaires in structured interview format were used for all three studies in this research. Conducting questionnaires in structured interviews is a common data collection method. Where possible, it is preferable to use questionnaires that have established reliability and validity [186]. However, this was not possible for this research and consequently the questionnaires were developed and trialled in the Pilot Study [5]. Additional questions were added in Study 3 (Chapter 6) to further explore Activities of Daily Living (ADL) function capability as the study required a greater subject burden. The questionnaires included rating scales (ease of opening; appetite and food quality/quantity); as well as mostly closed questions (reasons for difficulty opening pack; activities of daily living (ADL) tasks), with a few open ended questions (comments about packs). The open ended question responses were coded for analysis.

The development of the questionnaires began with review of relevant literature in packaging openability and accessibility as well as Occupational Therapy textbooks and ADL assessment tools. The research team of experienced health professionals reviewed and modified the questionnaires for the Pilot Study. As the quantitative data of timing and hand function was able to confirm the findings of the ratings of ease of opening and the reasons for difficulty questionnaires (that is there

was convergence), we can assume that these tools have adequate reliability and validity, and, in fact, established construct validity [183, 186].

This established construct validity of these questionnaires is essential for the thesis studies to ensure that the inherent disadvantages of customised questionnaires and structured interviews were addressed. These disadvantages include lack of clarity around the questions, respondents may feel socially pressured to answer in certain ways, and all the respondents' concerns may not be recorded. The benefits on the other hand are that it can elicit honest responses from large cohorts and be readily analysed to compare groups[183]. By conducting the structured interviews with each participant individually, the participant was provided with the opportunity to clarify the meanings of questions and not be socially pressured to answer in the same way as another participant. The open ended questions enabled a greater opportunity to capture the views of the respondents. While the categorisation of the questionnaires allowed for discrete data collection, some rich qualitative data could have been lost. Packaging designers rely on focus group and qualitative user experience data and this data was not collected in the thesis studies.

Table 3.4 outlines the use of questionnaires across the three studies (Chapters 4, 5, 6). Copies of all questionnaires can be found in Appendix 4.

Table 3.4 Context of questionnaires in the 3 studies

Questionnaire	**Study 1**	**Study 2**	**Study 3**
Ease of opening + Reason for difficulty	✓	✓	✓
Appetite + health rating + quality/quantity of food			✓
Hand function + ADL			✓

3.9.3 Plate waste

Plate waste was selected to address the key aim of Study 3, investigating the impact of sealed packaging on amount of food wasted to determine dietary intake. Plate waste is a common method of determining intake [61]. Two methods are routinely used for calculating plate waste, weighing and visual estimation [61, 202]. Visual estimation can be done at the time of eating or via digital photography. Using digital photography has been found to be a more reliable method [202, 203]. While some researchers have found that both visual methods and weighing plates are both individually valid methods for intake estimation [202], others have found this not to be the case [61]. Therefore,

Study 3 (Chapter 6) utilised both digital photography and plate weighing to estimate plate waste and determine intake.

As the meals served throughout Study 3 were consistent, sample meals were measured prior to the study to establish standard weights using one set of electronic scales (CAS Smart Weighing Scale SW-1; accurate to ±1g) . The only item open to variability in weight was the sandwich, however standard serves were established for the choice of three sandwiches (wholemeal/white bread): egg, mayonnaise and lettuce; chicken and lettuce; ham and tomato. Individual trays were photographed pre and post-delivery to the 'hospital ward' on the research days; and plate waste was measured back in the preparation kitchen after food was consumed. Figure 3.13 shows the scales used for standardised food serves and weighing plate waste in the preparation kitchen. Copies of the data collection forms can be found in Appendix 5.

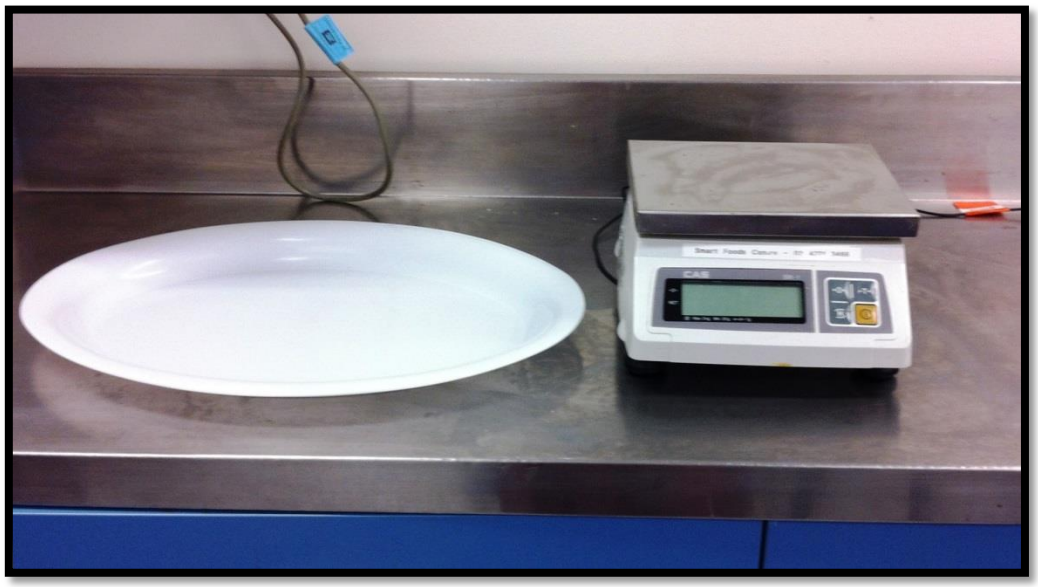

Figure 3.13 Digital scales used to measure standard food serve and plate waste

3.10 DATA ANALYSIS

Statistical advice and guidance was sought from the same biostatistician/dietitian for all studies in this PhD thesis. Descriptive statistics were conducted for all three studies to determine means, standard deviations and frequencies. Parametric and non-parametric tests were applied according to sample distribution. Differences in measurements between conditions (laying in bed, sitting in chair; sealed or pre-opened packaging) were explored with a range of t-tests and Wilcoxon Signed Rank Tests. Correlations were performed using Spearman's rho. Significant

differences were defined as $P < 0.05$. All analyses were calculated using Statistical Package for the Social Sciences software (SPSS IBM Inc. 2010; 2012, Chicago, IL, USA). Details of specific statistical tests used for each study can be found in the study chapters; Study 1 in Chapter 4, Study 2 in Chapter 5 and Study 3 in Chapter 6.

3.12 CONCLUSION

This chapter has outlined the theoretical underpinnings of the ergonomics approach used in this thesis research. Ergonomics provides a unique lens to review the issues surrounding the context, person, the pack, the person/pack interaction, and the task of eating as it is at its core a balance of qualitative and quantitative approaches. Such an integrated mixed methods design has been shown to be the most effective way to examine human and health service issues.The following chapters contain details (protocols and statistical analyses) of the studies conducted within this thesis and submitted as manuscripts to scientific journals:

Chapter 4 **Study 1**, the community study investigated grip, pinch strength, opening times and attempts

Bell, A.F., Walton, K. A., Tapsell, L. C., *Easy to open? Exploring the 'openability' of hospital food and beverage packaging by older adults.* Manuscript number: APPETITE-D-14-00985R2. (Second review submitted 9 October 2015)

Chapter 5 **Study 2**, the simulated hospital study investigated grip, pinch strength, opening times and attempts; but also dexterity and bed posture

Bell, A.F., Walton, K. A., Tapsell, L. C., Yoxall, A. *Accessing packaged foods and beverages in hospital: The importance of a seated posture when eating.* Journal of Human Nutrition and Dietetics. (Submitted 30 November, 2015).

Chapter 6 **Study 3**, a further simulated hospital study investigated grip, pinch strength, opening times and attempts, dexterity, bed posture; and also nutritional status and dietary intake

Bell, A.F., Walton, K. A., Tapsell, L. C., Batterham, M. *Exploring the effect of hospital food and beverage packaging on dietary intakes by older people.*
APPETITE-D-15-01077. (Submitted 30 November, 2015)

Chapter 7 **Integration of Research**: Methodology for assessing packs based on findings from studies, identifying dexterity as the critical factor in pack openability.

Bell, A.F., Yoxall, A., Walton, K. A. *Measure for Measure: Pack Performance versus human dexterity and grip strength.* Manuscript number: PTS-14-0110.R1.Packaging, Technology & Science. (Submitted 23 March 2015; under review).

CHAPTER 4 EXPLORING THE 'OPENABILITY' OF HOSPITAL FOOD AND BEVERAGE PACKAGING BY OLDER ADULTS

CHAPTER 4 PREAMBLE

This chapter consists of a manuscript reporting Study 1, submitted to Appetite October, 2015 following a second review:

Bell, A.F., Walton, K. A., Tapsell, L. C., *Easy to open? Exploring the 'openability' of hospital food and beverage packaging by older adults.* Manuscript number: APPETITE-D-14-00985R2.

This is the first empirical study, as outlined in Table 4.1.

Table 4.1 Study 1: Full range of hospital food and beverage packs

Study	Chapter	Pack	Sample (n)	Methods Applied						
				Video Timing	Q'nnaire	Grip + Pinch	Dexterity	Bed Posture	MNA	Food Intake
1	4	Full range hospital F&B packs	40	✓	✓	✓				
2	5	Problematic packs	34	✓	✓	✓	✓	✓		
3	6	B'fast, snack & lunch packs	62	✓	✓	✓	✓	✓	✓	✓

The research question for this first empirical study was:

Do well older people experience difficulties with opening hospital food and beverage packages; and is hand strength the critical factor for efficient pack opening?

EXPLORING THE 'OPENABILITY' OF HOSPITAL FOOD AND BEVERAGE PACKAGING BY OLDER ADULTS

4.1 ABSTRACT

Food is increasingly a packaged commodity, both in the community and in institutionalised settings such as hospitals, where many older people are malnourished. Previous research with patients aged over 65 years in NSW public hospitals identified difficulties opening milk, water, juices, cereal and tetra packs. The aim of this paper was to assess the ability of well older people living in the community to open food and beverage items routinely used in NSW hospitals. This data provides further insights into the older person/pack interaction and the role of hand and finger strength in pack opening. A sample of 40 older people in good health aged over 65 years from 3 community settings participated in the study. The attempts at pack opening were observed, the time taken to open the pack was measured and the correlation between grip and pinch strengths with opening times was determined. Tetra packs, water bottles, cereal, fruit cups, desserts, biscuits and cheese portions appeared to be the most difficult food products to open. Ten percent of the sample could not open the water bottles and 39% could not open cheese portions. The results were consistent with the previous research involving hospitalised older adults, adding emphasis to the conclusion that food and beverage packaging can be a potential barrier to adequate nutrition when particular types of packaged products are used in hospitals or the community. The ageing population is rapidly becoming a larger and more important group to consider in the provision of goods and services. Designers, manufacturers and providers of food and beverage products need to consider the needs and abilities of these older consumers to ensure good 'openability' and promote adequate nutritional intakes.

4.2 INTRODUCTION

Prevalence of malnutrition in the hospitalised older population is estimated between 6-53% in Australia depending upon diagnosis, assessment tool and timing [67] and between 20-65% in European and US hospitals [6, 85, 93, 204-206]. In NSW public hospitals, the Special Commission of Inquiry into Acute Care Services [3] reported that at any point in time there were around 7,480 people 65 years and older in hospital, representing 44% of all inpatients. With the projected growth in numbers of people aged 65 (older adults) and the corresponding growth in people aged above 85 (older old adults) and their complex and chronic health conditions, most hospital patients in the future will be 'elderly'. The report also discussed the provision of food and food services in NSW

hospitals and the move towards centralisation of production with the 'cook-chill' system. Here food is mostly prepared in advance, kept chilled in a refrigeration system at the hospital and then heated in customised trolleys in the kitchen or on the ward. This form of food provision signals the regular use of packaged foods as these are considered cost effective and provide standardised portion sizes. Packaged food service has implications for the older patient at risk or experiencing malnutrition, as to access the food, the older person must be able to open the pack.

While the reasons for malnutrition are complex and multifactorial [94-96], hospital food service systems have a key role to play in enabling patients to consume food, beverages and supplements to assure adequate nutrition for recovery [51, 207-209]. The system can play a role in the 'food as medicine' paradigm of the holistic care model. However, a number of previous studies and reports have identified that food and beverage packaging is a contributing factor to malnutrition for the older and disabled patient in hospital settings [6, 70, 87, 88, 99]. A 2007 NSW Health Service malnutrition prevalence audit identified that a number of patients did not eat their food because they could not open the packaging [89]. NSW Health has acknowledged that food and beverage packaging can pose an accessibility problem for the patient and they have implemented a tender checklist for products purchased by the hospital system in an attempt to order the best performing packs [210]. Many products, however, such as water, biscuits and supplements (served in tetra packs) are considered by patients to be difficult to open[5].

Malnutrition is not restricted to the hospitalised older population. Research has identified that many older people enter hospital in a malnourished state, indicating that their nutritional status was compromised prior to admission. For example, one study in Sweden found 14.5% of older people living in their own homes were at risk of malnutrition [81]. In a similar Australian setting of independently community living older people receiving home nursing services 34.5% were found to be at risk [83]; while in a Belgium based study 57% of older home-living participants were at risk of malnutrition [82]. More general reports indicate malnutrition amongst the community living older population is likely to be 8-10% [80, 83, 84]. The implications for this malnourished group on entering hospital includes longer recovery time, greater susceptibility to infection and medical complications as well as significantly longer length of hospital stay leading to greater cost of care [86, 211, 212]. In the community, malnutrition can lead to decreased mobility, depression, as well as an increased likelihood of other illness and falls [81, 85, 86, 213].

With the ageing Australian population, many older people in the community live alone. In 2011, 50% of people 65–84 years and 34% of those aged 85 years and over lived alone [214]. These percentages are projected to remain constant over the next 20 years while the number of those aged 65 and over living alone in Australia will almost double to 1.45 million people. These percentages are projected to remain constant over the next 20 years while the number of those aged 65 and over living alone in Australia will almost double to 1.45 million people. The packaging industry recognise this shift to single 'grey' households [19] with the development and increasing availability of 'easy-opening' packaging, single portion products and individual microwaveable meals. 'Easy-opening', however, is often a marketing term rather than a reality for many consumers. Traditional design criteria consider the user capabilities of the majority (95%) of the total population, rather than universal design [37, 156]. Universal design is considered inclusive in that this design approach allows the product to be used by the largest range of possible users in a variety of environments [24].

Researchers have investigated accessibility issues with food packaging, mostly concentrating on opening jars with vacuum lug closures (VLC) and determining how much force the user required to open the lid [37, 158], as well as biomechanical analysis with motion capture [157]. The size, shape and texture of the package has been found to determine the grip to be adopted – lateral pinch grip for small lids such as water bottles, tip or chuck (3 point) pinch for thin film and flexible packaging such as individual serves of yoghurt, cheese and biscuits [166] .

While much of this research has focussed on biomechanical aspects of opening packaging, a few researchers have also reviewed user satisfaction. Pousette [144] surveyed users from different age groups and found the key factor informing satisfaction with packaging was the ease of opening. A Japanese consumer survey found that users preferred packs that required low levels of strength to open, could be opened without a tool and the method needed to open the pack was easily understood [215]. Mixed methods packaging studies include a previous study of hospitalised older adults [5] and a recent study investigating the issues of peelable supermarket meat packaging and patients with hand disorders to determine a more efficient seal design [171].

The previous research conducted in NSW hospitals highlighted problems for older patients opening packaged products used in food service delivery through a combination of observation, self-report and grip and pinch strength measurement [5]. The study reviewed a limited range of hospital food and beverage items with 24 participants in the hospital environment, finding relationships between grip and pinch strength and efficient opening of tetra packs, cereal packs and biscuit portions. While

water bottles in the hospital study were described as impossible to open by 40% of survey respondents, no significant correlation with grip strength was found, despite the reasons for difficulty being attributed to strength [5]. The study had a small sample size and as it was conducted within a hospital environment the findings could have been affected by the health status of the individual and associated medical environment. Further research into the relationship between hand and finger strength of older people and efficient opening of food and beverage packs used in NSW hospital food service would be useful to examine this issue more fully and explore pack openability with older users generally.

The purpose of this study, therefore, is to comprehensively assess the full range of hospital food and beverage packs with *well* older people (aged 65 years and above). Well older people (aged 65 years and above) were selected as participants as the results of the previous study with hospitalised older adults may have been affected by participant's health status and competing demands of the hospital environment. The aim of this community study was to determine if well older people living independently at home have difficulty opening packaged foods commonly used in NSW hospitals and to gain further insights into the older person/pack interaction and the role of hand strength in pack opening. This research will inform better product selection and design that would optimise nutritional intakes.

4.3 METHODS

This study used an ergonomics research methodology, integrating qualitative and quantitative methods in order to triangulate data to more fully understand pack 'openability' [174, 175]. Integrated qualitative and quantitative approaches to research have been found to be '..the most comprehensive and productive approach to health and human service research [183].'

4.3.1 Participants

This study included a non-probability convenience sample of 40 well older men and women living in three community locations in regional NSW, Australia. Forty participants were deemed adequate for statistical power ($p<0.05$ and 80%). Criteria for joining the study were that participants were over 65 years of age, had no cognitive impairment or upper limb weakness, were living independently in the community and preparing their own meals. This judgemental sampling included snowballing recruitment methods through involvement of community groups and consequently, the participants were a self-selected group and may not be representative of the wider population. An over-

representation of women (68% of the total sample) was expected as they currently make up 55% of people aged 65 years and older [216].

The study was conducted by researchers from the University of Wollongong and a hospital based occupational therapist/hand therapist at three community locations, a community club; a church meeting location and an urban residence. Ethics approval was obtained by both the University of Wollongong and the former Eastern Sydney and Illawarra Area Health Service (SESIAHS). Written informed consent was obtained from all participants.

4.3.2 Sample meal tray

A range of hospital food and beverage items were supplied from a local hospital on the three testing days. The range of food and beverage items and number tested varied according to the availability of the items from the hospital. Items included breakfast, snack and lunch packs as outlined in Table 4.2. Note that milk (150ml), fruit cup, biscuit portions and sandwich triangle packs were the only items tested by all participants. The sequence of pack opening was not prescribed, allowing participants to determine the order of pack opening. Participants were asked to open the packs with their hands only. No time limit or restriction on number of attempts was imposed by researchers.

Participants consented to their hands being video recorded while opening food and beverage items from a sample meal tray. Items on the tray consisted of products served at breakfast and lunch, as well as snack items (see Figure 4.1).

Figure 4.1 Example testing tray with selection of hospital food and beverage items

Table 4.2 Range and number of hospital food and beverage packs tested in study

Breakfast Items	# packs tested	Snack Items	# packs tested	Lunch Items	# packs tested
Juice portion	37	Water bottle	36	Soup portion	38
Milk (150ml)*	40	Fruit Cup*	40	Dessert Bowl	20
Yoghurt	39	Biscuit pack single serve*	40	Mousse	19
Cereal sachet	21	Cheese portions	27	Jelly cup	37
Boxed cereal single serve**	7	Tetra pack	19	Pureed fruit jelly	9
Vegemite portion	38			Sandwich triangle pack*	40
Jam portion	38			Sugar sachet	31
Butter portion	29			Coffee sachet	35
Margarine portion	30			Salt & Pepper sachets	28
				Milk portion	37

*Tested by all participants.
**27 participants attempted this pack, however data is only available on 7 as only these participants opened the complete pack (box + inner bag).

Mini Digital Video Recorder/s were positioned on a tripod in front of each participant to record their hand actions. The video recording allowed accurate time recording of food and beverage package opening, number of attempts to be determined and a review of the strategies used to open the packaging.

4.3.3 Hand grip and pinch strength testing

Grip and pinch strength testing was conducted on each participant using a standardised protocol (American Society of Hand Therapists, 1992) with the Jamar Grip Strength Dynamometer (Lafayette Instruments, Indiana, USA) and the B&L Pinch Gauge (B&L Engineering, California, USA). Both instruments were calibrated prior to the study. For standardisation, the dynamometer's adjustable handle was set on the second handle position for all participants, with one trial and hand dominance recorded; while the B&L pinch gauge measured tip, lateral and 3 point pinch strength for a single effort. These two hand assessment tools are commonly used and considered to produce the most reliable and valid measurements of grip and pinch strength [108, 184, 217, 218].

4.3.4 Questionnaire

Participants were requested to complete a questionnaire that utilised components from an earlier study [5] as shown in Appendix 4. The questionnaire was delivered as a semi-structured interview with the researcher. The questionnaire provided greater qualitative detail about particpant experience with the packaging. Questions related to hand function (strength, tremor, pain, range of motion, arthritic conditions, hand dominance) and vision; as well as issues relating to opening the food items. Ratings of opening ability were organised by answering 'yes' or 'no' followed by a scale of 'no difficulty/easy', 'some difficulty', 'moderately difficult', 'very difficult', and 'impossible'. If a participant could not open a pack (many attempts and then left pack), it was coded as 'no' and the rating deemed 'impossible.'

4.3.5 Data analysis

Data for all phases were analysed using a standard statistical package, SPSS V19 (SPSS Inc., 2010). Questionnaires and sample meal tray recordings were analysed using descriptive statistics to measure participant views and time taken to open packs. One sample *t*-tests were used to compare grip strength with normative data. Correlations were performed using Spearman's rho to examine relationships between grip and pinch strengths and time taken to open the items. A correlation of 0 indicating no relationship, while a score of -1 or 1 indicating complete correlation. According to Cohen (1988) a small correlation is between ±.10 and ±.29, a medium correlation between ±.30 and ±.49 and a large correlation is ±.50 and ±1.0. Negative correlations indicated shorter opening times and therefore better pack efficiency.

4.4 RESULTS

4.4.1 Participants

Participants were recruited form Blackheath, Blue Mountains region (n=13); Warilla, South Illawarra region (n=16); and Thirroul, North Illawarra region (n=11). This resulted in a total sample of 40 participants with a mean age of 77 (SD 6.3) years, and an age range between 65 and 88 years. The mean age of females (n=27) was 76.4 years (SD 6.4) and males (n=13) was 77.2 years (SD 6.2). Participants in the Blue Mountains region were a friendship group of retirees; the participants in the South and North Illawarra regions from established community groups of retirees.

4.4.2 Food and beverage items

The mean time taken to open the food and beverage packs was determined and is shown in Figure 4.2. The juice portion had the fastest mean opening time (3.5 sec); the water bottle 8.5 sec, biscuit sachet 10.3 sec, fruit cup 17.3 sec and tetra pack 32.3 sec. The cheese portion took the longest time to open with a mean time of 50.9sec, while the shortest time was 9.0 sec.

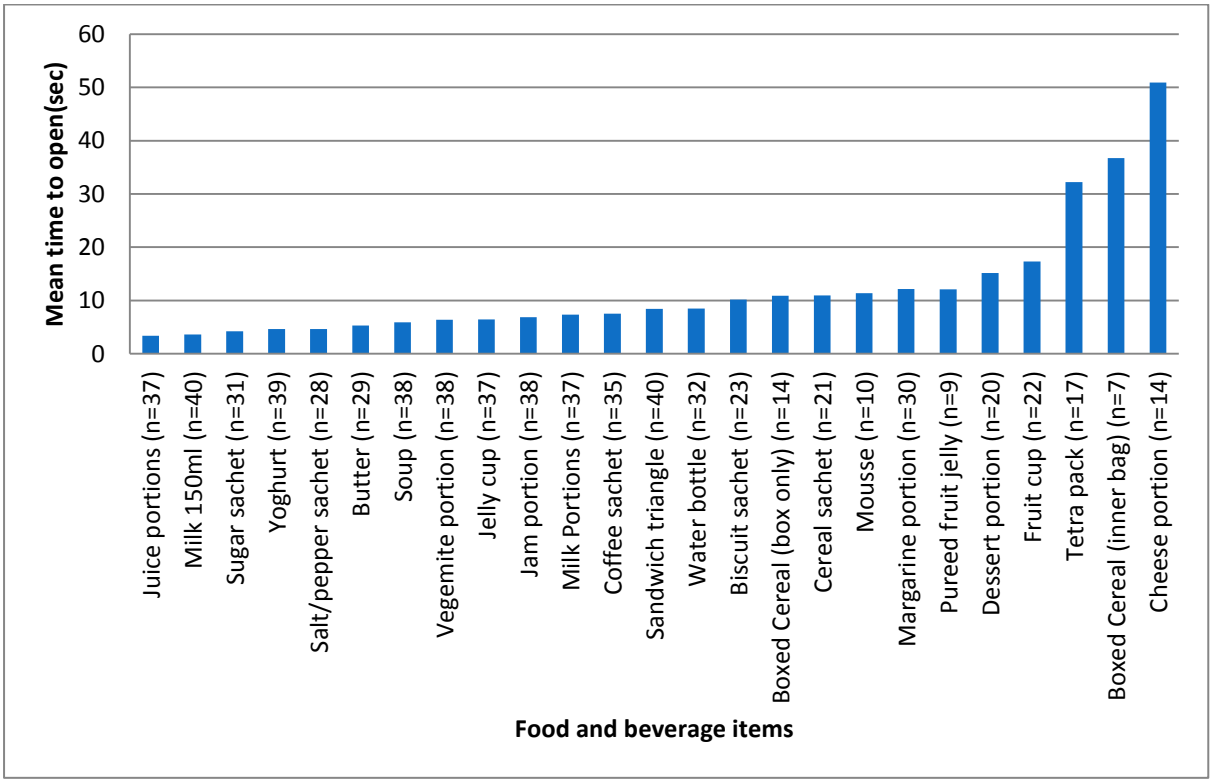

Figure 4.2 Mean time taken to open packs (sec)

Figure 4.3 shows the number of attempts to open each food and beverage item. The juice portion had the least attempts (mean 1.1); the biscuit sachet a mean of 2.5 attempts; the water bottle a mean of 2.8 attempts, and the fruit cup with the most attempts to open with a mean of 5.8. The cheese portion had the longest mean time (50.9 sec), a mean of 5.6 and minimum of one attempt to open.

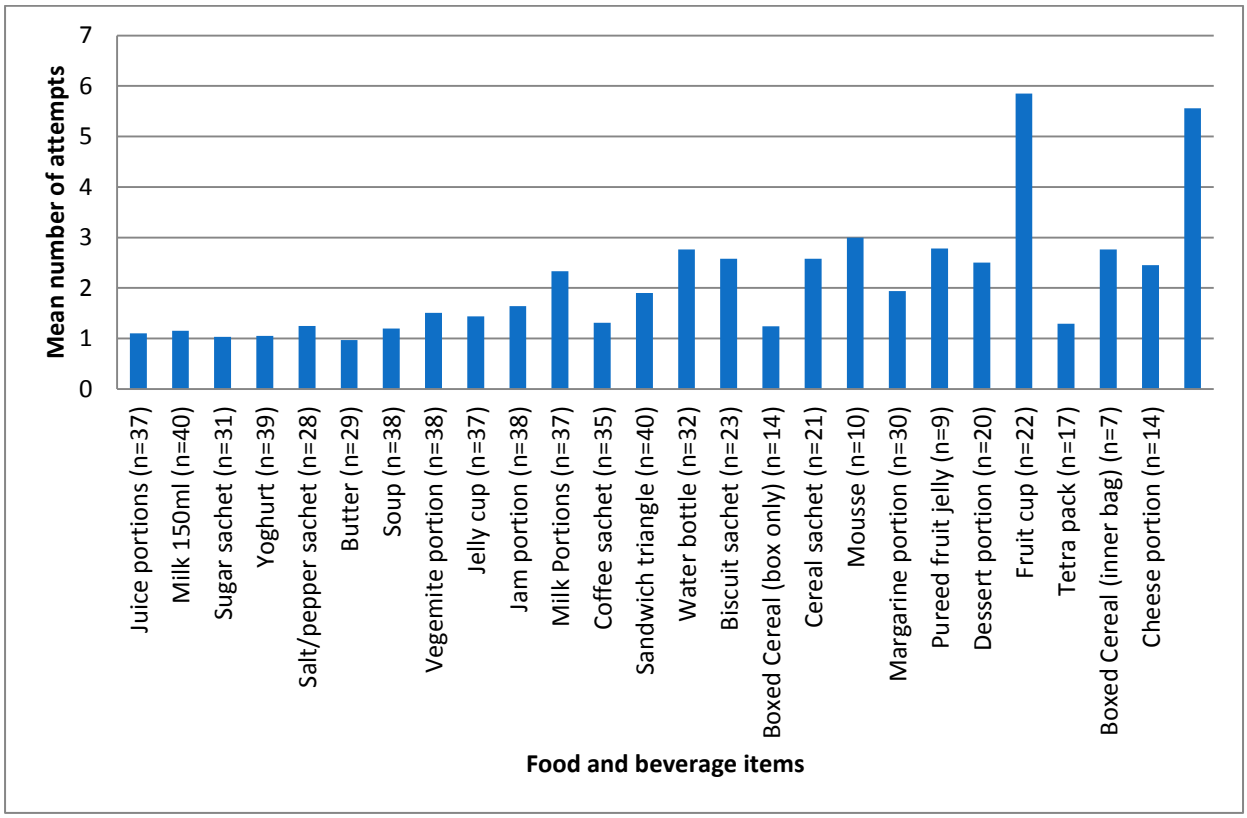

Figure 4.3 Mean number of attempts to open packs

4.4.3 Hand grip and pinch strength testing

Grip and pinch strength test results showed a normal distribution across the sample (n=40) for Dominant Grip and Dominant 3 point pinch grip. Dominant lateral pinch grip and non-dominant lateral pinch grips with all other grip and pinch tests were not normally distributed (Table 4.3). Please note that data for dominant 3 point and lateral pinch grips represent 39 of the 40 participants as one participant did not complete this aspect of the protocol. Please see Chapter 2, Section 2.4.3.1 and Chapter 3, Section 3.7.3 for definitions of grips and detail of grip assessment.

Table 4.3 Mean grip and pinch strength values of total sample, n=40 (kg/f)

	Dominant Grip (kg/f)	Non Dominant Grip (kg/f)	Dominant Pinch Grips (kg/f)			Non Dominant Pinch Grips(kg/f)		
			Tip	3 point*	Lateral*	Tip	3 point	Lateral
Mean	24.99	24.00	3.68	4.90	5.01	3.18	4.18	4.88
SD	8.35	7.64	1.62	1.58	1.51	1.47	1.32	1.58

*n=39

Grip strength of this sample compares well to normative data using the same instruments [108] with normative dominant mean grip being 28.33kg/f and non-dominant mean grip being 24.0kg/f. No significant differences were found between the normative mean scores and the mean scores for this cohort.

Correlations were performed to investigate the relationship between different types of grips and time taken to open the packs and are outlined in Table 4.4. Results for the water bottle indicated a large correlation between dominant grip and shorter opening times as well as a medium correlation for non-dominant grip. Medium correlations were also found for both dominant and non-dominant grips and shorter opening times for biscuit portions, indicating that stronger grips are important for successful and efficient opening of these products. Genders have not been separated in this analysis as the focus on the research is the interaction of packaging and older people, regardless of gender.

Medium correlations were found for non-dominant tip pinch and the biscuit portion and fruit cup, indicating that stronger non-dominant tip pinch grips were associated with faster and efficient pack opening for these particular products.

Table 4.4 Correlations between grip strength, pinch strength and package type.

Pack	Grip Strength		Tip Pinch		3 Point Pinch		Lateral Pinch	
	Dominant	**Non Dominant**	**Dominant**	**Non Dominant**	**Dominant**	**Non Dominant**	**Dominant**	**Non Dominant**
Water bottle correlation coefficient	-.521**	-.389*						
p value	.001	.019						
Biscuit portion correlation coefficient	-.442**	-.347*	-.271	-.353*	-.114	-.095	-.237	-.286
p value	.004	.028	NS	.026	NS	NS	NS	NS
Fruit cup correlation coefficient			-.286	-.316*				
p value				.047				

* Spearman Rho Correlation is significant at the 0.05 level (2-tailed)
**Spearman Rho Correlation is significant at the 0.01 level (2-tailed)

4.4.4 Questionnaire

The accompanying questionnaire highlighted particular openability issues with the packaging, ranging from the participants inability to actually open the item/s and reasons why the opening was difficult. A number of packs were unable to be opened by all participants and these are detailed in

Table 4.5. Of the 23 cheese portions attempted, nine were unable to be opened (39% of sample); while four (10%) of the sample could not open the water bottle.

Table 4.5 Percentage of participants unable to open packs

Pack	Number attempted	Number unable to be opened	Percent of participants
Biscuit portion	25	2	8%
Water bottle	38	4	10%
Tetra pack	19	2	11%
Boxed cereal (box + bag)	17	3	18%
Mousse	13	3	23%
Fruit cup	29	7	24%
Cheese	23	9	39%

The participants were also asked to rate the opening of packs on a 5-point likert scale, ranging from 'easy' to 'impossible' (Figure 4.4). The water bottle was rated as 'easy' by 24 participants (63% of sample), with the tetra pack rated as 'easy' by 11 participants (58% of sample). However, the cheese portion ratings were spread across the categories, with only four participants (17% of sample) rating it as 'easy' to open, nine participants (39%) rating it as 'moderate' and 'very difficult' to open, and nine participants (39%) unable to open the pack and rating it as 'impossible.'

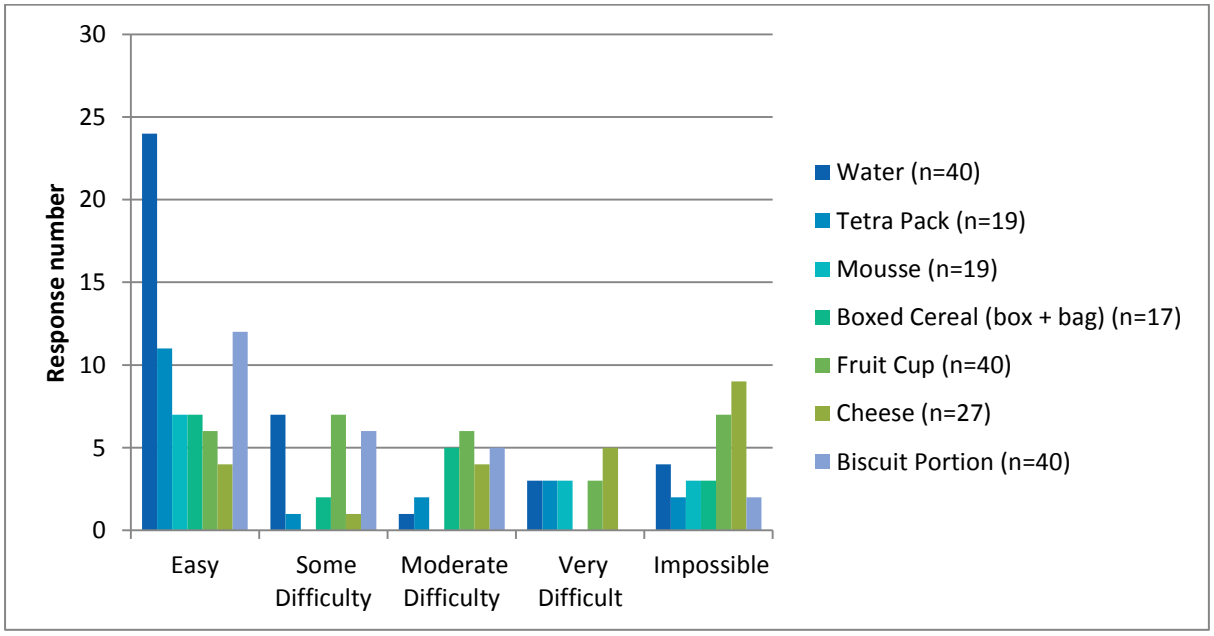

Figure 4.4 Ease of opening ratings for packs

Participants were also asked for reasons why the packs were difficult to open using four categories including vision, strength and pack characteristic of 'fiddly packaging' (Figure 4.5). 'Fiddly packaging' was the main reason given for pack opening difficulties, with the exception of the water bottle, which was attributed to strength issues.

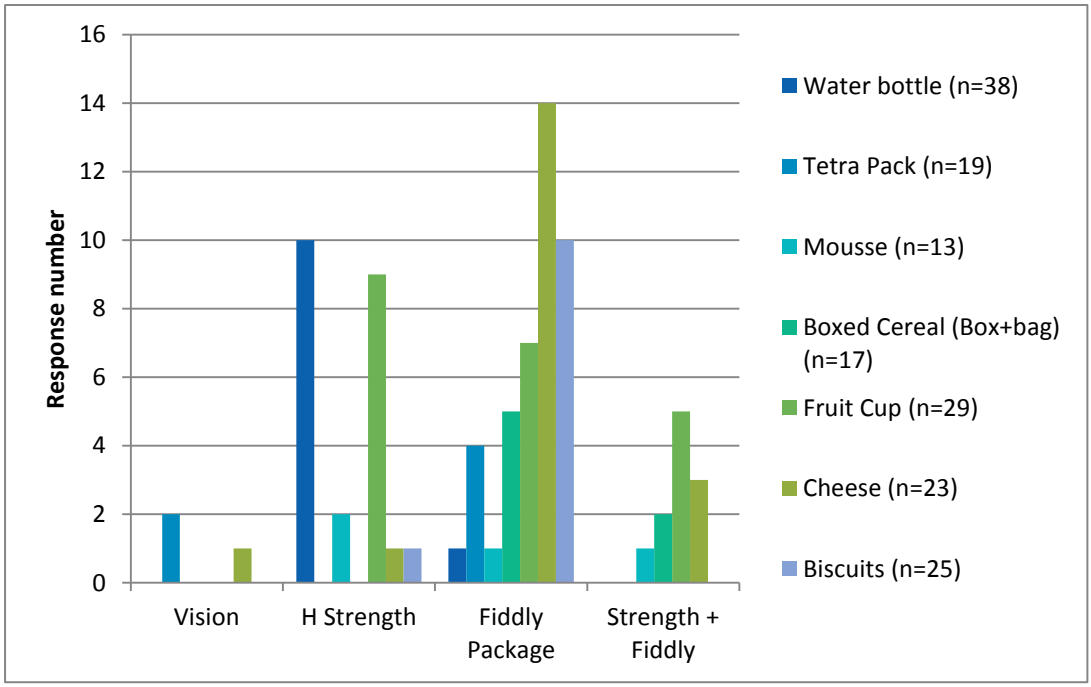

Figure 4.5 Reasons for difficulties in accessing packs.

When asked if they would like to comment on the packs to help identify where the difficulty lay with pack 'openability', most participants commented on mousse, cheese and biscuit portions. Participants stated that the tab on the mousse container was too small to grip and difficult to break the seal; seven people reported that the product spilt while they were opening it. Fourteen participants reported that the cheese portion was difficult to open because of the lack of instructions, while 10 participants reported the same issue with the biscuit portion.

4.5 DISCUSSION

Older people have disproportionate levels of malnutrition in both hospital and the community, with hospitalised older adults five times more likely to be at risk of malnutrition than younger patients [87, 88]. Packaged foods and beverages are a core component of food service in NSW hospitals and are commonly used in the community. While the reasons for malnutrition among older people in hospital, care settings and the community is multifactorial, packaging has been found to be a contributing factor in the hospital setting [6, 67, 70, 87-89, 99].

This study of well older adults interacting with packaged breakfast, snack and lunch items used in NSW hospitals, undertook a mixed method inquiry to examine the relationship of hand and finger strength with pack opening and reviewed user ratings of ease of opening. Hand strength is consistently associated with pack opening design and assessment in the literature [37, 154, 164, 166, 169]. However, the findings in both this study and the previous hospital study [5] show limited correlations between hand and finger strength and shorter opening times for the hospital food and beverage packs.

Only 3 packs were found to have significant correlations in this study, the water bottle, the biscuit pack and the fruit cup. Ten percent (n=4) of participants could not open the water bottle; 8% (n=2) could not open the biscuit pack and 24% (n=7) could not open the fruit cup. Four other packs could not be opened by some of the participants in this study. The tetra pack (11%; n= 2), boxed cereal (18%; n=3), mousse (23%; n=13) and cheese portion (39%; n=9). Hand and finger strength were not associated with efficient pack opening for any of these items with the well older people. This is a different finding to the previous study with hospitalised older adults [5] for both the tetra pack and the boxed cereal. In that study, strong correlations were found between hand and finger strength of the hospitalised older adults and efficient opening of the tetra pack. Similarly, finger 3 point pinch and lateral pinch grips were associated with faster cereal pack opening for the hospital study [5]. These differences could be due to a number of factors related to the hospital environment and/or the individual. Older people in hospital often eat in a semi-recumbent bed posture which could enhance or impair hand function; additionally their physical, social and mental well-being while in hospital may impact on how much hand strength they can exert. The impact of the hospital bed posture on hand function and ability to open packaging requires further investigation. Please see Chapter 5 for detailed analysis.

The limited correlations between hand and finger strength of well older adults and shorter opening times for the food and beverage packs in this study, indicates other aspects of hand function such as dexterity are likely to be involved with pack openability. This could be investigated in laboratory studies to determine if there is a relationship with an older person's dexterity and shorter pack opening times. Such information would be useful for pack designers, particularly for packs with multiple opening steps involving fine dexterity, such as the tetra pack which requires a small straw to be removed from the side of the pack, unwrapped and then inserted into the pack to access contents.

User satisfaction with packaging has been found to be closely linked with how easy the pack is to open [144]. The well older people in this study reported the cheese portion to be the most difficult pack to open, and attributed the reason for this accessibility issue to 'fiddly packaging.' Although the water bottle was rated as 'easy' to open by most participants, the reason for any difficulty opening the pack attributed to strength, consistent with the correlations for hand grips. The previous hospital study [5] reported that cereal boxes, condiments, tetra packs and milk/juice containers were the most difficult packs to open. Cheese portions were not assessed in the hospital study. It is likely that this difference between the two study groups of older people is due to aspects of the hospital environment such as the bed posture as noted above and this could be further explored through laboratory studies.

NSW hospitals have recognised there is a potential issue for patients. A number of strategies have been implemented to address the issues of food and beverage accessibility by colour coding trays to indicate which patients need assistance; and by instituting a checklist for the purchase of packaged food and beverages in consultation with Arthritis Australia [219]. As a result, cereal boxes are no longer used in NSW public hospitals. Colour coding of hospital trays and instituting tender checklists to utilise better performing packs is one approach to the issue of pack openability. A more lasting solution would be to either improve the design of products to enable access by every user or alter aspects of the food service delivery system to ensure all older adults can access their meal tray, be able to open the products and consume the contents.

Participants in this study noted a number of design characteristics which could be improved, including tab sizes being too small to grip and lack of opening instructions. Designing packs to optimise openability for the ageing population needs a universal design approach [220], to ensure the maximum number of people in a wide range of environments can access food and beverage packs. The packaging industry recognises the need to address the needs of the 'greying' market [19]. Mixed methodology research such as this study can 'bridge the gap' between users and designers to provide insights into the older person/pack interaction and inform better design; and in depth usability testing would provide opportunity to comprehensively explore users' views and experiences with pack opening.

What is clear from this research is that water bottles require strength to open – and strength decreases with age. Ten percent of the study group could not access the water at all, and 40% of

participants reported difficulty opening the bottle; while 17% of the hospitalised older people reported they could not open the water bottle [5]. Water is served in NSW hospitals to vulnerable and 'unwell' older adults in sealed plastic bottles and this practice has potential implications for the patient and the hospital system. Further research into the use of water bottles in hospitals is indicated to gather data on the effectiveness of bottled water meeting the hydration needs of hospitalised older adults, and assess any possible effects on length of stay.

The most difficult item for participants to open in this study was the cheese portion, with almost 40% of well older adults unable to open the pack. Cheese portions are an important high protein snack both in the hospital and the community. Older adults often eat smaller meals and use snacks to provide 'easy to eat' nutrition. A study of 2,000 Americans over 65 years was conducted to identify the extent and benefit of snacking [221]. Most participants (84%) were 'snackers' and the study concluded that snacking enabled adequate energy intake in this older population. While no studies were identified regarding Australian populations and snacking behaviours, older adults often eat smaller meals more often as their appetite decreases with ageing [86].

Tetra packs were unable to be opened by 11% of the well older people in this study, and 12% of the hospitalised older adults [5]. Tetra packs are used in institutional healthcare settings and the community for nutrition supplements. Further interrogation of the older person interacting with tetra packs could be undertaken using task analysis and usability studies to identify specific aspects of pack design to be improved.

There are a number of limitations to the research study outlined in this paper. Firstly, the participants were a non-probability convenience sample from community or friendship groups and self-selected to participate. As such, the researchers had little control over the participant involvement on the testing days. Secondly, participants completed the product testing in a shared environment in two settings (club and church venues) while in the third location (urban residence), participants completed the testing alone. This type of sampling approach is not random. Instead the participants are targeted, allowing judgemental bias as inclusion and exclusion criteria are determined by the researcher through a purposive sampling approach [177]. The sample size of the various packaged items varied and this has adversely affected the statistical power for products with less than 30 samples. As such this research is mostly observational in nature. Additionally, the influence of the central testing locations may have affected results in that participants were in an

artificial setting and not the normal environment for eating [222, 223]. True random sampling would prevent this bias but was considered impractical due to time and resource constraints.

The shared testing environment in two of the sample groups could have affected the time to open the pack – either delaying the time due to conversation, or shortening the time taken due to competition. While the testing environment may have influenced results, it does replicate the experience in hospital, where eating can be in a shared ward environment or alone in a single room. Thirdly, the participants opened the packaging on one occasion only and may have become fatigued during the testing, impacting on opening time. As the participants could determine their own order of pack opening, they could have elected to leave the more 'difficult' packs until the end and this may have affected their motivation to open the pack. The differences in grip strength between the hospital population and this well community dwelling population has not been examined. Further analysis of the effect of hospitalisation on grip strength is required to review the impact of the hospital environment and personal factors of the patient influencing grip strength.

Finally, while the participants considered themselves to be 'well', no formal testing of their physical, cognitive or mental health was undertaken and this could also have influenced the findings. However, as the driver for this research study was to assess an older person interacting with hospital food and beverage packaging as part of everyday life, a screening process was considered unnecessary. Additionally, these participants could be considered to be highly motivated users as they were socially active and encouraged by their social group to participate, and may not be reflective of older adults in the wider community.

4.6 CONCLUSION

This study has identified that well older adults experience difficulties opening single serve food and beverage items used by NSW hospitals, confirming and extending previous research with hospitalised older adults. A number of the well older adults in this study were unable to open a range of everyday packs, including the cheese portion, fruit cup, biscuit packs, tetra pack and water bottles. Hand strength was associated with successful opening of water bottles and biscuit packs only, indicating that dexterity is likely to be the most important aspect of hand function in determining openability.

Food and beverage packaging is now part of everyday life. It provides convenience for consumers and longevity for foodstuffs. As the population ages, many older adults are living alone and are purchasing single serve items to save on waste and for ease of use [224]. Food and beverage products that are highly nutritious and attractive with good 'openability' have an important role to play in enhancing independence and well-being of older people.

Further research is required to examine the role of dexterity and posture on pack openability and to explore the impact of packaging in the provision of foods and beverages for older people in hospital, care facilities and the community.

CHAPTER 5 ACCESSING HOSPITAL PACKAGED FOODS AND BEVERAGES: THE IMPORTANCE OF A SEATED POSTURE WHEN EATING

CHAPTER 5 PREAMBLE

This chapter consists of a manuscript reporting Study 2, submitted to the Journal of Human Nutrition and Dietetics, November 2015:

Bell, A.F., Walton, K. A., Tapsell, L. C., Yoxall, A. *Accessing packaged foods and beverages in hospital: The importance of a seated posture when eating.* Journal of Human Nutrition and Dietetics

This is the second empirical study, as outlined in Table 5.1.

Table 5.1 Study 2: Problematic packs

Study	Chapter	Pack	Sample (n)	Methods Applied						
				Video Timing	Q'nnaire	Grip + Pinch	Dexterity	Bed Posture	MNA	Food Intake
1	4	Full range hospital F&B packs	40	✓	✓	✓				
2	5	Problematic packs	34	✓	✓	✓	✓	✓		
3	6	B'fast, snack & lunch packs	62	✓	✓	✓	✓	✓	✓	✓

Study 1 (Chapter 4) established that well older community dwelling adults have difficulty opening the range of food and beverage packs supplied in NSW hospital food service, and that grip and pinch strength was only associated with the successful opening of water bottles and biscuit packs and did not account for the difficulty opening the other pack types. This second study built upon the first study by focussing on particularly difficult pack types identified in Study 1, and testing dexterity in addition to hand strength (grip and pinch). The environmental aspect of the hospital bed posture was also

included in this study, to compare the time taken to open packs in the two conditions (seated and lying down), in addition to examining the impact of posture on hand strength (grip and pinch) and dexterity.

The research question for this second empirical study was:

Is dexterity the critical factor for efficient opening of 'problematic' hospital food and beverage packs; and does lying in a semi-recumbent bed posture impede pack openability?

ACCESSING HOSPITAL PACKAGED FOODS AND BEVERAGES: THE IMPORTANCE OF A SEATED POSTURE WHEN EATING

5.1 ABSTRACT

Previous research has found that older people aged 65 years and over, both in hospital and in the community have difficulties opening food and beverage items used in hospital food service. Packs such as cheese portions and tetra packs regularly served in the New South Wales (NSW) public hospitals of Australia have been found to be particularly problematic. These studies investigated the role of hand strength on successful pack opening in in a seated position. However as many people in hospital eat in bed, this laboratory study used a qualitative method (satisfaction) and quantitative methods (grip and pinch strength, dexterity, time and attempts to open packs) in two conditions (bed; chair) with a sample of well older community dwelling adults (n=34).

Products tested included foil sealed dairy, foil sealed thickened water, tetra pack, dessert, custard, jam, cereal, honey sachet and cheese portions. Honey sachets, cheese portions, foil sealed dairy and tetra packs were found the most difficult packs to open and 15% of cheese portions could not be opened in either the bed or chair posture. Grip strength was consistent for each posture, while pinch grips and dexterity were adversely affected by the bed posture. Lying in a hospital bed required greater pinch strength and dexterity to open packs. Eating in a seated position while in hospital has been shown to improve intake. This study demonstrates that eating in a seated posture is also advantageous for opening the food and beverage packs used in NSW hospital food service and is applicable to other care settings. The research further explores the issues surrounding hand function and pack opening for older users.

5.2 INTRODUCTION

Food and beverages in NSW public hospitals are routinely served in a packaged format to deliver standardised portion sizes and cost effective nutrition [53]. This food service delivery model has to meet both the requirements of the organisation and the patient's need for adequate nutrition to aid in recovery [51, 208]. As such, the system of food service delivers 'food as treatment' [225]. Older people are disproportionally represented in hospitals and this is set to increase rapidly with the ageing population [214]. Consequently, ensuring the system of food service is equipped to meet the needs of the older inpatient is paramount. However, meeting these needs is challenging in hospitals where patients have been referred to as 'unwilling customers' [57], who are often malnourished [85, 93,

[204]; and experience physical, organisational and environmental barriers to eating [226]. While the primary purpose of food service in hospitals is to deliver adequate nutrition for recovery from illness or injury [51, 207, 227], this has proved hard to achieve for older patients who continue to have high rates of malnutrition [228]. A great deal of research has been undertaken to suggest and test interventions to improve the situation, such as changes to food service [51, 227, 229]; food fortification [46, 64, 65]; and volunteer feeding programmes [230, 231].

Positioning patients to eat by sitting them in a chair is one of the strategies shown to increase intakes by older people in the hospital environment [230, 232]. Intake has also been shown to significantly increase when patients are in a dining room where socialisation is possible [233, 234]. In an observational study of older people eating in hospital, dietary intakes were found to increase with the presence of visitors, dietitians and nutrition assistants; and to decrease with inappropriate food tray placement, medication rounds and when packaging was found difficult to open [232]. However, despite the importance of eating in a chair, many patients continue to eat in bed due to absence of dining areas and the low priority of nutrition in nursing and medical care [5, 6, 235, 236].

Previous studies have demonstrated that hospital food and beverage packaging is difficult to open by both the hospitalised older patient and community living older people [5, 37, 46, 67, 158, 159, 166, 237]. The role of grip and pinch strength in successful and efficient opening of hospital food and beverage items has been investigated [5, 237] as hand and finger strength have been associated with packaging assessment [37, 159, 164, 166]. However, the studies by Bell [5, 237] found limited associations for grip and pinch strength for a range of different hospital pack types with the only packs having an association between grip and efficient opening being water bottles and biscuit portions. Consequently, it was postulated that dexterity could be a critical aspect of hand function for efficient opening of packs. Studies of dexterity and pack opening are limited to one which investigated the role of dexterity in accessing medicine bottles, finding that dexterity was a good predictor of openability [152]. All of these studies were conducted with participants in a seated position and the findings may not be transferable to the lying in a hospital bed posture.

Standardised testing for grip and pinch strength is conducted in seated postures [108, 109, 134]. Very few studies have examined grip strength in other postures, and no other research was identified that examined pinch strength or dexterity in any posture other than sitting. There is conflicting results for grip strength and postures, with one study finding that sitting produced the greatest grip

strength [135]; another finding standing led to the greatest grip strength [137]; and another finding no difference in grip strength between sitting and lying down [136].

As hospital food in NSW is mostly served in sealed packaging and many patients eat in bed, it is important to examine the use of food and beverage packaging by the older person and the way in which it is accessed in the hospital environment. The aim of this laboratory study was to compare the openability of a selection of hospital food and beverage items in both lying in a hospital bed and sitting, and to examine the role of grip strength, pinch strength and dexterity in successful and efficient pack opening by older people (aged 65 years and above). A simulated hospital laboratory setting with well, community dwelling older adults (aged 65 years and above) was used as conducting research within hospitals with older patients can be problematic. Patients have fluctuating medical conditions, can be unavailable due to medical procedures or discharge from hospital; and researchers may obstruct staff conducting their work. Additionally, using a laboratory setting allowed for a controlled environment in which to measure the hand function parameters and to standardise the bed and chair used in this exploratory study.

5.3 METHODS

A mixed methods approach was used in this research. Quantitative data collection included demographic data; time and attempts to open packs; measurement of grip and pinch strength; as well as dexterity measures. One-sample *t*-tests were used to compare grip strength scores with normative data. Qualitative measures included ratings of ease of opening (satisfaction), and asking participants who did not rate the pack as 'easy' to then attribute reasons for any difficulties in opening. All measures were conducted in both lying and seated postures with each participant. The order of posture was randomised throughout the sample. Using a mixed methodology approach such as this has been found to be advantageous when addressing health and human service research [183]. Ethics approval was obtained through the University of Wollongong. Details of the methods used can be found in Chapter 3.

5.3.1 Participants

This study gathered a non-probability convenience sample of well older adults of both genders living in the Illawarra region of NSW, Australia. Recruitment methods included word of mouth and an email invitation to the University community asking for volunteers. Criteria to participate included being 65 years or older, well and living independently in the community. A total of 34 people (11

male, 23 female) responded to the invitation and met the selection criteria (no upper limb weakness, no diagnosis of dementia, independently living in the community). Each participant was randomly allocated a time on one of the two days of testing. Written consent was obtained from all participants. Participants who normally wore reading glasses were asked to wear them for the study. A biostatistician was consulted regarding suitable sample size and 30 participants were deemed appropriate for statistical power ($p<0.05$ and 80%).

5.3.2 Setting

The study was conducted at the University of Wollongong in Nursing Simulation Laboratories. The facilities allowed for two simulation rooms, one set up with a table and chair and the other with a hospital bed and table. In-situ recording devices are installed in each room with the control centre located between the two rooms, (see Figures 5.1and 5.2).

Figure 5.1 Simulation Room 1: Bed Posture

Figure 5.2 Simulation Room 2: Seated Posture

5.3.3 Study protocol

Participants completed the following protocol:

1. Consent and demographic data collection
2. Random allocation to bed or chair posture
3. Hand function data collection (grip and pinch strength; dexterity)
4. Filming of hands opening the hospital food and beverage items on hospital tray
5. Interview to rate ease of opening for packs and if not easy to open, attribute reasons for opening difficulty

6. Repeat steps 3, 4, 5 in alternate posture.

5.3.4 Posture

5.3.4.1 Bed Posture

Bed angle and bed table height were standardised for the study. The distance between the mattress and top of bedside table was 27cm to enable leg clearance and reasonable eating height. The bed angle was set at 60% - a 'modified' Fowler's bed position [185] with two standard hospital pillows. In this way, participants were given the optimum posture for eating in bed.

5.3.4.2 Chair Posture

A standard waiting room style chair was used for the study (see Figure 5.2). The chair had no arms, allowing participants to sit close to the table for dexterity testing and opening of products, as well as complete the standard protocol for grip and pinch strength testing with the chair at right angles to the table and away from it to ensure good elbow clearance.

5.3.5 Hand function testing

5.3.5.1 Grip and pinch strength

Grip and pinch strength testing was conducted on each participant using a standardised protocol [125] with the Jamar Grip Strength Dynamometer (Lafayette Instruments, Indiana, USA) and the B&L Pinch Gauge (B&L Engineering, California, USA). Both instruments were calibrated prior to the study. For standardisation, the dynamometer's adjustable handle was set on the second handle position for all participants with single effort and hand dominance recorded. The B&L pinch gauge measured tip, 3 point, and lateral pinch strength for a single effort. These two hand assessment tools are commonly used and considered to produce the most reliable and valid measurements of grip and pinch strength [108, 184, 217, 218].

5.3.5.2 Dexterity

The dexterity of participant's hands was analysed using the Purdue Pegboard Test [112]. This test was initially developed to assess suitability to factory assembly tasks but is now used for a variety of purposes including assessment of brain impairment and learning disabilities. The test consists of a battery of four different tasks administered in a standardised protocol with the participant seated at a table as follows:

Test One (Dominant Hand): Participant uses their dominant hand to pick up a pin from the cup that is on the same side as the hand that is being used. The pin is then placed in the topmost hole that is also on the same side. This action is repeated to see how many pins the participant can place in thirty seconds.

Test Two (Non-Dominant Hand): The non-dominant hand is used to repeat test one with the pins swapped to the cup on the participant's non-dominant side.

Test Three (Both Hands): The third test involves a repeat of the previous two tests; however, both hands are working simultaneously. In this test, only the number of pairs of pins is recorded. Macro dexterity is determined by the sum of these three tests, Right + Left + Both (R+L+B). This score therefore, provides the optimal dexterity assessment.

Assembly Test: The final test performed is the assembly test. The assembly test involves picking a pin up from the dominant hand side of the board and then placing it in the hole at the top of the dominant hand side of the board. At the same time, the other hand picks up a washer and places it over the pin the dominant hand has just placed. After placing the pin, the dominant hand picks up a collar and places this on the same pin so that the collar rests on top of the washer. The dominant hand now places a collar on top of this washer, followed by another washer placed by the non-dominant hand. The final assembly consists of a pin running through the centre of a washer, collar and another washer. This process is repeated down the dominant hand side of the board. The time limit for this test is one minute and the score is determined by the number of individual components the participant is able to place in that time. This score determines the participant's Micro dexterity score.

A previous laboratory study conducted at Sheffield Hallam University [238] determined that macro dexterity was the critical dexterity component related to successful pack opening. As macro-dexterity provides the optimal measure of dexterity ability, and the capacity to compare with other research findings, this study uses macro dexterity to correlate with opening time and attempts.

5.3.6 Food and beverage packs

Nine packs were sourced from a local hospital for testing. These included: foil sealed items (dairy, thickened water, custard); tetra packs; condiment packs (jams, marmalade); individual honey 'squeeze' sachets; single serve cereal boxes; sealed desserts and cheese portions. These items were

selected as previous studies had found them to be difficult to open, participants had reported the packaging as 'fiddly', and there were poor correlations between faster opening times and grip strength, indicating that dexterity may have been the key factor in openability [5, 237]. Due to the limited range and numbers of products supplied by the hospital, each participant opened seven of the nine in the two postures. Researchers ensured products were consistent in the two postures for each participant in order to ensure each participant was their own control. The participants had no choice in pack selection.

An example of a participant's tray (taken from the video footage) can be seen in Figure 5.3. The range of products tested is shown in Figure 5.4.

Figure 5.3 Participant and example testing tray in bed posture

Figure 5.4 Range of products in the study; each participant tested seven of the nine. Categories of packs include foil sealed items; tetra packs, condiment packs, boxed packs; dessert pouch; sealed plastic wrap.

5.3.7 Video capture (timing and attempts)

Video recordings of participant's hands were conducted using in situ cameras in the simulation suite. This allowed for later analysis of both the time and number of attempts taken to open a pack to be measured. Researchers independently reviewed video footage of three participants in order to jointly determine consistent criteria for the beginning and end of opening as well as number of attempts. Video recording is commonly used in ergonomics research to examine the interaction of people, products and environments [199-201]. Opening the pack was measured from the time of gripping the tab or pack; end of timing was the release of the tab/pack from grasp. The number of

attempts to open the pack was determined by changing grips, orientations and manipulations of the pack. Please see Chapter 3, Section 3.9.1 for description of video capture used in the thesis studies.

5.3.8 Interview

Participants were interviewed to complete two questionnaires to firstly rate the ease of pack opening and secondly to attribute reasons for any difficulties encountered. Both questionnaires have been used in previous packaging research by the authors [5, 237]. The reasons for difficulty were piloted in the initial exploratory study in hospitals and found to have good face validity [5]. Ratings of opening ability were organised by answering 'yes' or 'no' followed by a scale of 'no difficulty/easy', 'some difficulty', 'moderately difficult', 'very difficult', and 'impossible'. The reasons for difficulty could be attributed to 'vision', 'hand strength', 'fiddly package', or a combination of 'strength + fiddly'.

5.3.9 Data analysis

Data for all phases were analysed using the Statistical Package for the Social Sciences [239]. Questionnaires and sample meal tray recordings were analysed with descriptive statistics. Correlations using Spearman's rho were performed to determine whether or not a relationship existed between participant's hand function elements (grip, pinch strengths and dexterity) and time taken to open the items in the lying down and seated postures. Significant differences between the two postures for hand function tests and time taken to open the products were analysed using Paired Samples T-tests and Wilcoxon Signed Rank Tests. The effect size of the differences between the two postures for hand function on the Paired Samples T-tests was determined using the eta squared statistic. Cohen [240] states that an eta squared value of .01 is a small effect; .06 a moderate effect; and .14 a large effect. Effect size for the Wilcoxon Signed Rank Test items was determined by r [240] whereby .1 represents a small association; .3 a medium association; and .5 a large association.

5.4 RESULTS

5.4.1 Participants

Thirty-four participants participated in the research, aged between 65 and 86 years, with a mean age of 73 years (SD 5.4). 23 (68%) participants were female with a mean age of 74 years (SD 5.5); 11 (32%) participants were male with a mean age of 71 years (SD 4.8).

5.4.2 Hand Function Tests: Bed vs Chair

5.4.2.1 Grip and Pinch Strength

Grip and pinch strength scores for the total study population were normally distributed in both postures with the exception of dominant three point pinch strength in the bed posture, and non-dominant grip and non-dominant lateral pinch in the chair posture. The mean grip strength for the bed and chair posture are shown in Table 5.2. No significant differences were found for grip strength between the two postures. Normative data is available for older adults [108] with dominant mean grip for both genders being 28.33kg/f and non-dominant mean grip 24.0kg/f. No significant differences were found between the study grip strength results and normative data.

Table 5.2 Grip strength data, bed and chair posture (n=34)

	Dominant Grip (kg/f)		Non Dominant Grip (kg/f)	
	Bed Posture	Chair Posture	Bed Posture	Chair Posture
Mean	29.19	28.58	27.46	27.56
Standard Deviation	10.61	10.29	11.52	10.85

Significant differences were found for all pinch grip measures, with stronger pinch grips in the chair posture. Tables 5.3 and 5.4 contain the dominant and non-dominant pinch strength data and significance values (2-tailed) between the postures and outline the effect size. Less pinch strength was able to be exerted by participants in the bed posture compared to the chair, with a large negative effect for all pinch grips except the dominant 3 point pinch grip, which had a medium negative effect (z= -2.93, p= .003, r = -.36); and the non-dominant lateral pinch grip with a medium negative effect (z=-2.82, p=.005, r= -.34).

Table 5.3 Dominant pinch grip strength data in bed and chair posture (n=34)

	Dominant tip pinch (kg/f)*				Dominant 3 point pinch (kg/f)*				Dominant lateral pinch (kg/f)**			
	Bed	Chair	Sig.	Eta Sq	Bed	Chair	Sig.	*r*	Bed	Chair	Sig.	Eta Sq.
Mean	3.82	4.31	.001	.30	5.76	6.21	.003	-.36	6.87	7.25	.016	.16
Standard Deviation	1.58	1.32			2.28	2.07			2.50	2.28		

* Spearman Rho Correlation is significant at the 0.05 level (2-tailed)
**Spearman Rho Correlation is significant at the 0.01 level (2-tailed)

Table 5.4 Non-dominant pinch grip strength data in bed and chair posture (n=34)

	Non-dominant tip pinch (kg/f)**				Non-dominant 3 point pinch (kg/f)**				Non-dominant lateral pinch (kg/f)**			
	Bed	Chair	Sig.	Bed	Chair	Sig.	Bed	Chair	Sig.	Bed	Chair	Sig.
Mean	3.79	4.16	.044	3.79	4.16	.044	3.79	4.16	.044	3.79	4.16	.044
Standard Deviation	1.43	1.3		1.43	1.3		1.43	1.3		1.43	1.3	

**Spearman Rho Correlation is significant at the 0.01 level (2-tailed)

5.4.2.2 Dexterity

Dexterity measures were normally distributed for the bed posture. Dominant and non-dominant dexterity was not normally distributed in the chair posture. The bed posture had a large negative effect on macro dexterity (*M*=32.36, *SD*=5.59) compared to the chair posture (*M*=35.29, *SD*=5.54), z=-4.15, p<.001, r=-.71.

5.4.3 Food Products

The time taken to open the products by each participant in each posture was calculated. The item with the maximum opening time was the honey sachet in the bed posture (144 sec) followed by the cheese portion in the chair posture (133 sec). Figure 5.5 shows the median time to open each product in each posture. The thickened water, custard and condiments were the only products with a longer median opening time in the bed posture. No significant differences in opening times between postures were observed.

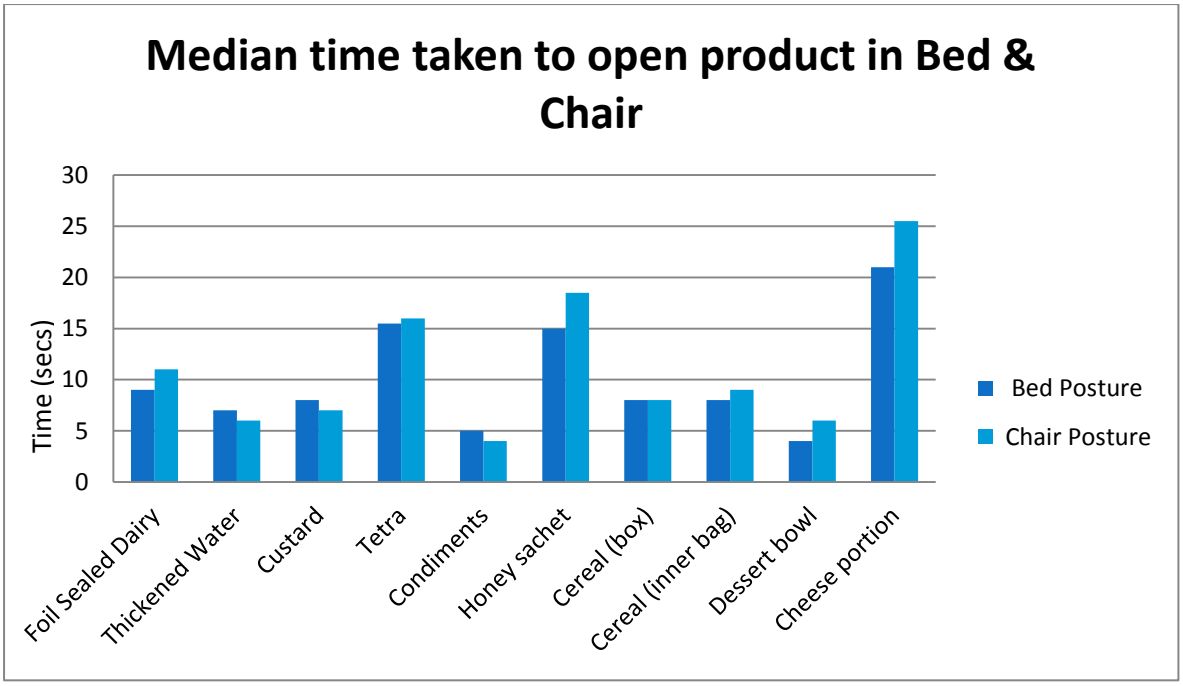

Figure 5.5 Median time taken to open product in the Bed and Chair postures

The range of opening times varied for each product, however. Data was not normally distributed, with the exception of bed posture for the Custard, Cereal (box) and Thickened Water. Details for the range of time taken to open products in both postures are outlined in Table 5.5.

Table 5.5 Range of times taken to open each item in each posture (sec).

Item	N	Posture	Mean	Median	Std Dev	Min	Max
Dairy	19	Bed	12.84	9.00	6.72	4	31
		Chair	12.59	11.00	5.19	5	22
Thickened Water	9	Bed	6.44	7.00	2.13	3	9
		Chair	9.22	6.00	5.59	3	19
Custard	13	Bed	9.54	8.00	6.49	3	28
		Chair	7.77	7.00	3.88	3	15
Tetra	32	Bed	17.94	15.50	12.80	7	81
		Chair	17.94	16.00	9.92	7	57
Condiments	34	Bed	5.59	5.00	2.62	2	14
		Chair	5.47	4.00	4.73	2	28
Honey sachet	34	Bed	29.09	15.00	33.87	2	144
		Chair	26.74	18.50	28.00	2	131
Cereal (box)	33	Bed	8.33	8.00	4.20	2	24
		Chair	7.91	8.00	3.18	3	19
Cereal (inner bag)	33	Bed	11.06	8.00	7.41	2	35
		Chair	9.58	9.00	4.59	4	20
Dessert	15	Bed	4.60	4.00	1.88	3	9
		Chair	5.67	6.00	2.19	3	11
Cheese portion	34	Bed	30.26	21.00	25.45	2	106
		Chair	31.03	25.50	25.00	7	133

The number of attempts to open each product was also calculated from the video footage to further explore the interaction of the person and package (Table 5.6). The data for number of attempts to open products was not normally distributed, with the exception of the bed posture for the Custard.

The differences in the maximum amount of attempts in the bed and chair posture reflect the median time differences for the postures in Figure 5.5for the thickened water, custard and condiments but not for other items such as the foil sealed dairy, honey sachet and cheese portion. The packages that took the longest time to open in each posture (cheese, honey and tetra pack) also demonstrate a large number of attempts to open. For example the cheese portion mean number of attempts to open in the bed posture is five attempts, with a maximum of 30 attempts to open the pack. A number of participants were unable to open the honey sachet and cheese portion in either posture as follows: Honey six (18%) in bed posture; eight (24%) in chair posture; Cheese five (15%) in bed and chair posture.

Table 5.6 Number of attempts to open each item in each posture

Item	N	Posture	Mean	Median	Std Dev	Min	Max
Dairy	19	Bed	5	4	3	1	10
		Chair	5	4	3	1	13
Thickened Water	9	Bed	2	2	1	1	3
		Chair	3	2	2	1	7
Custard	13	Bed	2	2	1	1	4
		Chair	2	2	1	1	5
Tetra: remove straw	32	Bed	5	4	3	2	13
		Chair	5	5	3	1	16
Tetra: insert straw	32	Bed	1	1	1	1	2
		Chair	1	1	2	1	10
Condiments	34	Bed	1	1	1	1	3
		Chair	1	1	0	1	5
Honey sachet	34	Bed	3	3	3	1	13
		Chair	2	1	3	1	12
Cereal (box)	33	Bed	3	2	1	1	6
		Chair	3	2	2	1	7
Cereal (inner bag)	33	Bed	3	2	3	1	13
		Chair	3	2	2	1	7
Dessert	15	Bed	1	1	0	1	2
		Chair	2	1	2	1	7
Cheese portion	34	Bed	5	3	5	1	30
		Chair	4	2	5	1	20

5.4.4 Questionnaire

Participants rated the ease of opening of the products and commented on reasons for difficulty opening the pack. Ease of opening ratings were consistent between the two postures, with the cheese portion, foil sealed dairy, honey sachet and tetra packs found the more difficult packs to open, scoring 'some difficulty-moderately difficult'. The reasons attributed to this difficulty were problems seeing how to open the item (tab size, contrast), lack of instructions/directions (honey and cheese), as well as 'fiddly packaging'.

5.4.5 Packaging and hand function

5.4.5.1 Grip and pinch strength

A significant correlation only was found for non-dominant grip strength and the opening of thickened foil sealed water in the bed posture [r=-.71, n=9, p=.032]. No other significant correlations were found for grip strength and time to open the packs. A significant correlation was found between a shorter opening time for the foil sealed thickened water and the dominant tip pinch grip in the bed posture only [r=-.71, n=9, p=.031]. No other significant relationships between pinch grips and more efficient opening times were found.

5.4.5.2 Dexterity

Significant negative correlations were found between macro-dexterity (Right, Left, Both on the Purdue pegboard test) and time taken to open for six of the nine packs in both postures as shown in Table 5.6. A negative correlation indicates that macro-dexterity was associated with shorter opening times. Consistent relationships were demonstrated in both postures for dexterity and the custard and the tetra pack. Macro-dexterity has a stronger relationship with efficient pack opening in the bed posture for the foil sealed dairy [r=-.46, n=19, p=.047]; condiments [r=-.63, n=34, p=.001]; and cereal inner bag [r=-.54, n=33, p=.002]. Conversely, macro-dexterity is strongly correlated with faster opening of the honey sachet in the seated posture [r=-.65, n=34, p=.000].

Table 5.7 Significant correlations between dexterity and time to open packages in 2 postures

Food/Beverage Item (time to open)	Sample size (*n*)	Macro dexterity (Right, Left, Both)			
		Chair		Bed	
		Sig (2-tailed)	*r*	Sig (2-tailed)	*r*
Foil sealed dairy	19	N/S		.047	-.46**
Custard	13	.001	-.80*	.001	-.82*
Tetra pack	32	.010	-.49**	.010	-.45**
Condiments	34	.015	-.41**	.001	-.63*
Honey sachet	34	.000	-.65*	.031	-.38**
Cereal inner bag	33	.038	-.36**	.002	-.54*

* Spearman Rho Correlation is significant at the 0.05 level (2-tailed)
**Spearman Rho Correlation is significant at the 0.01 level (2-tailed)

5.5 DISCUSSION

The purpose of food service in hospitals is to deliver the nutrition required for recovery and to encourage patients to eat [51, 208, 225]. This is a challenging proposition with cost pressures from government and large numbers of patients, who are increasingly older people with complex medical issues [3]. Additionally, food service is conducted in an environment where there are conflicting priorities of medical procedures over meal times, lack of meal choice, increasing use of cook-chill options and lack of assistance to eat and open packaging [67]. The cook-chill system of food service is used by NSW hospitals and packaged products are an intrinsic component [53]. NSW Health has recognised that food and beverage packaging can pose a barrier to patients in hospital and have instituted a number of strategies to address the issue [210]. As a consequence of this initiative individual cereal packs are no longer served in NSW hospitals as they were at the time of this study.

Previous research has examined the association between grip and pinch strength and time taken to open hospital food and beverage items and highlighted that dexterity was likely a critical aspect of hand function for 'openability' of these items and yet to be measured [5]. This paper explores the role of dexterity to open the items found to be 'fiddly' in these previous studies by testing the packs with well older people (aged 65 years and above) in a controlled laboratory setting [5, 237]. The study also reviews the impact of a bed posture on hand function and time to open packs, attempts to open packs, and satisfaction with a selection of pack types. Consistent with the previous studies with older adults and hospital food and beverage packaging[5, 241], grip and pinch strength were not significantly associated with the openability of packs in this study, with the exception of non-dominant grip and dominant tip pinch strength and opening thickened foil sealed water in the bed posture.

Studies into postural differences in grip strength are very limited and have conflicting results [135-137]; and no studies were found that examined pinch strength or dexterity in different postures such as undertaken in this research. No significant difference was found for grip strength between the bed and chair postures in this study. It is likely that grip strength was unaffected as the participant was seated in a supported and almost upright posture with the trunk stable in the bed as determined by our protocol, and therefore able to exert maximum effort in comfort. However, this study demonstrated that a bed posture negatively affects both pinch grips and macro-dexterity.

The correlations between hand function elements and efficient pack opening suggest that the bed posture required recruitment of more elements of hand function to open packs when compared to the seated posture, and that macro-dexterity was more important than strength. For example, stronger non-dominant grip and dominant tip pinch grip were associated with faster opening times for the foil sealed thickened water in the bed posture. This is likely due to the need for greater stabilisation of the pack with the non-dominant hand and greater tip pinch strength to pull the tab with the dominant hand compared to opening the pack in a seated posture. Macro-dexterity was associated with efficient pack opening in the bed posture for foil sealed dairy, condiments and the cereal inner bag. Similarly, macro-dexterity was associated with faster opening times for the honey sachet in the chair posture.

However, macro-dexterity was associated with efficient pack opening in both postures for foil sealed dairy, custard, tetra pack, condiments, honey sachet and cereal inner bag, illustrating the importance of macro dexterity in opening packs generally. This finding, in conjunction with participant's views on ease of opening and reasons for difficulty opening these packs, indicates that small tab size and ability to access 'fiddly' items such as the straw on tetra pack should be addressed and improved. Suggestions from participants also indicated that visual cues were lacking; one design change to assist would be the use of different colours on tabs to the rest of the pack to promote visual discrimination. The honey sachet was particularly difficult for participants to open in either posture, primarily due to pack unfamiliarity and lack of instructions. Pack familiarity has been shown to be an important factor in 'openability' [242]. The design could be improved with simple instructions on the back of the pack, such as arrows highlighting the action required to squeeze it.

This study has found that the seated posture facilitates better pinch grip strength and macro-dexterity ability than lying in a hospital bed. This is relevant as pinch strength and particularly macro-dexterity are important in efficient opening of the foil sealed dairy, custard, tetra pack,

condiments, honey sachet and cereal inner bag packs reviewed in this study. Nutrition researchers have found that being seated for meals in hospital is beneficial and improves intake as well as improving the eating experience for patients [232, 235]. Sitting to eat requires less 'effort' (in terms of hand function) to open packs, and this supports the notion that it should be the preferred posture for the patient to eat in as less effort is better when the person is feeling unwell and the effort of eating itself can be a burden [6, 62].

As in the previous studies [5, 237], the tetra and cheese portions were found to take a long time to open, required repeated effort and were rated more poorly on the 'ease of opening' scale. Again, as in the previous papers, a number of participants could not open the cheese portion (15%). Interestingly, this was unaffected by posture, indicating that the cheese portion is poorly designed for 'openability'. Cheese portions are an important source of protein and energy, a quick and easy (once opened) way for the patient to access valuable nutrition and is served as a between meal snack for this purpose. Tetra packs are provided in hospitals to deliver supplements to frail and unwell older patients who are malnourished or at risk of malnourishment. Further research is required to investigate the impact of packaging on intake in older people as these products are routinely used in hospitals, care facilities and the community.

There are a number of limitations to this research. Firstly, for study efficiencies, the sampling approach and testing location were controlled by the researcher. The participants were a non-probability sample, recruited using a purposive sampling approach with researcher-directed inclusion and exclusion criteria [177]. As such they were not a random sample and may not represent the wider population. No formal assessment was made of cognition, vision or health, relying on participants to self-select. However, as participants were required to attend the university, making their own way to and from the venue, they may in fact represent a more 'able' group than the general population. The laboratory setting of a simulated hospital was chosen as the research was testing a hypothesised difference of pack performance between postures and exploratory in nature.

However, the artificial setting of the simulated hospital laboratory could have affected the results through central location bias [222]. Ideally, this study would be conducted in a hospital setting with larger participant numbers. However such a study would require greater resources and administrative organisation and be difficult to access patients due to medical conditions, medical interventions and nursing activities. Secondly, while the bed posture was controlled by maintaining the bed angle and table height, participants varied their posture by sitting further forward or

removing a pillow for greater comfort. This may have affected the results in the bed posture. Finally, many participants were unfamiliar with the honey sachet pack type and this may have affected the time to open the pack. This could have been overcome by providing a 'practice' pack as used in the 2011 European technical specification for packaging ease of opening [142].

5.6 CONCLUSION

This study has two key findings. Firstly, pinch grip strength and macro-dexterity ability for the over 65 year old are better in a seated position than a semi-recumbent hospital bed posture. Secondly, macro-dexterity ability is associated with faster opening times for a range of hospital food and beverage items routinely served in hospitals and care facilities. These findings support the advice from nutrition experts: older patients should sit to eat to maximise intake and meal-time enjoyment.

Improvement of pack design for the cheese, an important protein and energy snack source; as well as the honey sachet and the most importantly, the tetra pack, which is routinely used to provide supplementary nutrition, is indicated. Involvement of older consumers and understanding the capacities and abilities of this population is integral to better design.

The implications for effective food service delivery in hospital is clear – food is an essential 'treatment' in hospital, delivering the nutritional elements necessary for recovery and is best delivered in an environment allowing a seated eating position, promoting social interaction, and where packaged food and beverages are used, in more easily accessible pack formats.

CHAPTER 6 EXPLORING THE EFFECT OF HOSPITAL FOOD AND BEVERAGE PACKAGING ON DIETARY INTAKES BY OLDER PEOPLE

CHAPTER 6 PREAMBLE

This chapter consists of a manuscript reporting Study 3, submitted to Appetite November, 2015:

Bell, A.F., Walton, K. A., Tapsell, L. C., Batterham, M. *Exploring the effect of hospital food and beverage packaging on dietary intakes by older people.*

This is the third and final empirical study, as outlined in Table 6.1.

Table 6.1 Study 3: Breakfast, snack and lunch packs

Study	Chapter	Pack	Sample (n)	Video Timing	Q'nnaire	Grip + Pinch	Dexterity	Bed Posture	MNA	Food Intake
1	4	Full range hospital F&B packs	40	✓	✓	✓				
2	5	Problematic packs	34	✓	✓	✓	✓	✓		
3	6	B'fast, snack & lunch packs	62	✓	✓	✓	✓	✓	✓	✓

Study 2 (Chapter 5) established that dexterity and pinch strength are adversely affected by a semi-recumbent bed posture. Additionally, macro-dexterity was found to be a critical element of hand function for successful and efficient pack opening. However, some packs were difficult to open regardless of posture, such as the cheese and tetra packs. This third study extends the work from the previous two studies by also exploring the effect of packaging on

consumption in a hospital bed setting and measuring the nutritional status of the participants, in addition to the review of hand function (grip, pinch, dexterity) and questionnaires on satisfaction with packs, appetite and health; and ADL abilities.

The research question for this third and final empirical study was:

Does sealed packaging inhibit dietary intake in a sample of well older people; and does nutritional status affect dietary intake when food is presented in a sealed pack?

EXPLORING THE EFFECT OF HOSPITAL FOOD AND BEVERAGE PACKAGING ON DIETARY INTAKES BY OLDER PEOPLE

6.1 ABSTRACT

Previous research has identified that hospital food and beverage packaging presents a barrier to dietary intake for the older hospitalised adult. This laboratory study explores the impact of packaging on intake by 62 well older people (65 years and over) in a simulated hospital ward at the University of Wollongong, NSW. Nutritional status was measured using the Mini Nutritional Assessment Short Form (MNA-SF©) and intake was measured from plate waste. Participants were allocated to either a breakfast and snack meal or a lunch and snack meal on two occasions one week apart. Meals were served in a shared ward environment and each participant experienced a 'sealed' and 'pre-opened' meal and snack condition. Significant differences in dietary intakes between pack conditions was determined by paired samples t-tests and effect size. Overall findings were not significant for intake and the 'sealed' versus 'pre-opened' conditions. However, effect size of the intake differences for the participants identified by the MNA-SF© as 'at risk', indicate that this vulnerable group ate less of the high protein snack (cheese and biscuits) in the 'sealed' condition. This finding has implications for the provision of packaged high protein snacks (cheese portions) for the older inpatient. Further research is indicated with 'at risk' and frail older people in the hospital environment to investigate the impact of packaging on dietary intake.

6.2 INTRODUCTION

Malnutrition in hospitals is well known [94, 95, 243-245] and poses a challenge for both food service providers and the hospital system. People who are malnourished usually have longer lengths of stay, increased risks of complications and an increased risk of mortality [212, 246, 247]. Food service provision in hospitals needs to be efficient and effective in order to deliver both good value for the hospital and high quality nutrition to the inpatient with minimal waste. This presents a challenge for catering within hospitals. Plate waste has been found to be 6-65% across 32 hospital studies [61], and malnutrition rates have remained constant [228, 248]. Packaged food and beverage products are used by NSW Health in food service provision within NSW hospitals and pre-packaged meals are gradually being introduced across the state [11], as well as in other localities around Australia, and internationally.

A number of researchers have identified an inability to access food and beverage packaging as a contributing factor for malnutrition in hospitals amongst older and or disabled people [6, 46, 70, 230]. The difficulties that packaging can pose to patients has been recognised by NSW Health, a state government health authority which was involved in the development of an Accessibility Benchmarking Scale for use in tender specifications [11]. Within this context is the challenge of encouraging intake in older adults, who have lower appetites and are less able to discern taste and smell [62, 63]. A number of strategies have been found to assist, including serving smaller, energy dense portions and high protein snacks, such as cheese [64-66]; having protected meal times and using smaller serving sizes [67].

In a recent hospital study we demonstrated a reduced ability to open food and beverage packaging by older patients, with 40% reporting difficulty opening both water bottles and tetra packs [5]. Subsequent observational laboratory studies with well older people [249] have demonstrated that lying in a hospital bed significantly decreases the older person's pinch grip strength and macro-dexterity; both required for efficient pack opening. In a similar laboratory context, this study extends that previous research by investigating not only the relationship between hand function and opening packaging, but exploring the effectiveness of packaging to deliver nutrition by measuring food intake in two pack conditions: sealed and pre-opened. To further explore this phenomenon, the nutritional status of the well older participants was also characterised.

6.3 METHODS

The participants in this study were well older adults living in the Illawarra region of NSW, Australia. A non-probability convenience sample was recruited via newspaper advertisement, flyers distributed to local aged care providers, General Practitioner practice location and seniors' organisations, as well as an email invitation to the University community and volunteers of the University Medical School. Inclusion criteria included being 65 years or older, well (no limb weakness or cognitive impairment) and living independently in the community. Participants were excluded if they ate a special diet (e.g. diabetic; lactose free), had a visual deficit which could not be corrected with glasses, had severe arthritis, a history of CVA or a diagnosis of dementia). Participants were required to attend the university on two occasions, one week apart, forgo their normal breakfast or lunch meal and remain for three hours. Meals were consumed in a hospital bed in a simulated shared ward hospital environment over a total of four days (two days in week one and two days in week two), with each participant attending one day per week. A biostatistician advised that the design and associated

analyses required a sample size of 60 people to be adequately powered ($p<0.05$ and 80%). Figure 6.1 shows an overview of the research design. Participants were randomly allocated to condition (a) 'pre-opened' or (b) 'sealed' and sample evenly split to ensure participants were their own controls (if packaged meal pre-opened on occasion 1, the same meal will be sealed on occasion 2 for the individual participant or vice versa).

Study Day	**Meal**	**Condition (a) packages pre-opened**	**Condition (b) packages sealed**
1	Breakfast + snack	15 Participants	15 Participants
1	Lunch + snack	15 Participants	15 Participants
2	Breakfast + snack	15 Participants	15 Participants
2	Lunch + snack	15 Participants	15 Participants

Figure 6.1 Overview of Research Design

The Nursing Simulation facilities allowed for two by 3 bed shared ward suites and interview rooms. In-situ recording devices were installed at each end of the bed. Beds were colour coded with signs and ribbon, green for 'pre-opened' condition (a) and red for 'sealed' condition (b) as shown in Figure 6.2. The colour coding was continued for all forms and trays in the study to ensure the correct condition was adhered to. Ethics approval for the study was obtained from the University of Wollongong (HE13/465). Written consent was obtained from all participants.

Figure 6.2 Simulated hospital shared ward with in-situ cameras and colour coding on beds

6.3.1 Participants

Participants registered their interest to the study via email or telephone and were sent an information pack. A telephone interview was conducted with tacit approval obtained to gather relevant information to screen for suitability. The pre-screen questionnaire (as seen in Appendix 4), included baseline demographic data, transport arrangements; normal diet and appetite questions (special diets, food intolerances were excluded); reminder to bring reading glasses to the study days if needed; preferred meal for the study (breakfast + snack **or** lunch + snack) and menu choice. Participants were advised that the study would take about 3 hours on each occasion.

6.3.2 Bed Posture

Bed angle and bed table height were standardised for the study. The distance between the mattress and top of bedside table was 27cm to enable leg clearance and reasonable eating height. The bed angle was set at 60% - a 'modified' Fowler's bed position (Metzler, 1996) with one standard hospital pillow. In this way, participants were given the optimum posture for eating in bed.

6.3.3 Food items

A range of regularly used hospital food and beverage items were sourced from a local hospital and served for breakfast, and snack or lunch and snack. The exception was the sandwiches which were prepared fresh in the teaching kitchen adjacent to the Nursing Simulation Suite and the boxed cereal which was purchased separately. Breakfast consisted of orange juice, fruit cup (fruit pieces in syrup), individual cereal box, 150ml milk bottle, bread in bag, margarine serve, condiment (jam or vegemite), coffee sachet, tea bag, cup boiling water, sugar serve, milk portion. It should be noted that cereal boxes are no longer routinely used in NSW public hospitals; however, they were used to provide consistency with 2 previous studies by the author.

Lunch consisted of a sandwich in triangle pack, individual custard, fruit cup (fruit pieces in syrup) and flavoured milk in an individual tetra pack. The snack provided to all participants was a single serve cheese portion, individual serve savoury biscuits and health service bottled water.

Examples of food trays provided to the participants for each meal/snack are shown in Figures 6.3, 6.4 and 6.5.

Figure 6.3 Breakfast tray

(Participant number is arranged for video capture at foot of bed)

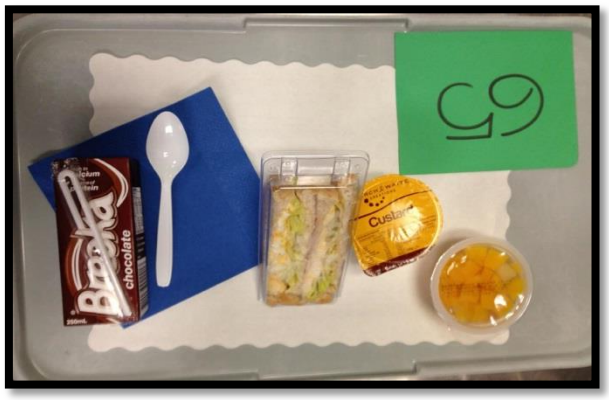

Figure 6.4 Lunch tray

(Participant number is arranged for video capture at foot of bed)

Figure 6.5 Snack tray

Review of the video data was used to calculate both the time taken and the number of attempts to open the packs.

6.3.4 Nutritional Assessment

The Mini Nutritional Assessment-Short Form (MNA® - SF) was used to establish the nutritional status of each participant. This form was selected as it is a valid and reliable tool suitable for use with well independently living older adults as it has high sensitivity and specificity [250]. It consists of 6 scored items distilled from the 18 items in the full MNA [196, 197]. A score of 0-7 indicates malnutrition, 8-11 'at risk' of malnutrition and a score of 12-14 indicating normal nutritional status. The form was administered by Dietitians experienced in its use. Weights (kg) and heights (m) were measured using a portable SECA scales (SECA 874 +/- 100g) and stadiometer (SECA 217 1mm graduation).

6.3.5 Questionnaires

6.3.5.1 Assessment of usual food intake and appetite,

An appetite and dietary intake questionnaire was conducted before meals with each participant on each research day so as to further understand other influences on intakes. Participants were asked when they last ate or drank, how they rated their appetite that day ('about normal', 'better than normal', 'worse than normal'), how they rated their general health ('excellent', 'very good', 'good', 'fair', 'poor') and how they rated the quality of the food provided ('excellent', 'very good', 'good', 'fair', 'poor') and the quantity of the food provided ('excellent', 'very good', 'good', 'fair', 'poor').

6.3.5.2 ADL and packaging assessment

Participants experiencing condition (b) sealed packaging, were asked if they required reading glasses to open packaging and if their vision affected their ability to open packaging. The author also developed a screening questionnaire for activities of daily living .to determine if any participants had difficulty with everday tasks. (Please see Appendix 4, Form 7). Participants were asked to rate a series of activities of daily living items such as their ability to use a toothbrush, zippers and buttons, open a range of everyday items such as milk bottles and cereal boxes. Ratings for this section were on a 3 point scale: 'easy', 'some difficulty', 'difficult'. Participants were then asked to rate the ease of opening of the packaged food and beverage items in the study using a 4 point scale: Ratings were 'easy', 'some difficulty', 'difficult', 'impossible'.

6.3.6 Intake calculation

Each meal offered was weighed using a single set of electronic scales (CAS Smart Weighing Scale SW-1; accurate to ±1g). On the research days, the individual trays were photographed pre and post-delivery to the 'hospital ward'. Additionally, all plate waste was measured by weighing after the meal was consumed. Intake was determined by subtracting the final plate waste from the standard weight for each meal offered.

6.3.7 Data analysis

Data for all phases were analysed using the Statistical Package for the Social Sciences [239]. Descriptive statistics were developed for data from questionnaires and observations of meal contents. Pearson's correlation coefficient was used to explore potential relationships between time taken to open the packages and dietary intake. Paired samples t-tests were used to compare the differences in food intake between meals with different pack conditions. As data was normally distributed, the effect of MNA-SF© status, gender, appetite and satisfaction with food quality and quantity on intake was investigated using the independent samples t-test. The effect of pack open or sealed conditions within each MNA-SF® status group was determined using the eta squared statistic. Cohen [240] states that an eta squared value of .01 is a small effect; .06 a moderate effect; and .14 a large effect.

6.4 RESULTS

6.4.1 Participants

Sixty-four participants aged between 66 and 87 years, with a mean age of 73.9 years (SD ±4.9) participated in the study; 45 females with a mean age of 73.6 years (SD ±4.6) and 19 males with a mean age of 74.6 years (SD ±5.5). Sixty three participants completed the nutritional screening component, 44 females and 19 males. 3% of the sample had a BMI < 21kg/m^2, while 84% had a BMI > 23kg/m^2. Results for MNA status and intake are reported on 62 participants with seven participants in this full protocol group found to be in the 'at risk of malnutrition' on the MNA®-SF assessment, representing 14% (N=6) of female participants (aged between 72 and 85 years) and 5% (N=1) of male participants (aged 76 years).

Nearly all participants (n=60; 94%) were right hand dominant and most (n=56; 88%) reported needing to wear glasses to open packaging. Nearly all people (n= 59; 92%) ate three meals per day and reported their appetite 'good' to 'very good' (n=61; 95%). Most people (n= 52; 83%) reported

their health as 'good' to 'excellent'. A small proportion were found to be malnourished (n= 7; 11%). These participants rated their appetite as 'poor' (n=3), 'good' (n=3) and 'very good' (n=1); and their health as 'fair' (n=2), 'good' (n=4) and 'very good' (n=1). As appetite on the testing days may have influenced intake, participants were asked to rate their appetite at each visit. Results are presented in Table 6.2 for the appetite responses for each category of MNA. Very little change was found in reported appetites between visit 1 and visit 2, with most participants rating their appetite as normal. However, two participants in the 'normal nutritional status' reported their appetite as better than normal for visit 1, while one participant from this group reported their appetite as worse than usual for the first visit. In the 'at risk of malnutrition' group, one person reported a worse than usual appetite on visit 2.

Table 6.2 Participant's appetite differences between visit 1 and 2 per MNA status

MNA status	**Appetite**					
	Normal		Better than normal		Worse than normal	
	Visit 1 (n)	Visit 2 (n)	Visit 1 (n)	Visit 2 (n)	Visit 1 (n)	Visit 2 (n)
Normal nutritional status	53	53	2	0	1	2
At risk of malnutrition	7	6	0	0	0	1
Total	60	59	2	0	1	3

Participants were asked when they last ate or drank prior to attending each of the study days. Lapsed hours were *M*= 11.3 (4.1)hrs and *M*= 9.7 (4.7)hrs for breakfast + snack, Visit 1 and 2; *M*= 3.8 (1.3)hrs and *M*= 3.5 (1.4)hrs for lunch + snack, Visit 1 and 2.

Participants were also asked to rate the quality and quantity of the food they were given for their meals. The lunch + snack meal was rated as better for both quality and quantity than the breakfast + snack meal with 67 % (n= 22) rating lunch + snack as 'very good to excellent' for both quality and quantity compared to 37% (n=11) of breakfast + snack participants on both these factors.

6.4.2 ADL questions

Participants were asked a set of activities of daily living (ADL) questions about their ability to use a toothbrush, zipper, buttons, open a range of everyday food and beverage items, handle hot items and use a can opener. The majority of participants found most tasks easy; twenty participants reported difficulty opening jars. Results are shown in Figure 6.6.

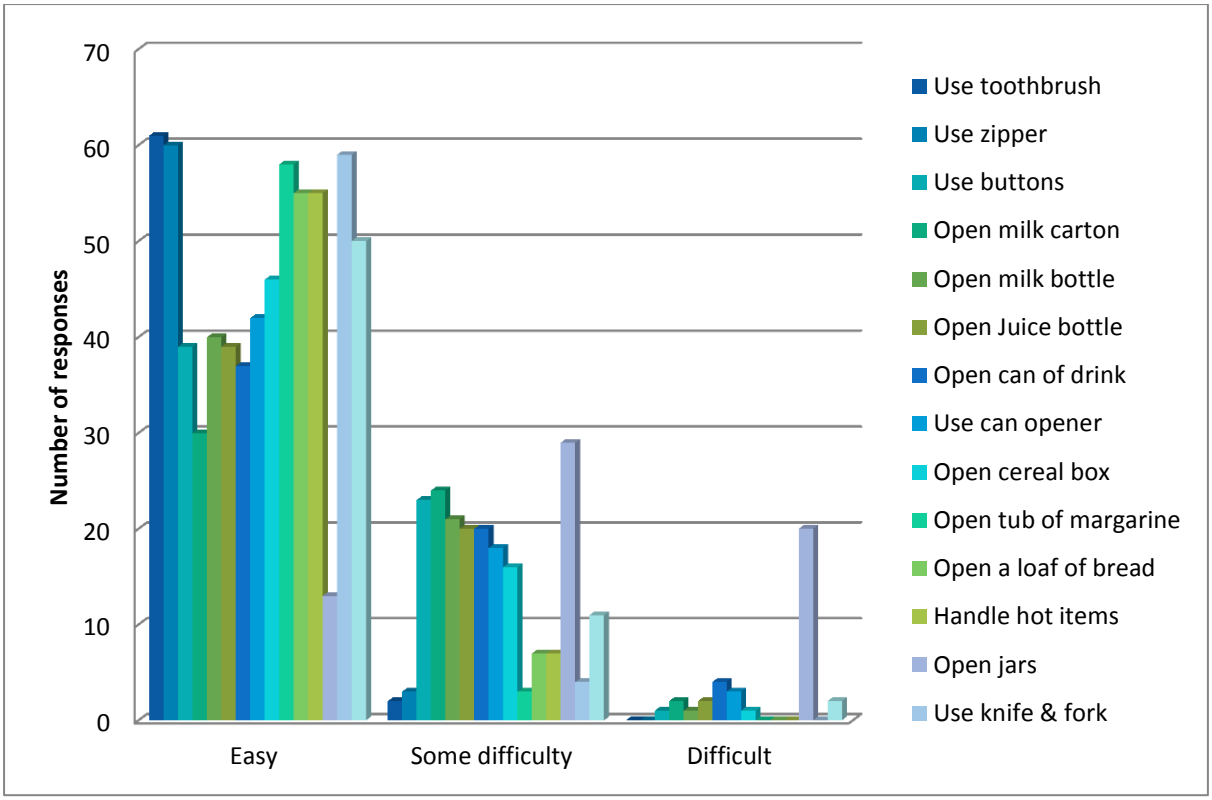

Figure 6.6 Ratings of ease of Activities of Daily Living Tasks

6.4.3 Food Packaging

Four pack types had greater than a mean of five opening attempts; the cheese portion, the biscuit portion, the water bottle and the tetra pack. Three people could not open the water bottle or the biscuit portion at all. The cheese portion had the longest opening time among the packs, with a maximum time of almost 5 minutes (*M*= 45s, *SD*=.87); it also had the most number of attempts with a maximum of 46 (*M*= 5, *SD*=9). The biscuit portion had a maximum of 32 attempts to open (*M*= 6, *SD*=6.32), with a maximum of 3 minutes (*M*= 30s, *SD*=.40). The water bottle had a maximum of 20 attempts at opening (*M*= 7, *SD*=3.18); while taking a maximum of 1 minute (*M*= 15s, *SD*=.16). The tetra flavoured milk pack had a maximum time of 1.1 minutes (*M*= 36s, *SD*=.27); as well as a maximum of 13 attempts to remove the straw from the side of the pack (*M*= 6, *SD*=3.31). Items with a mean number of attempts greater than 2.5 also include the fruit cup (*M*= 4, *SD*=2.55) the milk portion (*M*= 3, *SD*=2.5) and the milk 150ml (*M*= 3, *SD*=.98). Time to open the packs was normally distributed with the exception of boxed cereal and custard.

Table 6.3 reports the satisfaction in terms of ease of ratings by the participants. The water bottle, cheese portion, biscuit portion, fruit cup and tetra pack rated the most poorly of the packs, indicated

by the dark grey shading; followed by the 150ml milk and boxed cereal, indicated by the light grey shading.

Table 6.3 Ease of opening ratings for food and beverage products

Product	N	Easy	Some difficulty	Difficult	Impossible
Juice	29	21	8	0	0
Milk 150ml	31	28	1	2	0
Box Cereal	31	24	5	2	0
Milk portion	29	24	5	0	0
Coffee sachet	31	30	1	0	0
Sugar sachet	29	28	1	0	0
Bread	30	30	0	0	0
Margarine portion	30	29	1	0	0
Vegemite portion	29	28	0	1	0
Condiment	28	28	0	0	0
Water bottle	63	48	6	6	3
Cheese portion	63	41	14	7	1
Biscuit portion	59	36	17	3	3
Fruit Cup	60	37	19	3	1
Tetra pack	31	19	9	3	0
S'wich Triangle	32	32	0	0	0
Custard	32	28	4	0	0

6.4.4 Dietary Intake

There were no significant differences in intake between the two conditions for any of the meals with intake for breakfast sealed (*M*=488.43, *SD*=171.09) and intake for breakfast open [*M*=458.87, *SD*=160.64, *t*(29)=1.14, *p*=.265]. Intake for snack sealed (*M*=282.08, *SD*=139.23) and intake for snack open [*M*=299.39, *SD*=143.27, *t*(61)=-.82, *p*=.415]. Intake for lunch sealed (*M*=478.03, *SD*=172.38) and intake for lunch open [*M*=485.09, *SD*=167.46, *t*(31)=-.20, *p*=.843].

There were no significant differences between the genders for total intake with the different pack conditions, pre-opened and sealed. About a third (n=21; 33%) of participants lived alone. No relationship was found between living alone and intake.

No significant differences were found between the pre-opened and sealed conditions for intake and MNA status, this may be explained by the small sample size. The mean intake of each group is shown in Table 6.4, with difference in intake in grams and percentage of mean 'normal' intake. The 'at risk

of malnutrition' participants ate less at each meal and in each condition, with the exception of breakfast in the pre-opened condition, where they ate 14% more than the nourished nutrition group. The 'at risk' participants ate 30% less of the snack sealed than the nourished nutrition group, compared to 5% less in the snack opened condition, as measured by plate waste.

Effect size was determined for intake differences for the snack pre-opened and snack sealed with the 'at risk' of malnutrition group. The sealed packaging condition had a large negative effect on intake for both breakfast and the snack meals. Breakfast [*M*= -44.25, *SD*=71.55; *t*(3)=-1.237, *p*=.304] with the eta squared statistic (-.34); and snack [*M*= -82.43, *SD*=157.90; *t*(6)=-1.381, *p*=.216] with eta squared statistic (-.24).

Table 6.4 Differences in intake of food (g) for the MNA groups for each meal and each condition*

Intake meal	MNA Status	N	Mean (g)	Std. Deviation (SD) (g)	'at risk' Intake difference (g)	'at risk'% Intake difference
Bfast sealed	Nourished	26	491.54	177.61	-23.29	-5
	'At risk'	4	468.25	139.46		
Bfast pre-opened	Nourished	26	447.85	153.52	+64.65	+14
	'At risk'	4	512.50	104.37		
Snack sealed	Nourished	55	299.66	144.11	-89.80	-30
	'At risk'	7	209.86	133.35		
Snack pre-opened	Nourished	56	307.09	142.08	-14.80	-5
	'At risk'	7	292.29	150.91		
Lunch sealed	Nourished	29	480.66	175.45	-27.99	-6
	'At risk'	3	452.67	169.03		
Lunch pre-opened	Nourished	30	495.87	152.41	-68.54	-14
	'At risk'	3	427.33	319.95		

***Effect size using eta squared statistic**

6.5 DISCUSSION

In a previous study, we found that at least 40% of older patients had difficulty opening the food and beverage packs used in their meal service delivery [5]. Further laboratory studies have found that well, community dwelling older people have similar issues with the packaging served in NSW hospitals [237]. Here we have extended that previous research to investigate the impact of packaging on intake in well, community dwelling older people. Our findings indicate that packaging has a negative effect on the dietary intake of snack meals for the older adults found to be 'at risk of malnutrition' in our exploratory study.

These results add strength to our previous research in both hospital and community settings, that older people may find cheese portions, biscuit portions, water bottles, tetra packs, fruit cups, milk portions and 150ml milk bottles the most difficult packs to open. This research further exposed the problem in terms of time taken, number of attempts to open and ratings of 'openability'. The participants in this study were independently functioning older adults living in the community, motivated and committed to the research, yet they found some of the packaging difficult to open and three people were unable to open the water bottle or biscuit pack at all.

Seven participants (11%) who completed the two day protocol were found to be 'at risk' of malnutrition. This finding is consistent with the estimate of 10% by British Association for Parenteral and Enteral Nutrition [80]. It demonstrates the silent nature of malnutrition in the community setting as this study had a high participant burden and older people feeling unwell may not have volunteered to take part. Participants were required to make their own way to the facility at identical times a week apart and eat identical meals, staying at the University for approximately 3 hours on each occasion.

No significant differences were found in intake between the two breakfast and lunch meals for the sealed and pre-opened packaging conditions for the overall sample. However, the sealed pack condition, while not statistically significant, had a large negative effect on the dietary intake of the 'at risk' of malnutrition group for both breakfast and the snack meals. The higher food intake for breakfast in the pre-opened condition suggests that breakfast would be a good meal for observing nutrition problems in people 'at risk' of malnutrition.

Energy dense snacks such as cheese portions are an important source of protein for older people, and have been used to encourage intake in malnourished older adults and those at risk of malnourishment [65, 67]. However we found that the packaging of this important item may have inhibited consumption in the 'at risk of malnutrition' group as it was part of the snack meal. Additionally, the tetra pack, often used to serve supplements to malnourished older adults presented difficulties for some of the participants, who took a maximum of 13 attempts to remove the straw from the side of the pack.

There are a number of limitations to this study. The participants were self-selected and may not be representative of the wider older adult community. Additionally, the sampling technique was purposive and judgemental in its approach in order to obtain well, community dwelling adults who

would be willing to travel and attend the research. In fact, it is our contention that due to the high participant burden, the participants in this study were more likely to present the 'best case scenario' for both pack opening ability and food intake. The shared ward environment may have encouraged competition between participants, and it was observed that a number of participants gave verbal 'clues' on opening packages to their neighbours. Errors could have been made in measuring the plate waste in that slight spillage could have occurred transporting meals to and from the test kitchen; and participants elected not to open and eat a number of items (as reflected in the data).

No discrete measures of nutrition and energy were undertaken, only gross plate waste. As such, detailed information regarding nutrient intake has not been included. Further research should include details of protein and energy consumed, foodstuffs eaten and products left on the plate, in order to provide greater information on nutritional intake. As the water bottle was a large component of the snack meal, differences in consumption over the two conditions could have adversely affected the plate waste calculation, with participants being inconsistent in their drinking between visits. The nursing simulation suite, however, was air conditioned and the study took place on two consecutive weeks in May, 2014 with mild ambient temperatures.

This study was conducted in a laboratory setting to simulate a hospital and the results may or may not be transferrable to a hospital setting. The results do suggest that there may be an issue with packaging and subsequent food intake amongst people who are 'at risk' or 'malnourished'. The most significant limitation of this study was the sample size of older adults 'at risk of malnutrition' and the associated difficulties with robust statistical analysis. This study should be replicated on a larger scale within a hospital or care setting to further investigate the impact of packaging on intake in vulnerable and unwell older people. Further studies with community dwelling older adults are also indicated. Packaged food and beverages are everyday items, regularly purchased and used by older consumers. Information from these consumers on pack preferences, views about well-designed packaging influencing purchase and use as well as reasons why some packs are avoided would be useful for designers and manufacturers of food and beverage packaging and for organisations purchasing packaging as part of their food service, such as care facilities and airlines.

6.6 CONCLUSION

This study is unique in investigating the impact of food and beverage packaging on food intake in an older population. While our sample of older people at risk of malnutrition was small, results do

indicate that food and beverage packaging impedes intake in this vulnerable group. This is relevant in light of many current conditions. As the population ages, older people are likely to form the majority of hospital inpatients and it appears food and beverage packaging is the default method of food service provision, at least in the context of our research (NSW public hospitals). In previous research we have shown that food and beverage packaging in hospital can be problematic for older people [5, 237, 249] and this is a critical issue given that malnutrition in hospital is an established and unfortunate reality [94, 95, 243-245]. Relying on packaged products in food service provision needs to consider the issues of pack openability. Our research has demonstrated that this packaging presents real barriers to dietary intake among older participants in our study found to be at risk of malnutrition. Further research is indicated to explore the impact of food and beverage packaging on intake in a hospitalised population, where many patients are 'at risk' of malnutrition or are malnourished.

CHAPTER 7 MEASURE FOR MEASURE: PACK PERFORMANCE VERSUS HUMAN DEXTERITY AND GRIP STRENGTH

CHAPTER 7 PREAMBLE

This chapter consists of a paper submitted to the Journal of Packaging Technology and Science in March, 2015:

> Bell, A.F., Yoxall, A., Walton, K. A., Tapsell, L. C. *Measure for Measure: Pack Performance versus human dexterity and grip strength.* Manuscript number: PTS-14-0110.R1.Packaging, Technology & Science. (Submitted 23 March 2015; under review).

This chapter is an integration of overall thesis findings to formulate a methodology for evaluating packaging openability based on time and dexterity measures. Data presented is from Study 2, using seated dexterity data only. Traditionally packaging is associated with human strength ability and strength is used as a design parameter. However, the findings of this thesis are that with the exception of water bottles and biscuit sachets, strength is not strongly correlated with successful and efficient opening of hospital food and beverage packs, but dexterity is. For this reason, this paper proposes the initial ideas to determine a packaging openability evaluation based on time and dexterity.

7.1 ABSTRACT

'Openability' of food and beverage packaging has been shown to be problematic for older consumers. Pressure on resources has seen the use of packaged food and beverages increase in hospitals within the NSW region of Australia. Studies at the University of Wollongong have explored the interaction between older people and the types of packages regularly encountered in the delivery of hospital food and nutrition. As these types of packs are commonly found in UK hospitals as well, a series of studies have been undertaken by the University of Wollongong, Australia and Sheffield Hallam University, UK to further evaluate the issues surrounding the 'openability' of hospital food and beverage packaging in an attempt to understand in detail the issues leading to difficulty in use.

Current methods of pack 'ease of opening' evaluation rely on hand strength as the core parameter. Our studies examine the role of dexterity in addition to hand strength in pack opening. Water bottles, single portion drink cartons and cheese portions were amongst the poorest performing packs. Dexterity, rather than strength is found to be a sensitive and reliable method to understand the issues surrounding the poor pack performance and a repeatable way of comparing different pack formats is presented.

7.2 INTRODUCTION

Society is ageing; in 2011 16% of United Kingdom's population was above 65 years of age and is predicted to rise to 19% in 20 years [251]. However, this is not just a UK phenomenon, the UN predicts the world population of over 65's to rise to over 1.5 billion in 2050 from 486 million in 2006 [7]. A society in which a large proportion of its citizens are aged creates a major public health challenge for government, health practitioners, older consumers and other stakeholders. As we age, the likelihood of living with some form of chronic illness is significant. The prevalence of disability from the US Census in 2005 demonstrates that for individuals over 75 years, the proportion of people who need assistance was 55.9% rising to 71% for those 80 years and over [252].

Health services across the world are under severe pressure due to this increase in longevity and associated likelihood of chronic illness. Older people are for example, more likely to visit hospital and stay for longer. However, many of the illnesses previously associated with old age have more recently been attributed to poor diets and there is undisputed evidence that diet and nutrition are directly linked to many of the chronic diseases afflicting older adults [253].

Researchers have estimated that 34 English hospital patients are malnourished and the prevalence rates increase with age and further studies have shown that older patients are five times more likely to be at risk of malnutrition than younger patients [87, 88]. A number of researchers [6, 70, 99], have identified inability to access food and beverage packaging as a contributing factor to malnutrition among the older adults and disabled in hospitals. A series of studies exploring the interaction of older users and hospital food and beverage packaging has been undertaken by the author. A study by Bell [5] looked at the issue of packaging accessibility in hospitals in the NSW region of Australia. This work used a patient and staff questionnaire along with pinch and grip strength measurements to assess reasons surrounding inability to access food and beverage products in the hospital

environment. A sample meal tray used for the study which offered a range of packaged item types is shown in the Figure 7.1.

Figure 7.1 Typical meal tray in the study by Bell[5]

This initial study by Bell [5], involved 140 hospital inpatients completing the packaging questionnaire, along with 60 staff. The mean age of the sample was 72 years (±15 years); 46% male and 54% female. The patient interviews in this initial study identified five problematic forms of packaging, with the percentage who could not open each type shown after each pack type: convenience dinners (23%), water bottles (17%), cereal (17%), single portion tetra packages (12%) and condiments (e.g. jam, 10%). The problematic packaging types are shown in Figure 7.2.

Figure 7.2 Problematic packaging types

Of those patients who could open the products, approximately 50% of patients had some difficulty opening the convenience meal, the milk and the cereal pack. Nearly 40% of these patients also had difficulty opening the water bottle and tetra packs. All staff reported that patients ask for help opening food and beverage packaging and 39% of staff reported some difficulty opening certain food and beverage packaging items themselves. Figure 7.2 shows items that participants were unable to open. The same items had the longest opening time, on occasions when the item could be opened. The work showed that for water bottles the accessibility issue was likely to be related to some form of hand grip strength or tip pinch strength, whereas for the cereal packages and tetra packs the issue appeared to be a problem of both dexterity and strength. Further laboratory studies with well older people has also identified issues with packaging used in NSW hospitals and found that dexterity is a key element of hand function for pack openability [237]. Hence this study aimed to further investigate the issues surrounding poor 'openability' and to develop a methodology whereby the authors could determine what pack was affected by which capability the most.

7.3 CURRENT METHODS TO MEASURE PACK 'OPENABILITY'

Packaging manufacturers, as well as bulk purchasers (such as a hospital) would benefit from a comprehensive method to assess 'openability' of food and beverage packaging. Several initiatives have been established to assist, such as the "User-friendly packaging – Guideline for the Industry" [254]; the 2011 European Committee for Standardisation technical specification for ease of opening [142]; the guidelines put forward by the Arthritis organisations in conjunction with Georgia Tech [255] and tender guidelines developed by NSW NSW HealthShare [143]. These guidelines are useful but not exhaustive – their focus is primarily on hand strength, usability guidelines (colour, contrast, text size, etc.) and/or user satisfaction. Additionally, much of the work is based on the DTI data for strength [110], which is based on small sample sizes and a standing posture, again not particularly relevant to to a hospital environment). Rodriguez Falcon and Yoxall [256] have investigated the role of dexterity in opening medical packaging and found that it is a useful indicator and predictor of 'openability.' The purpose of this paper is to demonstrate that dexterity is the more relevant aspect of hand function for assessing packaging 'openability' than strength (with the exception of twist top containers) and to present a method to rank pack ease of opening using dexterity scores.

7.4 WELL OLDER ADULTS AND HOSPITAL FOOD AND BEVERAGE PRODUCTS

A total of 34 people (11 male [32%], 23 female [68%]) responded to an invitation to participate in this study in the Nursing Simulation Laboratory at the University of Wollongong, NSW Australia. All participants were over 65 years of age, independently living in the community and considered to be well. Each participant was tested seated in a chair. A biostatistician was consulted regarding suitable sample size and 30 participants were deemed appropriate for statistical power ($p<0.05$ and 80%). Grip strength, pinch strength and dexterity were measured using validated testing procedures as well as the time taken to open a selection of hospital food and beverage items in each posture. Participants' hands were filmed opening the items in each posture using the *in situ* cameras (see Figure 7.3). Data was not divided into gender categories, as the focus of this research is ergonomics in nature, concerned with the user group and range within that group, as all users of packaged products come from both genders.

Figure 7.3 Participant opening packages in hospital training environment

7.4.1 Grip and Pinch Strength Testing: well older adults in a hospital environment

Grip strength was measured using a Jamar Dynamometer (Lafayette Instruments Company, 2014). Participants were tested on their dominant hand first for both the grip and pinch strength measurements. Pinch strength was tested with a Jamar Hydraulic Pinch Gauge (Lafayette Instruments Company, 2014) using three different tests; tip pinch, three point pinch and a lateral pinch. Both instruments were calibrated for the testing days.

7.4.2 Dexterity Testing: well older adults in a hospital environment

Dexterity of participants was analysed using the Purdue Pegboard Test first proposed by Tiffin in 1948 [112]. The Purdue Pegboard Test can be used for numerous purposes including testing for the presence and/or extent of brain damage, learning disabilities and dyslexia. There are four individual

tests that are carried out when using the Purdue Pegboard. Normally, for all of these tests, the participant sits at a table that is at comfortable height and all standard data 'norms' such as those provided by Lafayette Instruments (Lafayette Instruments Company, 2014) and Desrosiers [114] have previously been measured in this way. An example of a participant undergoing testing is shown in Figure 7.4.

Figure 7.4 Participant undergoing testing

Participants were then asked to open seven of nine differing pack formats sourced from the local hospital (specific items and number varied due to availability from hospital kitchen). The pack items are shown in Figure 7.5 (see also Chapter 5, Figure 5.4). Both the time to open the packs and number of attempts was later determined from the recordings of the participant/Pack interactions.

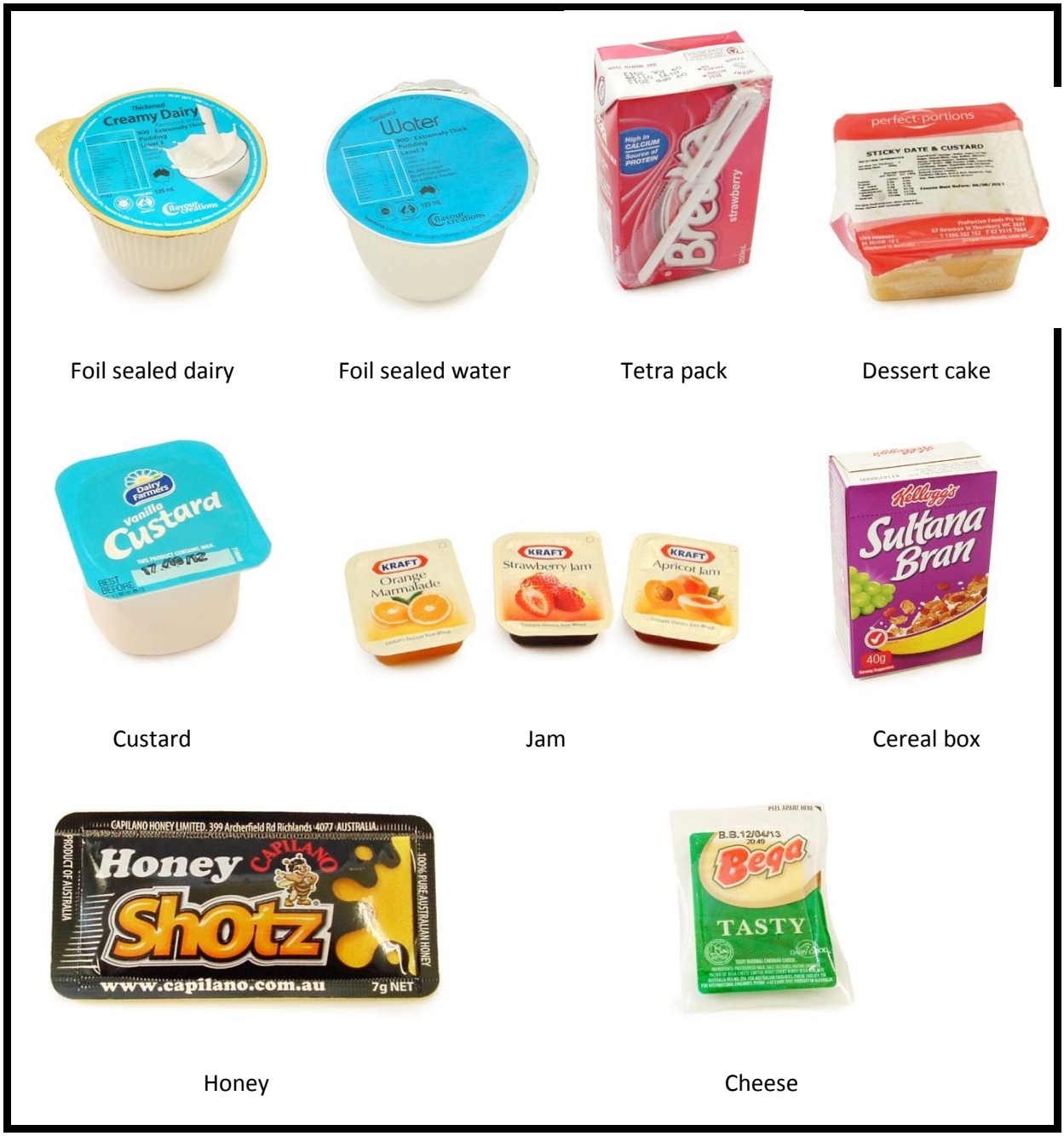

Figure 7.5 Differing packaging formats

A previous study identified a total of seven key grip types to open packaging [159]. However, in this study only four grip types were measured (overall grip strength, tip grip strength, 3 point pinch (or chuck grip) and lateral pinch strength) due to the nature of the packaging being studied, with the non-measured grip types not being generally used to access packaging of this type. Examples of a tip, 3 point pinch (or chuck grip) and a lateral grip are shown below in Figure 7.6.

Figure 7.6 Tip, 3 point (chuck) and lateral pinch grips

7.4.3 Determining Pack Performance

Correlations between time taken to open packs and aspects of hand function (grip and pinch strength, dexterity) were calculated. Moderate and strong correlations are then plotted, and trend lines placed through the data to provide a visual demonstration of the pack performance. This method not only visually demonstrates the performance of the pack; it provides opportunity to compare packs with respect to that measure. Packs which are influenced by any of the strength measures should show trend lines that are not horizontal, since a horizontal line would indicate that opening time is not influenced by the other measured variable. Figure 7.7 below shows results obtained from an initial Pilot Study undertaken on 29 participants to test the validity of the method. Three poorly performing packs types (cereal, juice and milk) identified by Bell et al., [5]were tested on 29 participants. The figure shows time in seconds on the vertical axis and dexterity as defined by the Purdue pegboard test on the horizontal axis. The gradients of the trend lines through the data are -0.09 for the cereal, -0.1 for the juice and -0.04 for the milk carton. Since the milk carton has the lowest gradient the results would indicate it is less associated with dexterity than the cereal packaging which has the highest gradient.

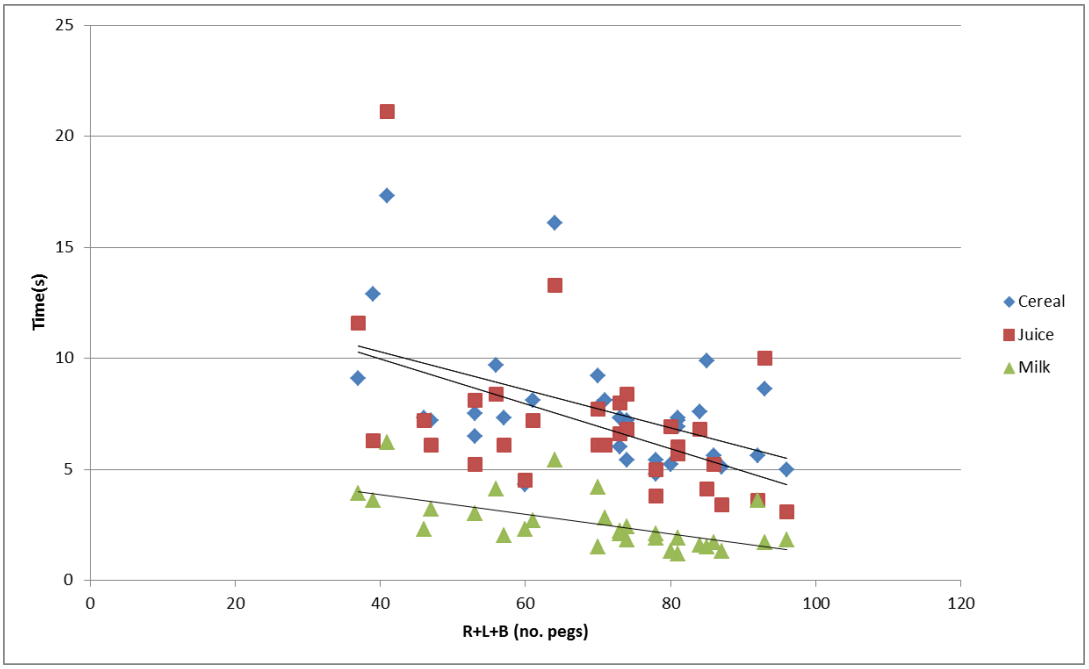

Figure 7.7 Times versus dexterity for cereal, juice and milk from an initial feasibility study (n=29).

7.5 RESULTS AND DISCUSSION

7.5.1 Grip and Pinch Strength and Products

The mean grip and pinch scores (with standard deviation) are shown below in Table 7.1. No significant correlations were found for either grip or pinch strength and time to open the packs.

Table 7.1: Grip and pinch strength data (kg/f), (n=34)

	Gross Grip		Tip		3 point pinch		Lateral pinch	
	Dom	Non-Dom	Dom	Non-Dom	Dom	Non-Dom	Dom	Non-Dom
Mean	28.58	27.56	4.31	4.16	6.21	5.88	7.25	6.66
SD	10.29	10.85	1.32	1.3	2.07	1.85	2.28	2.52

This finding is confirmed by plotting grip and pinch strength vs time and fitting trend lines through the data, allowing us to visualise the performance of the packs relative to each other and assess the influence of grip strength on the efficiency of opening a pack. Further, plotting the data provides richer detail than performing a purely statistical approach, which was limited in this research due to the sample size and mixture of normal and abnormal data distribution.

This approach to examining the data is shown in Figure 7.8. Here the relative 'flatness' of the dessert cake and jam packaging formats can be readily seen as opposed to the results for foil sealed dairy and foil sealed water, indicating that the latter packaged items influenced more by grip strength than the foil sealed dairy and foil sealed water packs. Of interest the foil sealed water is seen to have a positive slope indicating increasing strength relates to a corresponding increase in time to open this particular product.

Pinch strength and time data for the products are shown in Figures 7.9 and 7.10. Again, much of the data appears to be relatively flat indicating little correlation with tip or pinch strength however Figure 7.10 again shows foil sealed water to have a relationship to 3 point pinch strength.

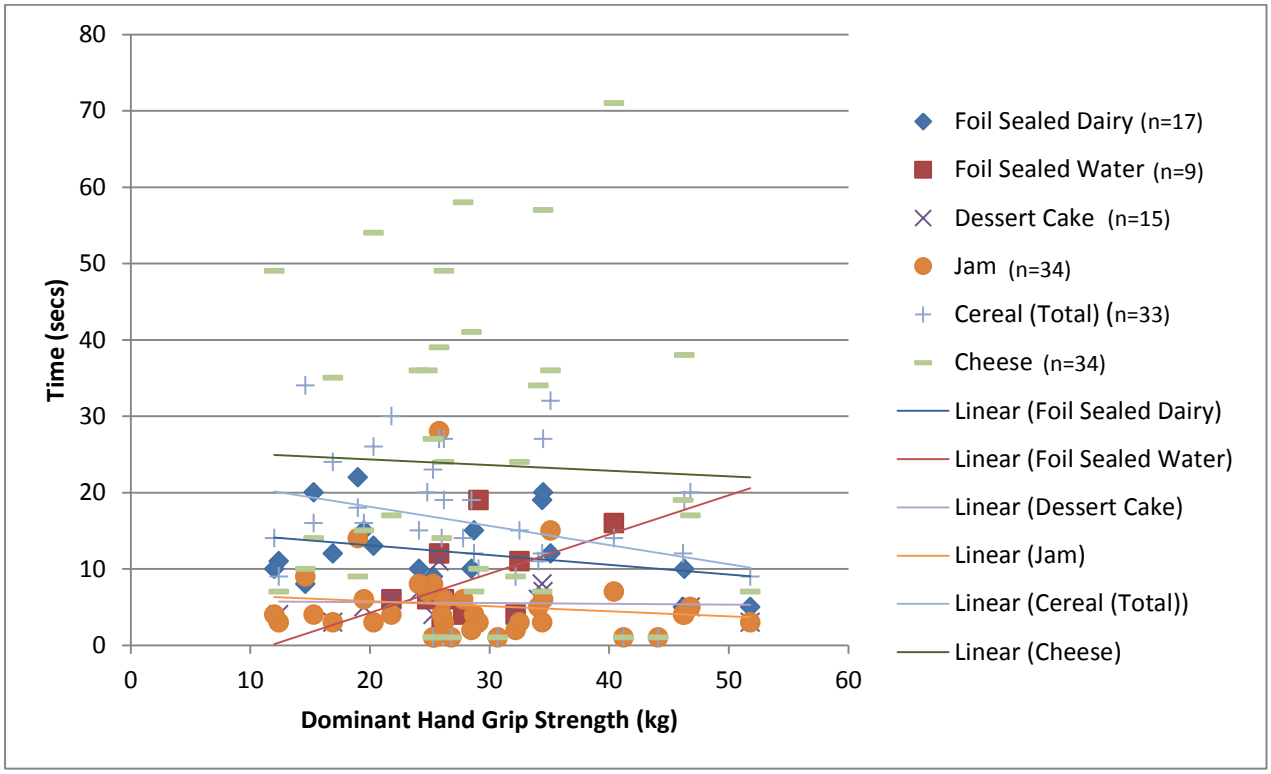

Figure 7.8 Time Vs Dominant Hand Grip strength for various pack formats

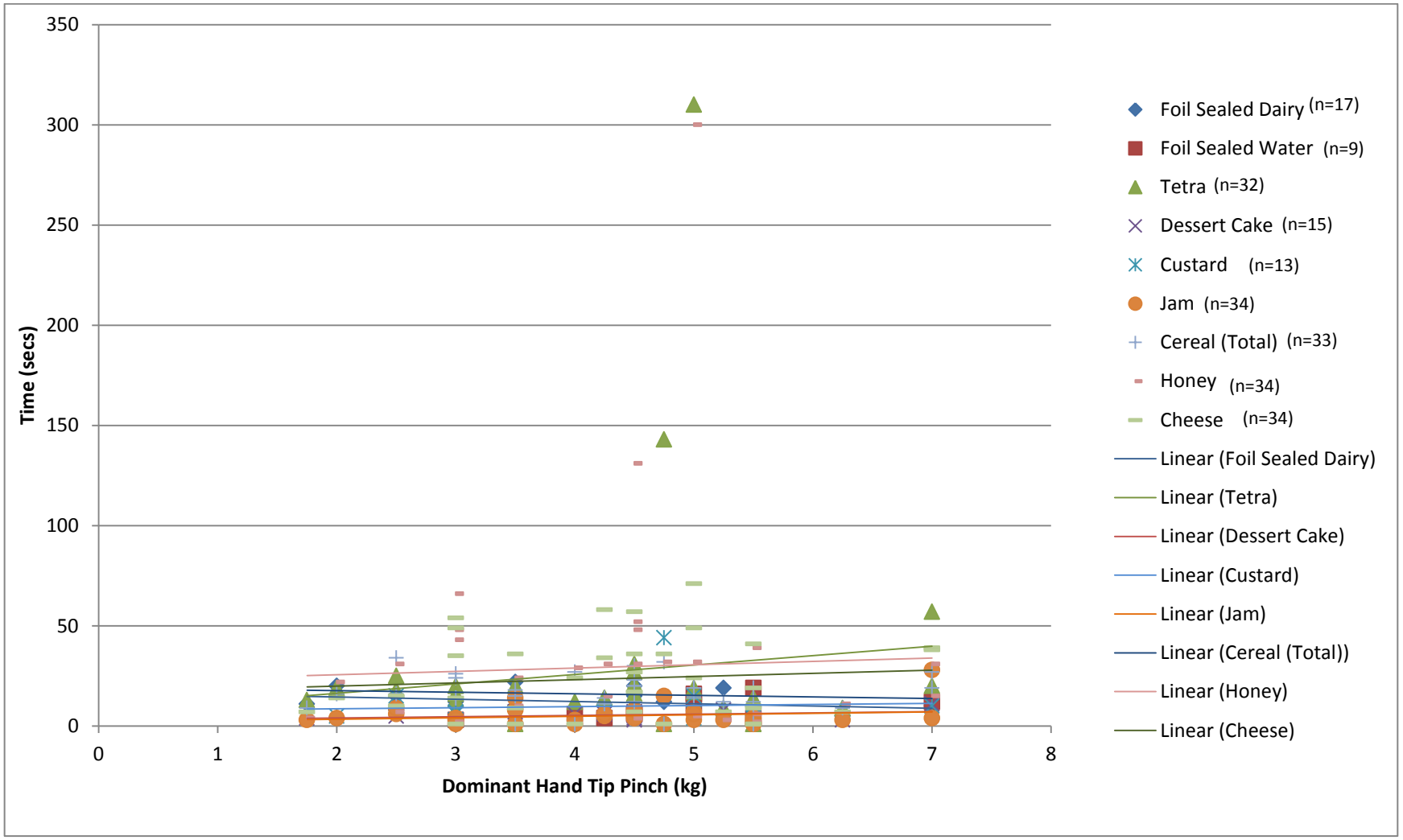

Figure 7.9 Time Vs Dominant Hand Tip Pinch strength for various pack formats

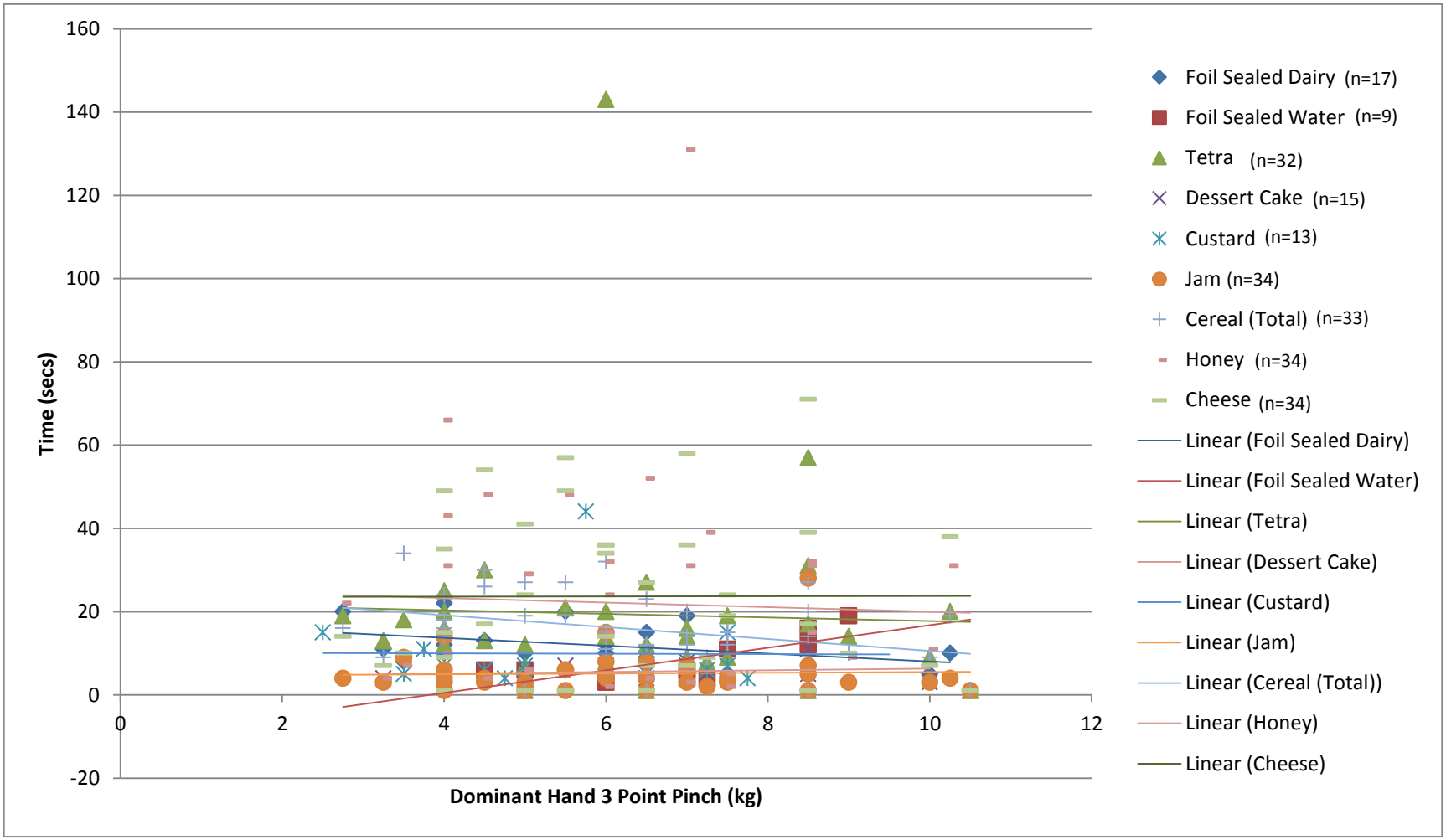

Figure 7.10 Time Vs 3 Point Pinch strength for various pack formats

7.5.2 Dexterity and Products

Using the instrumentation and the methods described in section 7.3 and Chapter 3, Section 3.7.3 and 3.7.4, the results for dexterity scores as well as significant correlations between dexterity and time taken to open a package was determined (Table 7.2). For all products except the foil sealed dairy, there was an inverse correlation between dexterity and time taken to open the products, indicating that all packs (except foil sealed dairy) were more easily opened when the participants had better dexterity scores. Table 7.2 represents the seated data from Table 5.6, Chapter 5.

Table 7.2 Significant correlations between Macro-dexterity scores and time to open packs

Food/Beverage Item	**Sample size (*n*)**	**Sig (2-tailed)**	***r***
Custard	13	.001*	-.80
Tetra pack	32	.010**	-.45
Condiments	34	.015**	-.41
Honey sachet	34	.000*	-.65
Cereal inner bag	33	.038*	-.36

* Spearman Rho Correlation is significant at the 0.05 level (2-tailed)
**Spearman Rho Correlation is significant at the 0.01 level (2-tailed)

Of particular concern is the finding for tetra packs [r=-.45 ≤-.30, n=32], as these packs are used in hospitals to provide high energy, high protein supplements for patients with reduced appetites; who are malnourished or are at risk of becoming malnourished. This issue has also been identified by another researcher who found that tetra packs were the most problematic type of packaging for patients to open [69].

This relationship between dexterity and time to open the packs is visually represented in Figure 7.10 which depicts the dexterity measure 'Right Left Both' or Macro-dexterity, from the Purdue Pegboard Test plotted against time for each product (see Chapter 3, section 3.7.4 for description of macro-dexterity). The steep trend lines for custard, honey and tetra packs show the strong relationship found in the correlations in Table 7.2.

7.5.3 Products and Hand Function

The data shows the different aspects of hand function and their relationship to the time taken to open the products. Figures 7.8-11 show that accessibility is not as simple as strength, however, as the data demonstrates that having a strong gross or pinch grip does not necessarily lead to efficient pack opening. No statistical significance was detected for grip or pinch strength and efficient pack opening. Dexterity, however, demonstrated a significant relationship to efficient pack opening for 5 packaged products: custard, honey sachet, tetra pack, condiments and the cereal box inner bag. Figures 7.8-11 demonstrate a visual representation of accessibility for the various packaging types based on the gradient of the trend line.

It can be seen that the gradients in Figures 7.10 and 7.11 allow for the relative visual comparison of each pack type against a particular variable, e.g. the cheese portion is more affected by dexterity than the dessert cake. The data shows that foil sealed dairy and the opening the cereal box (including the inner bag) are affected by pinch strength more than the jam or the custard (though no statistical significance is reached), and that both also have some element of dexterity. In this way, the graphs provide a richer description of the elements of hand function involved for the efficient pack opening than a purely statistical approach in this study.

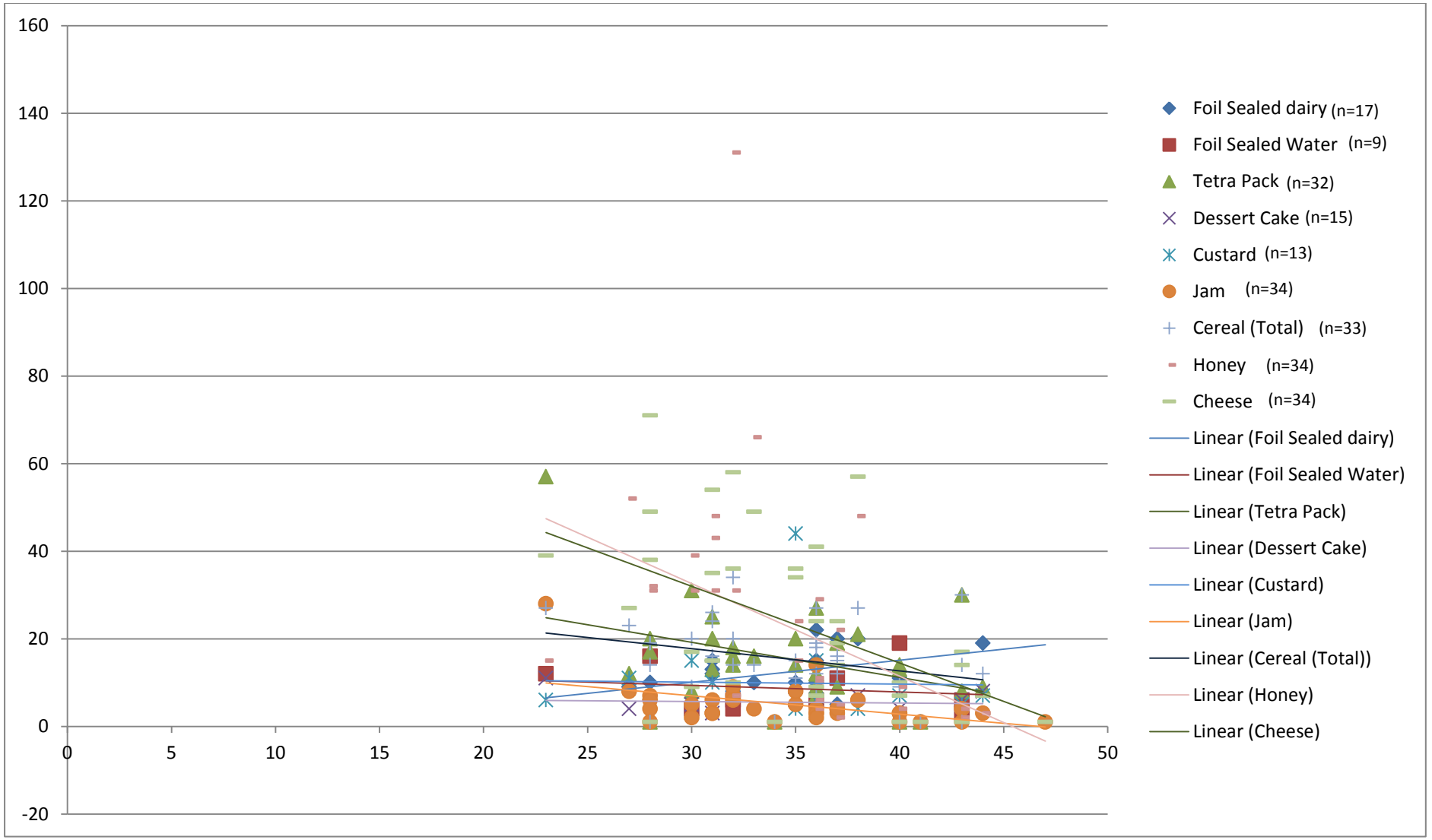

Figure 7.11 Time vs dexterity (RLBoth)

There are several limitations to this research. There is a wide dispersion of strength and dexterity data, so while trend lines can be seen and do reflect the significance found with statistical testing, greater sample size would be beneficial to gather more robust results. Additionally, no corrections were made for multiple statistical tests. Further research is required to develop our findings further. Larger sample sizes and systematic review of different pack types would allow for the development of a rating scheme based on dexterity and time to open packs. This could be combined with satisfaction questionnaires to assist pack designers and manufacturers design for better openability.

Further consideration should also be given to the visual and cognitive elements involved in the person-pack interface. This data represents well older adults with no diagnosed cognitive deficits, who are able to wear prescription glasses to correct any visual problems, and as such, represent the optimum cohort of people for testing. Additional research should be undertaken with hospitalised older adults as well as older adults living with dementia in the community in order to improve design of packs for our increasingly older and vulnerable population to examine pack openability and pack appeal so that older people are encouraged to engage with the food pack to access and eat the nutrition it contains.

7.6 CONCLUSION

The use of a Purdue pegboard to measure dexterity provides a cheap and reliable dexterity measure that is backed up with substantive normative data. From this method, dexterity is seen to effect the time to open packs more than strength in general (where packs could be opened). A combination of statistical analyses and graphical analyses enables stakeholders (pack designers, hospital catering suppliers, brand owners etc.) to make comparison between different packs and alternate designs of packs.

In measuring dexterity and strength and plotting those outcomes against time to access a pack we are able to make visual comparisons of relative pack performance and understand which packs are more problematic than others. From these trend lines we can give a 'score' to the pack which will give a useful, repeatable, valid and reliable method of assessing the pack performance that can be used by designers, manufacturers, marketers. It is anticipated that in using this method the attributes of packs that perform well can be observed and compared to those that perform badly and aid in pack redesign.

In this study, custard, honey, tetra packs, condiments and foil sealed water were all seen to be worse performing packs than the dessert cake pack. This is likely to be a combination of the number and complexity of tasks involved (for example the number of steps required to open a tetra pack). For the other packs a combination of strength is needed to overcome the seal and also the ability to grip and maintain the grip on the pack.

To understand the human pack interaction requires a multifaceted evaluation approach which has been demonstrated here through observation of participants and statistical and graphical visualisation of pack performance. From this were are able to evaluate both good and poorly performing packs.

Clearly some packs perform better than others which lead to the following recommendations:

- where possible hospital food should be served in pack formats that have been identified as easily accessible
- if the above is not possible concentrated effort should be made on the packaging supply chain to produce packs that are less susceptible to issues surrounding capability loss and in particular dexterity
- as part of the above process any new packs should be analysed using the type of techniques discussed in this paper to facilitate comparison with current practice.

CHAPTER 8 SUMMARY AND CONCLUSIONS

8.1 SUMMARY OF THIS RESEARCH

Using an ergonomics framework and with the help of older community dwelling adults, this thesis has confirmed the central hypothesis that receiving and accessing food in the hospital context is likely to be problematic for the older inpatient. The thesis set out to explore the person: pack interaction of older people with food and beverage packaging served in NSW hospitals. First a detailed analysis of the sociotechnical system in which older people consume food was conducted with reference to the scientific literature. Three empirical studies were then conducted based on pilot research of older people in hospital [5]. These studies examined the **person**, the **pack**, the **interaction/task** and the **context** for the interaction. The research questions examined in the studies were:

1. Do well older people experience difficulties with opening hospital food and beverage packages; and is hand strength the critical factor for efficient pack opening?
2. Is dexterity the critical factor for efficient opening of 'problematic' hospital food and beverage packs; and does lying in a semi-recumbent bed posture impede pack openability?
3. Does sealed packaging inhibit dietary intake in a sample of well older people; and does nutritional status affect dietary intake when food is presented in a sealed pack?

Finally, the findings of the studies were synthesised into a methodology for assessing pack performance based on dexterity and a review paper submitted for publication in a relevant scientific packaging journal.

The research was undertaken with well older adults as participants in these studies in order to eliminate the impact of illness, intermittent medical intervention, unavailability of participants and interruption to medical procedures of a hospital setting. The impetus for this thesis was a Pilot Study undertaken by the author, which had established that older people in hospital experienced real difficulties opening the packaged food and beverages provided to them for each meal.

The issue of food and beverage packaging as a core component of NSW hospital food service in this thesis is considered as part of the larger sociotechnical system of the hospital with drivers for cost containment and efficiency to treat people who are unwell and assist them to recover and leave hospital in a timely manner. In NSW, the food service system is a cook/chill service using pre-packed

food and beverage items in an effort to provide cost effective nutrition. This larger view of the issue of packaging in this context is shown in Figure 8.1 below.

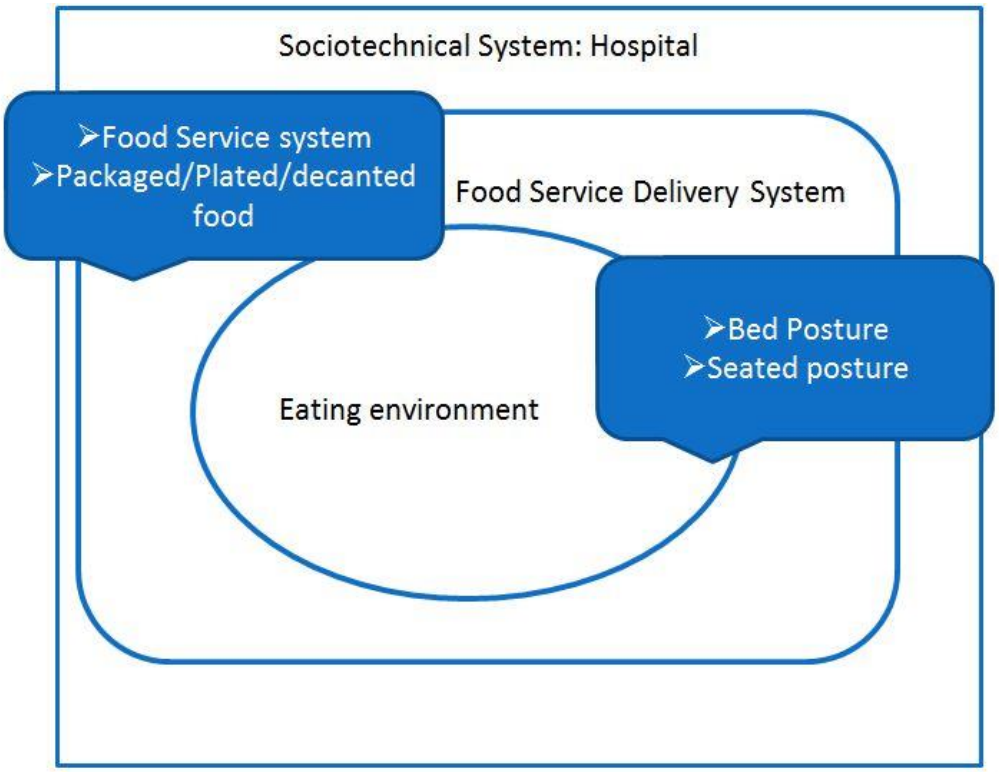

Figure 8.1 Hospital sociotechnical system and food service delivery subsystem

The research was conceptualised in the model developed by the author (Figure 3.2) whereby the interaction of the older person with the hospital food and beverage pack can take place in hospital in either a seated or bed posture.

The exploration of the research questions was undertaken in an iterative and inductive way including three empirical studies that built upon each other, starting with a review of the role of hand and finger strength in successful and efficient pack opening. The research was then expanded to include dexterity, the environmental context of lying in a hospital bed, and ultimately consuming pack contents, characterising the nutritional status of the participants and measuring dietary intake, as shown in Table 8.1 below.

Table 8.1 Outline of thesis studies

Study	Chapter	Pack	Sample (n)	Methods Applied						
				Video Timing	Q'nnaires	Grip + Pinch	Dexterity	Bed Posture	MNA	Food Intake
1	4	Full range hospital F&B packs	40	✓	✓	✓				
2	5	Problematic packs	34	✓	✓	✓	✓	✓		
3	6	B'fast, snack & lunch packs	62	✓	✓	✓	✓	✓	✓	✓

The findings of the three studies further allowed an initial concept for rating pack openability using dexterity and time measures, and this was presented in Chapter 7.

Findings in relation to these sub-hypotheses are as follows:

1. *Hand strength is necessary for efficient pack opening*

   The research has highlighted that strength is strongly associated with efficient opening of the water bottle which is currently the default method of hydration in the Illawarra and other NSW hospitals. Additionally, finger strength was associated with efficient opening of the biscuit portions provided with the cheese as a snack in hospital. However, strength was not associated with efficient opening of the other packs served as part of the hospital food service.

2. *Dexterity is necessary for efficient pack opening*

   The research has identified that macro-dexterity is a critical aspect of hand function to successfully and efficiently open packs. As packs are designed around strength parameters, this is an important finding.

3. *Laying in a hospital bed will increase the time and difficulty in opening packs*

   Both macro-dexterity and pinch strength decreased in the bed. However, gross grip remained unchanged. The decreased macro-dexterity and pinch strength did not necessarily result in faster opening times in the chair posture. Rather, the pack format proved equally as difficult in the bed and chair posture in terms of time and attempts to open.

4. *Different pack mode of opening will determine hand function requirements*

   Water bottles require strength to open; biscuit portions require pinch strength and dexterity to access. Other packs are mostly associated with dexterity for opening. The pack types are diverse, however. Many require fine motor coordination to lift tabs, the tetra pack requires a number of steps and fine motor skills to remove the straw from the side of the pack and then insert the straw into the pack. Pinch strength only was associated with efficient opening of the foil sealed dairy in Study 2, with the similar pack type of foil sealed water being associated with dexterity only.

5. *Sealed packaging will impede intake*

   Study 3 investigated the role of packaging in dietary intake. Dietary intake of older people 'at risk' of malnutrition was negatively affected for both the breakfast meal and the high protein snack (cheese, biscuits and bottled water), when these meals were served in a sealed pack condition than when the packaging was pre-opened for the participants.

8.2 SIGNIFICANCE OF THE RESEARCH

8.2.1 Overview

This research is important as it is the first time that the interaction of older adults with the packaging routinely used in NSW hospital food service has been investigated in depth. This research identifies that well community dwelling older adults encounter real difficulties with this packaging, and as many older people enter hospital in a state of malnutrition, it is imperative that the products used in hospital food service are accessible and enable patients to maximise the nutrition it can provide. Hospital food service should be '*…a part of the clinical aspect of a patient's stay*' [4] and an '*…essential part of treatment*' [248]. The finding that well, independent, community dwelling older adults had difficulty opening a selection of the packaging used in hospitals, and that some were unable to open the water bottle, the cheese portion or the biscuit pack at all, is certainly relevant. The results also identified that the tetra pack, thickened water, fruit cup and condiments presented challenges to users.

8.2.2 Water Bottles

Water bottles were found to present a serious challenge to the participants in this research, and this raises real concerns over water bottle use as the sole source of patient hydration in hospital. Water bottles required strength to open, they could not be opened by some participants; and all

participants had multiple attempts to remove the lid from the bottle; and many spilt the contents while attempting to remove the lid. Participants in these studies were well and independent, while hospital patients are unwell and vulnerable. Hospitalised older people routinely have cannulas and drips in their upper limbs further limiting their hand function ability. Additionally, there are issues associated with poor appetite in hospital due to medical interventions, unpleasant sights and sounds [97]; as well as issues with the food service itself such as inability to reach the food, lack of choice and poor timing of food service [97].

8.2.3 Existing strategies to improve packaged products in NSW hospitals

NSW Health has taken steps to address the issue of packaging accessibility in conjunction with Arthritis Australia and Georgia Tech Research Institute in the USA [11]. NSW HealthShare, the organisation responsible for food service in NSW, has instituted a tender specification for food product procurement which includes accessibility. The strategy influences manufacturers to supply more accessible food and beverage items by encouraging them to have their products assessed and rated by Georgia Tech in the USA, and in turn these ratings are used in the procurement process [210]. Unfortunately, as the arrangements are all commercial in confidence, the parameters and protocols for assessment of products is not available in the public domain and could not be referred to in this thesis. A number of changes to products have been seen in the local hospital as a result of this strategy – firstly the individual serve cereal boxes have been replaced with sachets (Figure 8.2); and the condiment packs with alternate designs (Figure 8.3).

Figure 8.2 NSW Health has replaced individual boxed cereal with cereal sachets

Figure 8.3 NSW Health has replaced condiment on the left with the alternate design on right.

While NSW Health should be acknowledged for their strategy to improve the accessibility of hospital food and beverage packs, the most problematic packs identified in this research (tetra packs, cheese portions, water bottles) continue to be served. Tetra packs and cheese portions are used in NSW hospitals and community care as sources of nutrition supplements (tetra) and high protein snacks (cheese). Older people have higher rates of malnutrition than younger people, both in hospital and in the community [6, 82, 83, 87]. Energy dense snacks are an important way for older people to access nutrition, especially as they often have medical, lifestyle/social and psychological factors impeding their dietary intake [97, 98].

8.2.4 Packaging and food waste

Food service should be an integral component of care in hospital. Many people in hospital look forward to meals as a distraction from the medical procedures and hospital environment and as a source of pleasure [57]. However, having packaged products which are difficult to open presents a significant barrier to meal access and enjoyment and likely contributes to food waste. Wasted food is wasted nutrition [60, 68]. This research has demonstrated that packaging does pose a barrier to accessing pack contents, in particular the finding that nutritionally compromised, well older adults ate less of the both their breakfast meal and high protein cheese snack when packaging was sealed, requires further investigation, and has great relevance to the hospital setting where many older people are already at risk of malnutrition [6].

8.2.5 Designing for older users

The research is also significant because it focusses on older users. The world is ageing at such a rate that in 2047, older people will outnumber children for the first time [7]. The ageing population poses challenges for health care. In 2008, 44% of all hospital patients were over the age of 65, while they represented just 14% of the general population[3]. The implications are clear, as the older population increases, their health needs will increase and they will represent the majority of hospital patients. Ensuring goods and services meet the needs and capacities of this user group is essential in order to achieve optimum results for recovery. Food service in hospital must have the needs of these people as a core value, and if packaging is used in food service provision, it must be designed, presented and opened with these users in mind.

8.2.6 The importance of dexterity over strength

Packaging design is based on human strength parameters. However, this research has demonstrated that dexterity and not strength (with the exception of water bottles and biscuit portions) is the critical aspect of pack openability. It seems that pack design has focussed on the mechanical force to peel, pull and lift tabs but not the actual person interacting with the pack. To exert force on a pack, the user has to be able to grasp the access point – and dexterity is the critical component of this action. The European specification for pack ease of opening predicates the number and gender of the pack assessment panel on the basis that females have less strength than men and should make up a greater proportion of the testing panel. In fact, men have less macro-dexterity than women and in light of this thesis finding, the proportion of genders on the testing panel should be reversed.

8.2.7 Packaging in the community

This research is also significant as it has implications for packaging selection and use by older people in the community. Packaging is ubiquitous – we are dependent upon it for food availability and no supermarket would exist without it. The older consumer is a growing market for packaging manufacturers and to effectively reach this market, manufacturers and designers must involve older users and implement universal design principles.

8.2.8 Summary

To summarise, this research is significant because:

- There are no publicly available data on the interaction of older adults with the packaging routinely used in NSW hospital food service

- Packaging is the default food service provision mechanism in NSW hospitals and many older patients are at risk of malnutrition or are malnourished and rely on hospital food to provide suitable nutrition for recovery
- Well, community dwelling older adults encounter real difficulties with the packs served in NSW hospitals
- Sealed hospital food and beverage packaging had a negative effect on dietary intake for community dwelling older adults who were 'at risk' of malnutrition.
- The population is ageing and older adults are over-represented in hospitals and soon will be the majority of inpatients
- Packaging is designed around hand strength parameters and this research shows that dexterity is the most important aspect of hand function for successful opening of hospital food and beverage packaging, with the exception of water bottles and biscuit portions
- The current European technical specification for ease of pack opening is based on the assumption that packs require strength to open; this research shows that dexterity is the critical aspect of hand function to be considered
- The number of older consumers is increasing and the findings of this research will assist designers to provide more suitable packs.

8.3 LIMITATIONS

There are a number of limitations to this research. The sampling approach was purposive and judgemental and could have biased the findings. The participants were all well, community dwelling older people and as such were the optimum cohort. However, this thesis did not formally measure vision or cognition, both of which are implicated in pack opening, and this may have influenced results. Additionally, the iterative nature of the research led to greater participant burden with each study and consequently the abilities of each study group could have been better than the previous one, leading to inconsistencies between studies.

The food products were obtained from the local hospital for each study and so there was some inconsistency between studies. For example, the condiments from Study 1 (Chapter 4) were unavailable for Study 2 (Chapter 5) with the honey sachets being substituted, and an alternate set of challenges resulting for the users with this pack. The breakfast cereal packs were withdrawn from the hospitals prior to Study 3 (Chapter 6) and consequently these items were purchased by the researcher to provide consistency with Study 1 (Chapter 4), in order to avoid the condiment/honey

issue from Study 1 (Chapter 4) and Study 2 (Chapter 5). While this is not an ideal situation, it did represent a 'real' selection of food and beverage products that would have been served to the patients in the hospital at that time.

Participants in Study 3 (Chapter 6) were placed in a shared ward environment while Study 2 (Chapter 5) was conducted in a single room. The shared ward provided participants with the opportunity to talk to each other, providing advice on how to open packs. Also, a level of competition was observed between participants when opening the packaging, even though the design ensured that the same pack conditions (sealed/pre-opened) were not placed in adjacent beds (as shown in Figure 8.4).

Figure 8.4 Package condition alternated in shared ward, Study 3 (Chapter 6). Pack condition indicated with colour coded signage and ribbons on beds

The bed posture and bed table height, while standardised, did not suit the very tall or very short participants. It could be argued that by not allowing adjustability, the researchers have affected the ability of the participant to access the packaging and complete hand function tests. The rationale for this was that in hospital it would be very unlikely for the equipment to be routinely adjusted for every patient. Additionally, for ease and speed of moving participants in and out of the test environment, a standardised approach was the most efficient and deemed appropriate. Similarly, Study 2 (Chapter 4) allowed for 2 pillows for participants to sit upright in bed should they choose, while one pillow only was available in Study 3, (Chapter 6). However, it was observed that most participants in Study 2 (Chapter 4) used one pillow only during the testing.

Fatigue may have played a role in the time and attempts taken to open packs – although the order of pack opening was not prescribed and so the effect could have been mitigated. However, it may be that the packs perceived as more difficult to open were left until last when the order was randomised, particularly in Study 1 (Chapter 4) and Study 2 (Chapter 5).

Measurement of time and in particular, attempts to open the packs was participant to observer interpretation. Although assessment of attempts was developed by both researchers measuring this parameter, there is potential for observer error. Additionally, the participants hands occasionally obscured the packs during filming, and this may have affected both time and attempts data.

Bias could also have been introduced by conducting this research in artificial settings and not the authentic context of use (hospital). Participants were aware of our research purpose and this could have influenced their interaction with the products and with the research questionnaires/interviews. Central location bias [222] is a recognised phenomenon in marketing research and may have impacted on this research. Conducting the research in a hospital setting would have overcome this bias and provided a much more realistic participant cohort in terms of strength and dexterity ability, however was considered impractical for this research.

As the participant numbers were small for the 'at risk' of malnourishment group in Study 3 (Chapter 6), there was insufficient statistical power to detect significance, although a strong negative effect was found for the sealed condition on dietary intake for the breakfast and snack meals. A larger study, ideally situated in a hospital, would address this issue.

Overall, larger sample sizes would have substantially enhanced this research, allowing for statistical analysis to determine significance of results. Thesis results could have found no significance in relationships between variables either because the sample size was too small, or there is in fact no relationship. Further research requires large sample sizes, in particular, larger sample sizes of older people characterised as 'at risk' of malnutrition.

8.4 FUTURE RESEARCH

A number of areas for future research are indicated following the findings of this thesis. Starting at the food service level of the thesis context, the impact of packaging on dietary intake of the older person in hospital could be investigated through a comparison of food service delivery methods – plated/decanted food service compared to a packaged food service, and subsequent plate waste measurement to determine intake differences. Such an investigation would be invaluable to determine the cost effectiveness of packaged food and beverage in delivering nutrition to older inpatients. Additionally, the real cost of package waste should be included. At the time of this research, the local hospital did not recycle any packaging used as part of its food service. The overall waste cost should include both nutritional and 'green' aspects of the waste stream – pack disposal and food miles as the cook/chill system relies on food preparation kitchens remotely situated from the hospital in a decoupled model of food service.

Reviewing the total picture of food service provision in this way would provide clarity for cost effectiveness of this critical component of patient care and inform tender specifications, as illustrated in Figure 8.5.

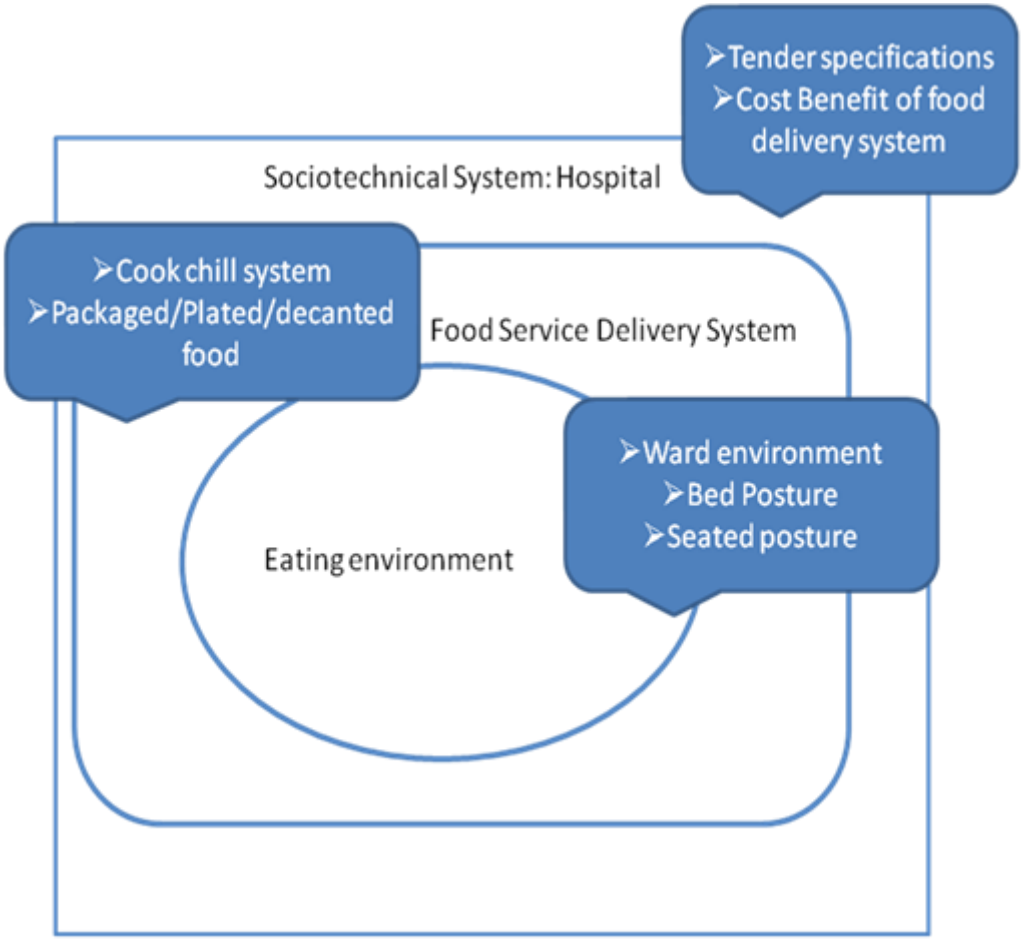

Figure 8.5 Future research to include cost benefit analysis of packaged/plated food service

Given the findings that sealed packaging had a negative effect on the older adults 'at risk' of malnutrition for the breakfast and the high protein snack in Study 3, future research is required on the effect of packaging on intake in a nutritionally compromised group. This could be conducted with larger cohorts in community, care, and hospital settings.

The design of key pack formats, tetra pack and cheese portions needs to be addressed. New and emerging technologies for packaging need to incorporate inter-disciplinary collaboration involving ergonomics, engineering, design and older users to improve the pack design along universal design principles. For example, using focus groups of older people to inform design; involving an ergonomist at the design phase; trialling different pack prototypes; and involving older users in usability testing to gather useful insights in use of packs.

Provision of water bottles in hospitals should be reviewed. The findings of this research indicate that water bottles are difficult to open by older users. As inadequate hydration has potentially severe consequences for older people in hospital which could prolong recovery and length of hospital stay, this issue needs to be investigated. Such an investigation should take place in a range of hospitals and range of ward types with large participant numbers to gather adequate data to assess the issue.

The increase of older people in the general population has implications for the prevalence of dementia in community dwelling and hospitalised older adults. This research has established that cognitively intact older people face issues with packaging. An exploration of pack openability and usability with both community and hospitalised people with dementia is indicated. This should also be explored with community meals on wheels services, as the increasing ageing population will have a corresponding effect on uptake of this type of community food service.

The finding that dexterity is the critical aspect of hand function for successful and efficient opening of hospital food and beverage packs requires further investigation. It could be that dexterity is important per se, or it could be that packs are designed in such a way that accessing them is 'fiddly' and requires dexterity because the tabs and other access points are too small and therefore dexterity is required to access these before strength can come into play. This could be investigated by trialling prototypes of the same pack with different tab lengths, for instance. Further laboratory studies would inform this question.

This thesis did not address the appearance of packs. How a pack looks will determine how much the user wants to interact with it. If packaging is to be continued to be used as a core component of hospital food service, it should be designed to be easy to open and it should also be designed to be appealing to the user – older people need encouragement to eat and the pack appearance could have a valuable role in assisting the motivation to eat. Laboratory studies would be a good starting point to test this affective aspect of pack ergonomics.

Further research is required to explore older users and packaging generally, such as:

- Qualitative studies on purchasing preference for packs (including appearance and appeal)
- Qualitative and quantitative studies of pack modifications to optimise openability
    - Increased tab size on flexible packs
    - Contrasting colours on tabs
    - Use of texture on tabs
    - Visibility, legibility, clarity of instructions
    - Appeal/appearance of packs.

8.5 RECOMMENDATIONS

This research has explored the use of hospital food and beverage packs by well, community dwelling older people using an ergonomics approach. A number of important recommendations have emerged as follows:

1. The method to supply water to patients in hospital needs to be investigated. This research has established that water bottles require strength to open and many well older adults had difficulty opening the bottles and a number could not open them at all. It is understood that plastic bottles were introduced in Illawarra hospitals as the handling of water jugs previously used caused injuries to staff. An overall risk assessment process needs to be conducted to identify injury costs to staff and potential costs to the system of inadequate patient hydration affecting length of stay through medical complications. It could be that an alternate jug design could eliminate the issues for staff and improve the access to water by patients, however this would need to be considered in light of risk assessment findings and could be part of a comprehensive control strategy.

2. The impact of packaging on the dietary intakes of older hospitalised patients should be investigated through a large hospital based study, comparing pre-opened or plated food with a packaged food service system in order to determine the cost effectiveness of each system of food service.

3. The cost-benefit analysis of food service systems should include the real cost of food provision such as food miles and waste disposal.

4. The provision of supplements in tetra packs needs to be reviewed. Alternate designs should be encouraged and assessed for suitability for older users. Bulk purchasers such as hospitals and care facilities need to advocate for change in pack type; Tetra packs could be redesigned for better access by increasing tab size, introducing different texture on the tab, and using a contrasting colour; as well as integrating the straw within the container to avoid the need for multiple steps in access.

5. The design and/or nature of the cheese portion packaging needs to be improved for greater openability. Changes such as longer tabs, textured tabs, larger serrations, accentuating colour on tab and clear directional arrows for line of pull could be implemented. Any changes would need to be trialled with older users.

6. Overall design of packaging should be inclusive for all users, implementing a universal design approach and involving ergonomics, design and older users from the design phase, prototyping through to commission.

7. Further research is required to investigate the role of cognition in pack openability.

8. Further research is required to investigate the role of vision and colour in pack openability.

9. Exploration of the older person with dementia and packaging use is indicated, in the community, care settings and hospitals.

10. The role of dexterity in successful pack opening needs to be explored with alternate pack designs to determine if the ‘fiddly’ nature of packaging tabs, seals and other access points leads to the importance of dexterity, or if dexterity ‘burden’ can be decreased with larger access points.

11. Qualitative research into older people and their use and preference in packs should be conducted to gain insights into their interaction with packaging in order to inform design.

12. The use of packaging to encourage older people to interact with the pack and consume the contents needs investigating. Older people are increasingly living alone; they have higher risk of malnutrition than the rest of the community. Packaging potentially could be used to encourage these people to eat.

This thesis was prompted by an exploratory study in Illawarra hospitals reviewing the use of food and beverage packaging in public hospital food service. [5] That Pilot Study found that older inpatients were challenged by the packaging in the hospital food service and many had difficulties opening the packs. Using an ergonomics framework and with the help of older community dwelling adults, this thesis has confirmed that the food and beverage packs used in hospital and commonly available in the community are problematic for older people in general. Older people are a significant and growing segment of society and packaging needs to meet their needs. Ergonomics has a key role to play in informing improved design incorporating universal design principles which will cater for **all** users.

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APPENDICES

APPENDIX 1: ETHICS APPROVALS

University of Wollongong

INITIAL APPLICATION APPROVAL
In reply please quote: HE09/340
Further Enquiries Phone: 4221 4457

8 April 2010

Ms Alison Bell
41.315, School of Health Sciences
University of Wollongong
Wollongong NSW 2522

Dear Ms Bell,

Thank you for your letter of 23 February 2010 responding to the HREC review letter dated 1 December 2009. I am pleased to advise that the application along with the amendment listed below have been **approved**.

Please complete the attached additional researcher declaration form and submit back to the HREC.

Ethics Number:	HE09/340
Project Title:	Open Sesame! Assessing the 'openability' of hospital food and beverage packaging.
Name of Researchers:	Ms Alison Bell, Dr Karen Walton, Ms Jacqueline Chevis, Professor Linda Tapsell, Ms Corrine Cox
Amendments:	Notification that the study will now take place in the community setting and not in the hospital
	Additional researcher – Ms Corrine Cox
	Request to include the community organisation (VIEW Club) in the research plan and a letter of support from the VIEW Club National Councilor has been provided
	Request to include testing of hand and finger grip strength
Approval Date:	25 March 2010
Expiry Date:	24 March 2011

The University of Wollongong/SESIAHS Health and Medical HREC is constituted and functions in accordance with the NHMRC *National Statement on Ethical Conduct in Human Research.* The HREC has reviewed the research proposal for compliance with the *National Statement* and approval of this project is conditional upon your continuing compliance with this document. As evidence of continuing compliance, the Human Research Ethics Committee requires that researchers immediately report:

- proposed changes to the protocol including changes to investigators involved
- serious or unexpected adverse effects on participants
- unforseen events that might affect continued ethical acceptability of the project.

Research Services Office University of Wollongong NSW 2522 Australia
Telephone: +61 2 4221 3386 **Facsimile:** +61 2 4221 4338
research_services@uow.edu.au www.uow.edu.au/research
CRICOS Provider No: 00102E

You are also required to complete monitoring reports annually and at the end of your project. These reports are sent out approximately 6 weeks prior to the date your ethics approval expires. The reports must be completed, signed by the appropriate Head of Unit, and returned to the Research Services Office prior to the expiry date.

Yours Sincerely,

Dr Nadia Crittenden
Chairperson
UOW&SESIAHS Health and Medical HREC

Cc: Dr Karen Walton, 41.226, School of Health Sciences

UNIVERSITY OF WOLLONGONG

INITIAL APPLICATION APPROVAL
In reply please quote: HE12/248
Further Enquiries Phone: 4221 3386

6 August 2012

Ms Alison Bell
School of Health Sciences
Room 248, Building 41

Dear Ms Bell,

Thank you for your letter dated 31 July 2012 responding to the HREC review of the application detailed below. I am pleased to advise that the application has been **approved.**

Ethics Number:	HE12/248
Project Title:	Does lying in a hospital bed affect hand function and the ability to open hospital food and beverage packaging in the over 65 year old?
Name of Researchers:	Ms Alison Bell, Dr Karen Walton, Ms Nicola Westblade, Ms Kate Morson, Mrs Jacqueline Chevis, Professor Linda Tapsell
Documents Approved:	1. Recruitment notice received 31 July 2012
	2. Participant Information Sheet – amended received 13 July 2012
	3. Consent Form – amended received 13 July 2012
Approval Date:	3 August 2012
Expiry Date:	2 August 2013

Please note that, in general, mention of vouchers would be in the Participant Information Sheet, not on the recruitment notice.

The University of Wollongong/ISLHD Health and Medical HREC is constituted and functions in accordance with the NHMRC *National Statement on Ethical Conduct in Human Research.* The HREC has reviewed the research proposal for compliance with the *National Statement* and approval of this project is conditional upon your continuing compliance with this document.

A condition of approval by the HREC is the submission of a progress report annually and a final report on completion of your project. The progress report template is available at http://www.uow.edu.au/research/rso/ethics/UOW009385.html. This report must be

Ethics Unit Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

completed, signed by the appropriate Head of School and returned to the Research Services Office prior to the expiry date.

As evidence of continuing compliance, the Human Research Ethics Committee also requires that researchers immediately report:

- proposed changes to the protocol including changes to investigators involved
- serious or unexpected adverse effects on participants
- unforseen events that might affect continued ethical acceptability of the project.

Please note that approvals are granted for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date.

If you have any queries regarding the HREC review process, please contact the Ethics Unit on phone 4221 3386 or email rso-ethics@uow.edu.au.

Yours sincerely,

Associate Professor Sarah Ferber
Chair, UOW & ISLHD Health and Medical
Human Research Ethics Committee

UNIVERSITY OF WOLLONGONG

APPROVAL after review
In reply please quote: HE13/465
Further Enquiries Phone: 4221 3386

26 November 2013

Ms Alison Bell
School of Health Sciences
University of Wollongong

Dear Ms Bell

Thank you for your letter responding to the HREC review letter. I am pleased to advise that the Human Research Ethics application referred to below has been **approved**.

Ethics Number:	HE13/465
Project Title:	Comparison of nutritional intake with 2 different food and beverage packaging conditions.
Name of Researchers:	Ms Alison Bell, Dr Karen Walton, Mrs Jacqueline Chevis
Documents Approved:	Initial Ethics Application Consent Form Version 2/AB - November 2013 Participant Information Form Version 2/AB - November 2013 Recruitment Flyer Telephone Interview & Screen Form Version 1/AB - October 2013 Mini Nutritional Assessment MNA Pre-Meal Questionnaire Form 2 Food Record Form 3 Version 1/AB - October 2013 Meal Time Observation (Video) Form 4 Version 1/AB - October 2013 Dexterity Testing Form 5 Grip Strength Testing Form 6 Post-Meal Questionnaire (Condition (b) packaged) Version 2/AB - October 2013
Approval Date:	26 November 2013
Expiry Date:	25 November 2014

The University of Wollongong/SLHD Health and Medical HREC is constituted and functions in accordance with the NHMRC National Statement on Ethical Conduct in Human Research. The HREC has reviewed the research proposal for compliance with the National Statement and approval of this project is conditional upon your continuing compliance with this document.

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

A condition of approval by the HREC is the submission of a progress report annually and a final report on completion of your project. The progress report template is available at http://www.uow.edu.au/research/rso/ethics/UOW009385.html. This report must be completed, signed by the appropriate Head of School and returned to the Research Services Office prior to the expiry date.

As evidence of continuing compliance, the Human Research Ethics Committee also requires that researchers immediately report:

- proposed changes to the protocol including changes to investigators involved
- serious or unexpected adverse effects on participants
- unforseen events that might affect continued ethical acceptability of the project

Please note that approvals are granted for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date.

If you have any queries regarding the HREC review process, please contact the Ethics Unit on

Yours sincerely

Professor Jim Greenstein
Chair, UOW & ISLHD Health and Medical
Human Research Ethics Committee

cc: Dr Karen Walton

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
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APPENDIX 2: HAND FUNCTION TESTING

Form 5: Dexterity Testing

Subject Number: _____

Subject Initials: _____

Date (circle): Friday 23/30 Saturday 24/31

Condition (circle) : Open (bed posture for testing)

Sealed (chair posture for testing)

Assessor_____

Dominant Hand (circle): Right or Left

	Result
Right Hand	
Left Hand	
Both Hands	
Right + Left + Both	
Assembly	

Form 6: Grip Strength Testing

Subject Number: _____

Subject Initials: _____

Date (circle): Friday 23/30 Saturday 24/31

Condition (circle) : Open (bed posture for testing)

Sealed (chair posture for testing)

Assessor_____

GRIPS AND PINCH STRENGTH TESTING

Dominance: **R** **L**

Grip: **Right** **Left**

_____ _____

Pinch: **R** **L**

Tip _____ _____

3 Point _____ _____

Lateral _____ _____

Measurements are in Kg.

DEXTERITY TESTING PROTOCOL

PERDUE PEGBOARD INSTRUCTIONS

"This is a test to see how quickly and accurately you can work with your hands. Before you begin each part of the test, you will be told what to do and then you will have an opportunity to practice. Be sure you understand exactly what to do."

RIGHT HAND

"Pick up one pin at a time with your right hand from the right-hand cup. Starting with the top hole, place each pin in the right-hand row (DEMONSTRATE). Now you may insert a few pins for practice. If during the testing time you drop a pin, do not stop to pick it up. Simply continue by picking up another pin out of the cup."

"Stop. Now take the practice pins out and put them back into the right-hand cup."

"When I say begin, place as many pins as you can in the right-hand row, starting with the top hole. Work as rapidly as you can until I say stop."

"Are you ready? Begin"

After **30 seconds** say stop.

Record the **total number of pins** inserted with the right hand.

Leave the pins in the holes.

LEFT HAND

"Pick up one pin at a time with your left hand from the left-hand cup. Place each pin in the left-hand row, starting with the top hole (DEMONSTRATE). You may insert a few pins for practice."

"Stop. Take out the practice pins and put them back into the left-hand cup."

"When I say begin, place as many pins as you can in the left-hand row, stating with the top hole. Work as rapidly as you can until I say stop."

"Are you ready? Begin."

After **30 seconds** say stop.

Record the **total number of pins** inserted with the left hand.

Return all pins to the proper cups.

BOTH HANDS

"For this part of the test you will use both hands at the same time. Pick up a pin from the right-hand cup with the right hand and at the same time pick up a pin from the left-hand cup with your left hand, and place the pins down the rows. Begin with the top hole of both rows (DEMONSTRATE – REPLACE PINS). Now you may insert a few pins with both hands for practice."

"Stop. Take out the practice pins and put them back in the proper cups."

"When I say begin, place as many pins as you can with both hands, starting with the top hole of both rows. Work as rapidly as you can until I say stop."

"Are you ready? Begin."

After **30 seconds** say stop.

Record the **total number of pairs** inserted and return the pins to the proper cups.

ASSEMBLY

"This sequence consists of assembling pins, collars and washers (DEMONSTRATE WHILE EXPLAINING). Pick up one pin from the right hand cup with your right hand, and while you are placing it in the top hole in the right-hand row, pick up a washer with your left hand."

"As soon as the pin has been placed, drop the washer over the pin. While the washer is being placed over the pin with your left hand, pick up a collar with your right hand."

"While the collar is being dropped over the pin, pick up another washer with your left hand and drop it over the collar. This completes the first assembly, consisting of a pin, a washer, a collar and a washer."

"While the final washer for the first assembly is being placed with your left hand, start the second assembly immediately by picking up another pin with your right hand."

"Place it in the next hole; drop a washer over it with your left hand, and so on, completing another assembly. Now make a few assemblies for practice."

EMPHASIS THE ALTERNATING PROCESS

"Stop. Now return the pins, collars, and washers to the proper cups."

"When I say begin, make as many assemblies as you can, beginning with the top right-hand hole. Work as rapidly as you can until I say stop."

"Are you ready? Begin"

After **1 minute** say stop.

Count the **number of parts assembled** and record the score.

Return all parts to the proper cups.

APPENDIX 3: MNA-SF®

Mini Nutritional Assessment
MNA®

The MNA® Form on page 209 removed for copyright reason, please refer to this web link: http://www.mna-elderly.com/mna_forms.html

APPENDIX 4: QUESTIONNAIRES (ALL STUDIES)

Study 1 (Chapter 4)

Hospital Food Packaging Review

We are conducting some research in the area of hospital food packaging, specifically regarding the degree of difficulty involved in opening various packages.

Age: _____ Gender: M / F Initials: _____ Subject #:_____

Items	Able to recognise?		Able to open?		Ease of opening 1 (no difficulty) **5** (impossible)					If you experience difficulty, why is it difficult to open?							Other	Please explain	Do you require assistance opening this item?	
	Yes	No	Yes	No	1	2	3	4	5	V	HS	HT	HP	R	FP	U			Yes	No
Soup																				
Milk portions																				
Juice portions																				
Water bottle																				
Tetra pack drinks																				
Dessert bowl																				
Yoghurt																				
Mugs																				
Milk 150ml																				
Vegemite portion																				
Jam portion																				
Margarine/butter portion*																				

*circle which one used

Legend:

Degree of difficulty	**1**: Easy, **2**: Some difficulty, **3**. Moderately Difficult, **4**: Very Difficult, **5**: Impossible
Why the product is difficult to open	**V**: Vision, **HS**: Hand strength, **HT**: Hand tremor, **HP**: Hand pain, **R**: Range of motion, **FP**: Fiddly package, **U**: Unsure how

Study 2 (Chapter 5)

Hospital Food Packaging Review

Items	Able to recognise?		Able to open?		Ease of opening 1 (no difficulty) **5** (impossible)					If you experience difficulty, why is it difficult to open?							Other	Please explain	Do you require assistance opening this item?	
	Yes	No	Yes	No	1	2	3	4	5	V	HS	HT	HP	R	FP	U			Yes	No
Jelly cups																				
Bagged bread																				
Sandwich triangles																				
Cereal: weet-bix Boxed*																				
Fruit																				
Biscuits																				
Disposable cutlery																				
Sugar/sweetener sachet																				
Coffee sachet																				
Salt & pepper sachet																				
Cheese sachet																				

*circle which one used

Legend:

Degree of difficulty	**1**: Easy, **2**: Some difficulty, **3**. Moderately Difficult, **4**: Very Difficult, **5**: Impossible
Why the product is difficult to open	**V**: Vision, **HS**: Hand strength, **HT**: Hand tremor, **HP**: Hand pain, **R**: Range of motion, **FP**: Fiddly package, **U**: Unsure how

Study 3 (Chapter 6)

Hospital Food Packaging Review

We are conducting some research in the area of hospital food packaging, specifically regarding the degree of difficulty involved in opening various packages

Date: 24th August 2012 Assessor: KM/JC/NW Subject #: ____ Glasses required: Yes/No

Items		**Able to recognise ?**		**Able to open?**		**Ease of Opening 1 (no difficulty) 5 (impossible)**					**If you experience difficulty, why is it difficult to open?**							**Additional Notes**
		Yes	No	Yes	No	1	2	3	4	5	V	HS	HT	HP	R	FP	U	
Tetra Packs	Breaka																	
	Ensure																	
Cheese portion																		
Cereal pack (rice bubbles)																		
Condiments	Honey																	
	Jam																	
Dessert bowl																		

Legend:

Degree of difficulty	**1**: Easy, **2**: Some difficulty, **3**: Moderately difficult, **4**: Very difficult, **5**: Impossible
Why the product is difficult to open	**V**: vision, **HS**: hand strength, **HT**: hand tremor, **HP**: hand pain, **R**: range of motion, **FP**: fiddly package, **U**: unsure how

Study 3 (Chapter 6)

Form 2: Meal Questionnaire

Subject Number: _____

Subject Initials: _____

Date (circle): Friday 23/30 Saturday 24/31

Condition (circle) : Open Sealed

Assessor: _____

Appetite & Health

When did you last eat and drink before the study meal?

Please describe what you ate and drank.

How is your appetite today? (tick box)

About normal ❑ Better than normal ❑ Worse than normal ❑

How would you rate the quality of the food you have eaten today? (circle)

Excellent Very good Good Fair Poor

In general, would you say your health is: (circle)

Excellent Very good Good Fair Poor

How would you rate the quantity of food provided today? (circle)

Excellent Very good Good Fair Poor

Describe what you would normally eat at this meal and for a snack?

Form 7: Post-Meal Questionnaire (Condition (2) sealed package)

Subject Number: _____ Date (circle): Friday 23/30 Saturday 24/31

Subject Initials: _____

Assessor_____

Information self-reported and questions read to Subjects. The researcher will tick/circle the responses.

Do any of the following conditions influence the use of your hands? (You may select more than one)

Hand strength Hand tremor Hand pain Range of motion Arthritis
If so, is it your **left** hand, **right** hand or **both** hands?

Are you **Left** or **Right** Handed? **Left/Right**

Do you wear glasses to open packages or food containers? Yes/ No.

Does your vision influence your ability to open packages or food containers? **Yes/ No**.
If yes, would you like to describe how you go about opening food packages and containers?

Handling everyday items at home

Are you able to use a toothbrush?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to do up a zipper?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to do up buttons?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult

Opening food and beverage packages at home

Are you able to open a milk carton?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to open a milk bottle?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to open juice bottle?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to open a drink can?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to use a can opener?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to open a cereal box?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to open a margarine tub?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to open a loaf of bread?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to handle hot items?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to open a jar?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to use a knife and fork?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult
Are you able to carry a grocery bag?	**Yes** or **No**	If **Yes:** Easy	Some difficulty	Difficult

Hospital Food and Beverage Items on Meal Tray: Breakfast + Snack

Itemised Food & Beverage Products	Are you able to open?		Degree of difficulty				If you experience difficulty, why is it difficult to open?						
	Yes	No	E	SD	D	I	V	HS	HT	HP	R	FP	U
Orange Juice													
Cornflakes													
Sustain													
Sultana Bran													
150ml milk													
Bread bag													
Margarine													
Strawberry Jam													
Vegemite													
Coffee/Tea													
Milk portion													
Sugar													
Cheese portion													
Savoury biscuits													
Two fruits/fruit cup													
Water bottle													

Legend

Degree of difficulty E: Easy SD: Some difficulty D: Difficulty I: Impossible

Why the product is difficult to open V: Vision HS: Hand strength HT: Hand tremor HP: Hand pain
R: Range of motion FP: Fiddly package, U: Unsure how to open

Hospital Food and Beverage Items on Meal Tray: Lunch+ Snack

Itemised Food & Beverage Products	Are you able to open?		Degree of difficulty				If you experience difficulty, why is it difficult to open?						
	Yes	No	E	SD	D	I	V	HS	HT	HP	R	FP	U
Sandwich wedge													
Custard													
Breaka													
Cheese portion													
Savoury biscuits													
Two fruits/fruit cup													
Water bottle													

Legend

Degree of difficulty E: Easy SD: Some difficulty D: Difficulty I: Impossible

Why the product is difficult to open V: Vision HS: Hand strength HT: Hand tremor HP: Hand pain
R: Range of motion FP: Fiddly package, U: Unsure how to open

APPENDIX 5: INTAKE DATA COLLECTION FORMS (STUDY 3, CHAPTER 6)

Form 3: Food Record (Lunch + Snack) KITCHEN

Subject Number: _____

Subject Initials: _____

Date (circle): Friday 23/30 Saturday 24/31

Condition (circle) : Open Sealed

Assessor_____

Time	Meal Observed	Food Items (circle items)	Standard Pre-serve weight (g)	Post serve weight (waste) (g)	Intake (g)
	Lunch	Sandwich: Egg, mayo & lettuce Chicken & lettuce Ham & tomato Bread: White/Wholemeal Custard Breaka: Strawberry/Chocolate			
	Snack	Cheese portion Savoury biscuits Two fruits/fruit cup Water bottle			

Form 3: Food Record (Breakfast + Snack) KITCHEN

Subject Number: _____

Subject Initials: _____

Date (circle): Friday 23/30 Saturday 24/31

Condition (circle) : Open Sealed

Assessor_____

Time	Meal Observed	Food Items (circle items)	Standard Pre-serve weight (g)	Post serve weight (waste) (g)	Intake (g)
	Breakfast	Orange Juice			
		Cereal: Cornflakes Sustain Sultana Bran			
		150ml milk			
		Bread: White/Wholemeal			
		Margarine			
		Condiments: Strawberry Jam Vegemite			
		Coffee/Tea			
		Sugar			
		Milk portion			

Time	Meal Observed	Food Items (circle items)	Standard Pre-serve weight (g)	Post serve weight (waste) (g)	Intake (g)
	Snack	Cheese portion			
		Savoury biscuits			
		Two fruits/fruit cup			
		Water bottle			